

# On the Respective Contributions of Awareness of Unconditioned Stimulus Valence and Unconditioned Stimulus Identity in Attitude Formation Through Evaluative Conditioning

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Evaluative conditioning (EC) is a central mechanism for both classic and current theories of attitude formation. In contrast to Pavlovian conditioning, it is often conceptualized as a form of evaluative learning that occurs without awareness of the conditioned stimulus–unconditioned stimulus (CS-US) contingencies. In the present research, the authors directly address this point by assessing the respective roles of US valence awareness and US identity awareness in attitude formation through EC. Across 4 experiments, EC was assessed with evaluative ratings as well as evaluative priming measures, and the impact of valence and identity awareness on EC was evaluated. EC effects on priming and rating measures occurred only for CSs for which participants could report the associated US valence, and US identity awareness did not further contribute to EC. This finding was obtained both for semantically meaningless (i.e., nonword letter sequences) and meaningful (i.e., consumer products) CSs. These results provide further support for the critical role of contingency awareness in EC, albeit valence awareness, not identity awareness.

*Keywords:* attitude formation, evaluative learning, preference acquisition, evaluative conditioning, contingency awareness

Social psychological research has long been concerned with how attitudes can be measured, with how attitudes can be changed, and with the conditions that moderate the attitude-behavior link. In comparison, there is a relative lack of empirical research concerned with the basic learning processes through which new attitudes are acquired. One current view in social psychology, mainly in dual-process models of attitude formation, is that attitudes can be learned through purely associative processes. These processes are generally conceptualized as a low-level, automatic type of learning. The best case for this associative form of attitude learning is evaluative conditioning (EC), which has classically been thought

to be independent of awareness, goals, and resources. The present research brings together new findings from the social psychological and learning literatures to elucidate the conditions under which attitudes can be learned through EC.

EC refers to the change in valence of initially neutral stimuli (conditioned stimuli [CSs]) after their pairing with evaluatively positive or negative stimuli (unconditioned stimuli [USs]). For example, if an unfamiliar face is encountered repeatedly in spatial and temporal proximity to a friendly face, EC predicts that the unfamiliar face will eventually be evaluated more positively. Since its initial discovery (Levey & Martin, 1975), EC has received considerable attention, and the amount of research on EC is ever increasing (for recent reviews, see De Houwer, 2007; De Houwer, Thomas, & Baeyens, 2001; Lovibond & Shanks, 2002). Theoretically, EC is conceptualized as one of the simplest evaluative learning mechanisms, and it is typically recruited to explain how attitudes and preferences are acquired with relatively little cognitive effort. Indeed, EC is often considered a purely associative learning mechanism in recent dual-process models of human evaluative learning and attitude formation that requires little, if any, attention and awareness (e.g., Gawronski & Bodenhausen, 2006; Hammerl, 2000; Olson & Fazio, 2001). However, recent research, mainly published in the learning literature, has raised doubts about the view that EC is independent of awareness, attention, and goals (e.g., Corneille, Yzerbyt, Pleyers, & Mussweiler, 2009; Dawson, Rissling, Schell, & Wilco, 2007; Lovibond & Shanks, 2002; Mitchell, De Houwer, & Lovibond, 2009; Pleyers, Corneille,

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The research reported in this article was supported by a Seedcorn Grant from the European Association of Experimental Social Psychology to Christoph Stahl, by Grant ARC06/11-337 from the Communauté Française de Belgique to Olivier Corneille, by Grant KL 614/31-1 from the Deutsche Forschungsgemeinschaft to Christoph Klauer, by a Feodor Lynen scholarship from the Humboldt Foundation, and by Grant UN 273/1-1 from the Deutsche Forschungsgemeinschaft to Christian Unkelbach.

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Luminet, & Yzerbyt, 2007; Pleyers, Corneille, Yzerbyt, & Luminet, 2009; Stahl & Unkelbach, 2009; Wardle, Mitchell, & Lovibond, 2007).

The present research contributes to this active theoretical debate by examining the role of contingency awareness in EC. We combined two recent empirical approaches: First, we investigated the impact of awareness on EC at the level of the CS-US pair instead of at the participant level (Pleyers et al., 2007). Second, we distinguished between two different types of awareness: awareness of the identity of the US that has been paired with a given CS, and awareness of the valence of the US (Stahl & Unkelbach, 2009). We believe that this combination may help reconcile contradictory findings about the role of awareness in EC. In addition, we measured EC using direct evaluative ratings as well as an evaluative priming task; the latter measure is especially suitable because it taps directly into stimulus valence and is largely uncontaminated by strategic influences or judgment concerns. We discuss the merits of combining these two approaches below.

### A Memory-Based Criterion of Awareness

People's awareness of their mental processes is a prime topic in psychology (Bargh, 1994), particularly so across the psychology of learning and memory (Reber, 1993). From a layman's perspective, some form of learning and/or memory process must exist that occurs without awareness: Subjectively, people lack the introspective ability to be aware of the operating principles of processes like typing, language production, or cultural norms that are followed in behavior.

How can we determine whether a phenomenon such as EC requires awareness of the CS-US relation (contingency or contiguity)? Definitions of implicit learning and memory provide a starting point: For example, Hayes and Broadbent (1988, p. 251) defined implicit learning (the *u*-mode) as the "unselective and passive aggregation of information about the co-occurrence of environmental events and features." Schacter (1992, p. 559) defined implicit memory in contrast to explicit memory: "Implicit memory is an unintentional, nonconscious form of retention that can be contrasted with explicit memory, which involves conscious recollection of previous experiences. Explicit memory is typically assessed with recall and recognition tasks."

These definitions provide a guiding framework to answer the question of whether EC depends on awareness. If EC is dependent on awareness of the CS-US relation—in other words, explicit memory for the pairings—then awareness should be reflected in recall and/or recognition tasks. Consequently, EC effects should vary as a function of performance in these memory tasks. We use this criterion in the following experiments. Note that it is not a circular criterion, as it is empirically possible to demonstrate learning without recognition or recall (e.g., Bowers, 1984; Tulving, Schacter, & Stark, 1982). In addition, this criterion presents a strict test for awareness in EC, as it is logically possible that there is awareness at the time of learning, which is lost across time and not reflected in subsequent recall or recognition tasks. In other words, participants who show no awareness on such memory tasks may have actually been aware of the pairings at learning.

### Examining the Role of Awareness in EC at the Level of CS-US Contingencies

Initial evidence suggested that EC could occur without awareness. For example, Baeyens, Eelen, and Van den Bergh (1990) reported that EC might be independent of participants' awareness of the CS-US pairings. Similarly, Walther and Nagengast (2006) found EC effects only for those participants who were classified as unaware of the specific CS-US pairings. However, several authors noted that conclusions regarding EC without awareness were often based on questionable experimental designs or on awareness measures and analytic strategies that failed to capture subtle but substantial manifestations of awareness (for a detailed discussion of these points see, for instance, Field & Davey, 1999; Lovibond & Shanks, 2002).

Recently, Pleyers et al. (2007) conducted a series of studies that resolved many problems and limitations of earlier experiments. These authors found evidence for EC effects only on CSs that could be correctly paired with their associated US in the context of an identification task. One major improvement of these experiments was that the authors defined awareness at the level of specific CS-US pairs, not at the level of participants. Both logically and empirically, it is possible that participants classified as unaware may still be aware of the CS-US relation for a subset of pairings. Therefore, an EC effect obtained for these participants might depend on awareness but would be taken as evidence for unaware EC when awareness is assessed at the level of the participant. This problem is resolved by investigating the role of awareness in EC at the level of specific CS-US pairs. Using this approach, Pleyers et al. (2007) obtained evidence for the role of contingency awareness in EC both on classic evaluative measures (i.e., evaluative ratings) and on evaluative measures that reduced the possibility of participants' control over their evaluative responses (i.e., using an evaluative priming task; see also below). The present research also assesses awareness on the appropriate level of specific CS-US pairs and uses evaluative priming as an indirect and unobtrusive evaluative measure.

### Contingency Awareness for US Identity and for US Valence

Shanks and St. John (1994) discussed two reasons why learning might erroneously seem to occur implicitly and, thus, without awareness. First, participants may seem unaware of a piece of information *I* because the measures to capture awareness of *I* are inadequate or not sensitive enough. This explanation fits with Pleyers et al.'s (2007) results: When awareness is measured at the level of CS-US pairings with a sensitive recognition task, EC emerges only for CSs for which participants show awareness.

Second, participants may be truly unaware of *I*, but they may be aware of *I*\* instead of *I*, where *I*\* is less complex or difficult than *I*. It is important to note that *I*\* is still sufficiently informative to support above-chance explicit learning performance. For example, in artificial grammar learning, it is often sufficient to consciously extract a microrule of the underlying grammar, instead of extracting the full grammatical production system, to show evidence for learning (Dulany, Carlson, & Dewey, 1984).

In EC, *I*\* could be the valence of the US with which a CS has been paired. If US valence can be consciously retrieved, EC might

be obtained, even if the US's identity cannot be reported correctly. This has been suggested in an experiment by Stahl and Unkelbach (2009), in which EC was dependent on contingency awareness. In contrast to standard awareness tests in EC, these authors tested for valence awareness (i.e., memory for the valence of the US with which a CS was paired) in addition to identity awareness (i.e., memory for the identity of the US with which a CS was paired). Results suggested that for EC to emerge, it was necessary and sufficient that participants recalled the valence of a given US with which a CS was paired.

Yet, the study by Stahl and Unkelbach (2009) is open to some criticisms with respect to their contribution to the awareness debate. For example, classification of a given CS as valence-aware or identity-aware<sup>1</sup> was not fully independent in their study; hence, the data were inconclusive about the relative contributions of valence-awareness versus identity-awareness to EC. In addition, Stahl and Unkelbach used the Extrinsic Affective Simon Task (EAST; De Houwer, 2003) as an indirect evaluative measure but failed to obtain overall EC effects on this task, which casts doubts on the sensitivity of this task as it comes to examining EC effects.

### The Present Research

This research examines whether valence awareness is a necessary condition for EC effects to be observed, on both direct and indirect evaluative measures and across different levels of identity awareness. We addressed the following questions: First, is valence awareness indeed necessary for EC? Second, what is the role of identity awareness, and does it contribute to valence acquisition through EC over and above valence awareness? For example, it might or might not be the case that identity awareness also contributes to EC effects, such that EC for valence- and identity-aware CSs is of greater magnitude than is EC for CSs for which only valence awareness (but not identity-awareness) is obtained.

Across four experiments, we investigate EC effects for valence-aware and valence-unaware CSs across different levels of identity awareness. In Experiments 1 and 2, respectively, we used meaningless nonword stimuli and more meaningful, familiar consumption products. Evaluative ratings served as the dependent variable in these experiments. Valence awareness and identity awareness were assessed with recognition memory tasks as recommended by Shanks and St. John (1994). In Experiments 3 and 4, we also used psychologically meaningful stimuli and evaluative ratings but included an evaluative priming measure (Fazio, Sanbonmatsu, Powell, & Kardes, 1986). This measure eliminates possible alternative explanations in terms of response strategies and assesses more directly the respective contribution of valence- and identity awareness to valence acquisition and attitude formation through EC.

In all experiments, we used the multiple-US pairing condition reported by Stahl and Unkelbach (2009; see also Olson & Fazio, 2001, 2002) to obtain substantial proportions of valence-aware CSs with varying levels of identity awareness. Specifically, five different USs of the same valence, instead of just one, were paired with each CS. This procedural modification has proven successful in reducing levels of US identity memory. In addition, by probing identity awareness for each of these five USs, we obtained a more fine-grained measure of identity awareness, as opposed to a mere binary, all-or-nothing classification. We compared the magnitude of EC across these different levels of identity awareness for

valence-aware and valence-unaware CSs. However, Experiments 3 and 4 also include the more standard procedure of pairing a given CS repeatedly with only one US; thus, the present findings cannot be attributed solely to the use of the multiple-US pairing procedure. Experiments 1 and 2 are first reported and then discussed together. Similarly, Experiments 3 and 4 are reported and discussed together; both sets of experiments and their implications for future EC research, as well as their relation to studies that demonstrate EC without awareness are summarized in the General Discussion.

We predicted that EC effects would vary as a function of valence awareness, such that EC would be observed only for valence-aware CSs. Before we test this prediction, it is important to anticipate two alternative explanations for such a finding and to describe how we deal with these in the following experiments.

### Alternative Accounts

If people only show EC when valence-awareness is present, this observation supports the notion that EC depends on valence awareness. However, there are two alternative explanations for such a finding: an inference account and a demand account. We discuss them below.

#### *Inference Account*

That EC is observed only on valence-aware CSs may simply mean that people infer the valence of the US (in the memory task) from their evaluation of the CS. In other words, the memory task would not reflect true awareness for the CS-US pairings. Rather, it would reflect an evaluative inference that is based on participants' liking or disliking of the CS. Participants may notice that they like (or dislike) a specific CS and infer from this evaluation that this specific CS was paired with a positive (negative) US. How can we rule out this account?

If participants infer US valence from their liking (disliking) of a CS, then they should consistently do so, no matter whether a CS took on the valence of the US it was paired with (i.e., successful EC) or a valence that is actually opposite to that of its associated US (i.e., negative EC). The latter case allows examining the degree to which the data support the inference account. Specifically, if participants report an incorrect US valence whenever they are negatively conditioned, then this finding would be clearly supportive of the inference account.

#### *Demand Account*

Whereas the inference account proposes that participants strategically infer the US valence from their liking (disliking) of the CS, the demand account conversely proposes that participants strategically infer the CS valence from their recollection of the US valence. Participants may give positive (negative) evaluative ratings for CSs that were paired with positive (negative) USs not because this reflects their true subjective evaluation but because they want to conform to the experimenter's expectations. This is

<sup>1</sup> For ease of communication, we refer to aware and unaware CS when participants could or could not report the respective CS-US relation. Naturally, the CSs are not aware of anything.

only possible when participants indeed remember the correct US valence. How can we rule out such demand effects? Similar to the inference strategy, the answer lays in the implications of the account for the memory data. The demand account predicts that incorrect memory leads to evaluating a CS in a way that is opposite to the valence of its associated US.

It is important to contrast the implications of the inference and demand accounts. Whereas the inference account makes predictions about responses on the valence memory test, given a certain evaluation (i.e., the evaluation causes the memory response), the demand account makes predictions about evaluative responses, given valence memory (i.e., memory causes the evaluative response). Specifically, the inference account predicts that valence memory performance is below chance for CSs that show a negative EC effect; it does not make any predictions about the evaluation of a CS for which valence memory is incorrect. It is important to note that it does not predict that CSs with incorrect valence memory would show negative EC. Conversely, the demand account does not make predictions about memory accuracy for CSs with negative EC; instead, it predicts that incorrect memory leads to an evaluation opposite to US valence.

There is, however, another simple way to rule out the demand account: reducing the possibility of participants' strategic control over their evaluative responses. The evaluative priming task used in Experiments 3 and 4 serves this aim. As a matter of fact, CSs are not evaluated at all during the priming procedure. Having clarified the implications of possible alternative explanations, we can test our predictions about the relation of valence awareness and EC effects.

### Experiment 1

In Experiment 1, we used nonwords as CSs, and they were paired with positive and negative pictures as USs. Afterward, participants evaluated each nonword on a rating scale. Finally, participants were asked to indicate for each nonword whether it had been presented with positive or negative pictures and to select the specific USs with which a given nonword had been paired.

#### Method

**Participants and design.** Sixteen University of Freiburg students (10 women, 6 men; mean age  $M = 23$  years) participated for a monetary compensation of €3.50 (approximately U.S.\$5). A 2 (US valence: positive vs. negative)  $\times$  2 (CS set: Set A = positive vs. Set B = positive) design was used with repeated measures on the first factor. The second factor was a control factor to exclude the possibility that preexisting features of the CSs could be responsible for the observed effects.

**Materials and procedure.** Materials were taken from Stahl and Unkelbach (2009). Two sets (A and B) of five neutrally evaluated, pronounceable nonwords were used as CSs. Pretest data obtained from a different sample yielded identical mean evaluative ratings ( $M = 3.88$ ) on a 7-point scale for both sets A and B. Two sets of 25 pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005) were used as USs. Mean evaluative ratings were  $M = 7.9$  for the set of positive pictures and  $M = 2.5$  for the set of negative pictures,  $t(48) = 117.80, p < .001$ . Assignment of CS sets to USs was counterbalanced. Five USs

were randomly assigned to each CS for each participant anew, creating 50 different CS-US pairs (i.e., 5 positive and 5 negative CSs, each paired with 5 USs).

The experiment was conducted in individual computer-controlled sessions and separated into three parts: conditioning phase, evaluative ratings, and awareness check. In the conditioning phase, participants watched 100 CS-US pairings (50 different CS-US pairs, each presented twice). CS and US simultaneously appeared on the computer screen for 2,000 ms, with the US picture in the upper half of the screen and the nonword CS in the lower half of the screen. Presentation order was randomized anew for each participant.

Next, participants evaluated the CSs in a random order. They evaluated each nonword on a scale ranging from 1 (*very unpleasant*) to 8 (*very pleasant*), using the number keys of the computer keyboard.

Subsequently, valence awareness and identity awareness were assessed for each CS-US pair, with recognition memory tests. The awareness test consisted of two blocks. In a first block, participants used the computer keyboard to indicate for each CS whether they thought it had been paired with pleasant or with unpleasant USs. In a second block, identity awareness was assessed: For each of the 50 CS-US pairs, participants were presented with six pictures from the set of USs of the correct valence, one of which was the target US. Participants selected the specific US with which they thought the CS had been presented in the conditioning phase by pressing the number key associated with that stimulus on the computer keyboard. Hence, awareness for US identity was probed five times for each CS, once for each of the five USs with which it was paired.

#### Results

The EC effect was computed as the difference between mean evaluative ratings for CSs paired with positive USs and those paired with negative USs (see Table 1). In a first step, all CSs were used to compute participants' mean difference, and significant EC was observed,  $t(15) = 3.06, p < .01$ .

**Memory for CS-US pairings.** US identity awareness was computed as the proportion of correctly selected USs; US valence awareness was computed as the proportion of cases in which US valence was correctly indicated. Mean awareness of US identity was  $M = .26$ ; by chance, one would expect 17% correct US identity assignments (i.e., one out of six). Mean awareness of US valence was  $M = .66$ ; by chance, one would expect 50% correct US valence assignments. Memory was above chance,  $t(15) = 3.33, p < .01$ , for US identity memory, and  $t(15) = 2.64, p < .05$ , for US valence memory.

**Awareness effects on evaluative ratings.** Awareness effects on EC were assessed on the level of the CSs, as recommended by Pleyers et al. (2007). A given CS was classified as valence-aware when the correct valence was reported (see Footnote 1). For 15 out of 16 participants, valence-aware CSs were thereby obtained. For these valence-aware CSs, a significant EC effect was observed across participants,  $t(14) = 4.66, p < .001$ .

A CS was classified as valence-unaware when the incorrect valence was reported. For 11 out of 16 participants, valence-unaware CSs were thereby obtained. EC was absent when only

Table 1  
 Evaluative Ratings for CSs Paired With Positive and With Negative USs in Experiments 1–4

| Valence awareness | N  | CS <sub>Pos</sub> |      | CS <sub>Neg</sub> |      | EC    | p     |
|-------------------|----|-------------------|------|-------------------|------|-------|-------|
|                   |    | M                 | SD   | M                 | SD   |       |       |
| Experiment 1      |    |                   |      |                   |      |       |       |
| Overall           | 16 | 4.91              | 1.63 | 3.34              | 1.08 | 1.57  | <.01  |
| Aware             | 15 | 5.12              | 1.85 | 2.78              | 0.78 | 2.34  | <.001 |
| Unaware           | 11 | 3.85              | 1.46 | 4.32              | 1.2  | -0.47 | .31   |
| Experiment 2      |    |                   |      |                   |      |       |       |
| Overall           | 28 | 4.81              | 1.05 | 3.85              | 1.05 | 0.96  | <.001 |
| Aware             | 26 | 5.31              | 1.09 | 3.38              | 1.28 | 1.93  | <.001 |
| Unaware           | 13 | 4.21              | 1.51 | 5.01              | 1.38 | -0.8  | .19   |
| Undecided         | 13 | 4.54              | 1.04 | 4.53              | 0.89 | 0.01  | .97   |
| Experiment 3      |    |                   |      |                   |      |       |       |
| Overall           | 34 | 4.84              | 1.09 | 4.11              | 0.9  | 0.73  | <.01  |
| Aware             | 32 | 5.23              | 0.95 | 3.73              | 1.03 | 1.5   | <.001 |
| Unaware           | 8  | 4.05              | 0.88 | 5.38              | 0.81 | -1.33 | <.01  |
| Undecided         | 13 | 4.16              | 1.78 | 4.13              | 1.29 | 0.03  | .96   |
| Experiment 4      |    |                   |      |                   |      |       |       |
| Overall           | 83 | 5.11              | 0.92 | 4.17              | 1.18 | 0.94  | <.001 |
| Aware             | 81 | 5.35              | 1.01 | 3.99              | 1.32 | 1.36  | <.001 |
| Unaware           | 17 | 4.47              | 1.48 | 5.11              | 1.79 | -0.64 | .27   |
| Undecided         | 16 | 4.52              | 1.13 | 4.84              | 1.45 | -0.32 | .43   |

Note. Higher ratings reflect more positive evaluations. Positive EC scores reflect a standard EC effect, and *ps* refer to paired-comparison *t* tests. CS = conditioned stimulus; US = unconditioned stimulus; CS<sub>Pos</sub> = CSs paired with positive USs; CS<sub>Neg</sub> = CSs paired with negative USs; EC = evaluative conditioning effect (i.e., difference between CS<sub>Pos</sub> and CS<sub>Neg</sub>).

valence-unaware CSs were considered,  $t(10) = -1.08$ ,  $p = .31$ . Table 1 reports the means and standard deviations.

Identity awareness was computed as the proportion of correct identity awareness judgments. For each CS, there were five trials on the identity awareness test (one for each US). Hence, identity awareness could vary between 0 and 1 in steps of .2. EC effects were compared across levels of identity awareness separately for CSs with valence awareness and for CSs without valence awareness, to evaluate whether identity awareness predicted evaluative ratings when valence awareness was controlled. Regression analyses were computed on the deviations of evaluative ratings from the scale's neutral point in the direction predicted by EC. These analyses were performed at the Participant  $\times$  CS level (i.e., without aggregating across items or participants), instead of at the participant level. This avoids listwise exclusion of participants with missing values at one or more levels of identity awareness. There were 160 cases in the analysis (i.e., 10 CSs for each of the 16 participants). Participants' mean evaluations across all 10 CSs were entered as a predictor in an initial regression, and the residuals of this analysis were used as the dependent variable. Thereby, variance between participants was removed from the evaluative ratings, rendering the analysis comparable in statistical power to a repeated-measures analysis.

A regression analysis of all CSs with identity awareness and valence awareness as predictors,  $F(2, 157) = 4.70$ ,  $p < .05$ , revealed that identity awareness did not predict EC,  $t(157) = -1.57$ ,  $p = .12$ ,  $\beta = -.12$ . In contrast, valence awareness significantly predicted EC when entered as a binary predictor (0: unaware, 1: aware),  $t(157) = 2.87$ ,  $p < .01$ ,  $\beta = .23$ . When valence-

aware CSs were analyzed separately, identity awareness did not predict evaluative ratings,  $F(1, 103) = 2.53$ ,  $p = .12$ ,  $\beta = -.16$ . That is, EC effects for valence-aware but identity-unaware CSs were of similar magnitude as those for valence- and identity-aware CSs. Similarly, for valence-unaware CSs, identity awareness did not predict evaluative ratings,  $F(1, 53) < 1$ ,  $p = .64$ ,  $\beta = -.06$ . In other words, no EC effects were found for valence-unaware CSs, regardless of the level of identity awareness.

## Experiment 2

In Experiment 1, we used meaningless nonwords as CSs. This may be considered advantageous, as it controls for potential confounds due to the effects of the semantic content and its interaction with the semantic content of USs. On the other hand, if semantic associations between CSs and USs underlie the EC phenomenon, the use of meaningless CSs is problematic because semantic associations play a limited role for initially meaningless materials. Identity awareness could play a larger role for more meaningful CSs, which may elicit more reasoned, identity-based, inferential processes during conditioning. Similarly, the mechanisms underlying EC effects could be sensitive to the CS and US materials, such that different processes might operate on meaningful, as compared with meaningless, stimuli (De Houwer, 2007). In particular, identity awareness may play a larger role in evaluative conditioning with more meaningful CS stimuli.

In Experiment 2, we address this possibility by examining the impact of valence and identity awareness on the conditioning of consumer products commonly used in applied research on EC

(e.g., Stuart, Shimp, & Engle, 1987). If our findings are restricted to the semantically meaningless nonword CSs, an effect of identity awareness on EC may emerge; if not, the nonword findings should replicate with consumer products.

Experiment 2 also addresses the inference strategy as an alternative explanation. Again, participants may have inferred US valence from their liking (disliking) of the CS. This implies that responses on the valence awareness test were based on participants' CS evaluations instead of on their memory for US valence. As discussed, the inference account predicts that participants should report the wrong US valence for CSs that are negatively conditioned (i.e., CSs that take on a valence that is opposite to the valence of the US they were paired with). There were some CSs with negative EC in Experiment 1, but valence awareness for these CSs did not differ from chance: Out of a total of 54 cases of negative EC, the correct US valence was indicated in 24 cases and the incorrect US valence was indicated in 30 cases. This distribution does not depart from chance,  $\chi^2(1, N = 54) = 0.67, p = .41$ , thus failing to lend support to an inference account.

Yet, a procedural feature in Experiment 1 might have masked the inference strategy: There were only two response options, *positive* and *negative*, implying that erroneous responses in the valence awareness are likely to also reflect guessing processes. As the associated evaluations can be assumed to vary unsystematically, the inference strategy might have been masked by the additional error variance. To examine this possibility, we increased statistical power in Experiment 2, and we also included a *don't know* option in both the valence awareness and the identity awareness test that should help reduce error variance associated with guessing processes.

## Method

**Participants and design.** Twenty-eight University of Freiburg students (19 women, 9 men; mean age  $M = 22$  years) participated for a monetary compensation of €3.50 (approximately U.S.\$5). US valence (positive vs. negative) was manipulated within participants.

**Materials and procedure.** The same USs as in Experiment 1 were used. As CSs, eight pictures of products were taken from Pleyers et al. (2007); two similar product pictures were added to complete the set of ten CSs, five of which were paired with positive USs and five of which were paired with negative USs. Each CS was randomly selected for each participant anew, to be paired with positive or negative USs. Procedures were identical to Experiment 1, with two exceptions: First, as in Pleyers et al. (2007), four evaluative ratings (global impression, attractiveness, pleasantness, willingness to buy) were collected instead of only one. For each rating, an 8-point rating scale was used, with higher values indicating a more favorable evaluation. Second, the valence-memory test and the identity-memory test both included an additional *don't know* response option.

## Results

Evaluative ratings were highly consistent across the four items (Cronbach's  $\alpha = .95$ ), and the mean evaluation across the four items was therefore computed as a single evaluative index. The EC effect was computed as the difference between the mean evalua-

tive ratings for the CSs paired with positive USs and those paired with negative USs (see Table 1). In a first step, all CSs were used to compute participants' mean EC effect, and significant EC was observed across participants,  $t(27) = 4.10, p < .001$ .

**Memory for CS-US pairings.** Awareness of US identity was computed as the proportion of correctly selected USs, and awareness of US valence was computed as the proportion of cases in which US valence was correctly indicated, after the responses that fell into the *don't know* categories were removed. In the US identity test, 43.1% of responses fell into the *don't know* category, the correct response was selected in 17.3% of cases, and an incorrect response was given in 39.6% of cases. In the valence awareness test, 22.9% of responses fell into the *don't know* category, the correct response was selected in 57.1% of cases, and an incorrect response was given in 20.0% of cases.

**Awareness effects on evaluative ratings.** As in Experiment 1, we classified a given CS as valence-aware when participants reported the correct valence, and as valence-unaware when participants reported the incorrect valence. We classified a CS as valence-undecided when participants indicated that they did not know the correct valence. For 26 participants, valence-aware CSs were present. For valence-aware CSs, a significant EC effect was observed,  $t(25) = 5.54, p < .001$ .

For 13 participants, valence-unaware CSs were present. For valence-unaware CSs, EC was absent,  $t(12) = -1.39, p = .19$ . The same is true for valence-undecided CSs,  $t(12) = 0.04, p = .97$  (see also Table 1).

To test possible inference strategy effects, CSs with a negative EC effect are critical (i.e., for which participants' evaluations are opposed to the valence of the paired USs). We evaluated whether participants tended to indicate the wrong US valence for those CSs for which they showed a negative EC effect). Out of the 92 CSs for which negative EC was observed, the correct valence was indicated in 31 cases (33.7%), the incorrect valence was indicated in 33 cases (35.9%), and the remaining 28 responses (30.7%) fell into the *don't know* category. These proportions do not differ from those predicted by chance (i.e., equal proportions of correct and incorrect responses),  $\chi^2(1, N = 64) = 0.06, p = .80$ . Given that the inference strategy predicts a systematic memory effect (i.e., negative EC should result in more incorrect valence responses), there was no evidence for an inference strategy.

Identity awareness was again computed as the proportion of correct responses on the identity awareness test, resulting in a score varying from 0 to 1 in steps of .2. EC effects on evaluative ratings were compared across levels of identity awareness separately for CSs with valence awareness, for CSs without valence awareness, and for valence-undecided CSs. We computed the same regression analyses as in Experiment 1 to evaluate whether identity awareness predicted evaluative ratings when valence awareness was controlled. To avoid list-wise exclusion of participants, we again used the Participants  $\times$  CSs level of analysis. With 28 participants and 10 CSs each, there were 280 cases in the analysis. We again removed variance due to participants by entering individuals' mean ratings as predictor and using the residuals from this regression as dependent variable.

As in Experiment 1, we predicted this new dependent variable for all CSs from identity awareness and valence awareness (with three levels, 0: unaware; 1: undecided; 2: aware; similar results were obtained when valence-undecided CSs were excluded),  $F(2,$

277) = 17.48,  $p < .001$ . Identity awareness did not predict EC,  $t(277) = 0.29$ ,  $p = .77$ ,  $\beta = .02$ ; valence awareness again significantly predicted EC,  $t(277) = 5.81$ ,  $p < .001$ ,  $\beta = .33$ . In a separate analysis of valence-aware CSs, identity awareness did not predict evaluative ratings,  $F(1, 158) < 1$ ,  $p = .48$ ,  $\beta = -.06$ . Similarly, for valence-undecided CSs, identity awareness did not predict evaluative ratings,  $F(1, 62) < 1$ ,  $p = .73$ ,  $\beta = -.04$ .

For valence-unaware CSs, a nonsignificant tendency toward an effect of identity awareness was found,  $F(1, 54) = 4.03$ ,  $p = .05$ ,  $\beta = .26$ . The positive regression coefficient indicates that the EC effect increased with increasing levels of identity awareness for valence-unaware CSs. This trend was due to a significant negative EC effect for valence-unaware CSs with zero identity awareness,  $t(30) = -3.19$ ,  $p < .01$ , an effect that is consistent with a demand account. We return to this effect below. It is important to note that there was no negative EC effect for higher levels of identity awareness,  $t(24) = -0.10$ ,  $p = .92$ , and when stimuli with zero identity memory were excluded from the regression analysis, the effect of identity awareness disappeared,  $F(1, 23) < 1$ ,  $p = .38$ ,  $\beta = .18$ .

### Discussion of Experiments 1 and 2

In replicating recent findings, Experiments 1 and 2 confirm the important role of awareness—defined as recognition memory for CS-US pairings—for the emergence of EC effects. It is important to note that the pairing procedures allowed separating the contributions of identity awareness and valence awareness. EC was assessed for valence-aware CSs (i.e., cases of correct assignment of a CS to US valence) and valence-unaware CSs (i.e., incorrect US valence assignments). For these levels of valence awareness, EC was assessed for CSs with different levels of identity awareness (i.e., a correct assignment of the specific USs with which a CS was paired). EC was observed for valence-aware CSs but not for valence-unaware CSs. When valence awareness was controlled, memory for US identity did not predict EC effects. This finding was consistently obtained both for semantically meaningless nonword CSs and for meaningful consumer products.

Experiment 2 also addressed the inference explanation for the observed relation between valence awareness and EC. As discussed above, the inference strategy predicts below-chance valence memory for those CSs with a negative EC effect. There was no evidence for this pattern in Experiments 1 and 2. Whereas the pattern might have been masked by a combination of error variance due to guessing and a lack of power in Experiment 1, this was less likely to be the case in Experiment 2, which created more optimal conditions for an inference strategy pattern to emerge in the memory task. As memory performance was at chance level for CSs with negative EC, an inference strategy was not supported by the present data.

One finding in Experiment 2 is consistent with the demand account. Specifically, a significant negative EC effect was obtained for those CSs for which US valence was incorrectly indicated and for which participants could not correctly identify even a single out of five USs. This pattern of negative EC for valence-unaware CSs can be explained by a demand account, as discussed above. Assuming that there were some CSs for which participants had false memory for the valence of their associated USs, a

demand account predicts that participants produce negative EC effects for these CSs.

Evidence for negative EC was restricted to the very specific condition of valence-unaware CSs with zero identity awareness. With those CSs removed from analyses, identity awareness did not affect EC for valence-unaware CSs across the remaining five levels of identity awareness. Note that the conclusion remains valid that the standard EC effect was obtained for valence-aware CSs and that there was no effect of identity memory on the magnitude of EC for these CSs. Nevertheless, it remains possible that the role of valence awareness in Experiments 1 and 2 may have been inflated by demand effects. We address this possibility in Experiments 3 and 4.

### Introduction to Experiments 3 and 4

Experiments 1 and 2 suggest that valence awareness is necessary for EC effects to occur and that identity awareness does not contribute to EC over and above valence awareness. When valence awareness was present, the same EC effect was obtained across all levels of identity awareness, both for semantically meaningless nonwords and for semantically meaningful images of consumer products. Hence, the absence of an effect of identity awareness does not seem to be related to the difficulty of forming associations between the semantic contents of CS and US. However, only explicit evaluative ratings were used in these first two studies. Such ratings cannot be taken to purely reflect participants' evaluations, as they may be contaminated by other processes, most notably demand effects as delineated in the introduction. In other words, we cannot exclude the possibility that the relation between valence awareness and EC may be a mere artifact.

Therefore, in the following two experiments, we assessed EC effects with an evaluative priming task (Fazio et al., 1986) that taps more directly into stimulus valence. Although the evaluative priming task is not completely out of participants' control, the outcome of this evaluative measure is less susceptible to strategic processes than are explicit evaluative rating measures (e.g., Klauer & Teige-Mocigemba, 2007; Teige-Mocigemba & Klauer, 2008). Priming tasks have been used successfully to assess EC effects (e.g., Hermans, Vansteenwegen, Crombez, Baeyens, & Eelen, 2002; Mallan, Lipp, & Libera, 2008; Olson & Fazio, 2002; Pleyers et al., 2007). If the above findings are replicated with evaluative priming, we may be confident that the role of valence awareness in EC does not simply reflect demand effects.

In Experiment 3, an evaluative priming measure was administered before participants' evaluative ratings were collected, and awareness was probed last. To control for order effects, in Experiment 4, evaluative ratings preceded the evaluative priming measure, and for half of the participants, awareness was probed before evaluations were assessed. In addition, we evaluated the possibility that the above findings were restricted to the specific CS-US pairing schedule that we implemented in Experiments 1 and 2, namely the pairing of each CS with multiple USs instead of with a single US (cf. Stahl & Unkelbach, 2009). In Experiments 3 and 4, single versus multiple CS-US pairing was manipulated between participants: For some participants, each CS was paired with a single US; for others, each CS was paired with five different USs of the same valence. Both experiments are first reported and are then discussed together.

## Experiment 3

### Method

**Participants and design.** Thirty-four University of Freiburg students (22 women, 12 men; mean age  $M = 25$  years) participated for a monetary compensation of €3.50 (approximately U.S.\$5). Half the participants were randomly assigned to the single-US condition; the other half was assigned to the multiple-US condition. A 2 (US valence: positive vs. negative)  $\times$  2 (pairing: single US vs. multiple US) design was used with repeated measures on the first factor.

**Materials and procedure.** The same materials as in Experiment 2 were used. CSs were randomly assigned for each participant anew, to be paired with positive or negative USs, and assignment of specific USs was also randomized for each participant anew. For the evaluative priming task, 10 positive and 10 negative German adjectives were taken from Hager and Hasselhorn (1994). Positive adjectives were rated as more positive ( $M = 12.81$ ) than were negative adjectives ( $M = -13.55$ ) on a scale from +20 to -20,  $t(18) = 26.85$ ,  $p < .001$ .

Procedures were identical to those in the previous studies, with the following exceptions: First, the conditioning phase differed between the single-US condition and the multiple-US condition: In the single-US condition, the same US was always paired with a given CS, and each pairing was repeated 10 times; in the multiple-US condition, each CS was paired with five different USs of the same valence, and each pairing was presented 2 times.

Second, immediately after the conditioning phase, the evaluative priming task was administered. CSs served as primes, and positive and negative adjectives served as targets that participants were instructed to evaluate. The procedure closely followed that used by Pleyers et al. (2007). Stimuli were presented at a central location on a white screen. Responses were given by pressing one of two keys on the computer keyboard, and the response labels *positive* and *negative* were visible throughout the task. Each trial started with the presentation of the prime for 120 ms, which was replaced by a blank screen for 50 ms, resulting in an stimulus onset asynchrony of 170 ms. The target word was then presented in a 20-point black sans-serif font and removed from screen after 200 ms, and responses were then registered. After an incorrect response, feedback was presented for 500 ms. The intertrial interval was 2,000 ms. A short 10-trial practice block was followed by three experimental blocks of 80 trials each. In each block, each of the 10 CSs was presented eight times: four times followed by a positive word and four times followed by a negative word. In sum, there were 12 priming trials per CS per valence. Order of CSs and targets as well as assignment of targets to CSs was randomized.

After the evaluative priming task, evaluative ratings of the CSs were collected as in Experiment 2. Finally, the awareness test was administered; it differed from Experiment 2 only in that participants in the single-US condition were presented with only 10 identity-awareness trials (i.e., one for each CS-US pair).

### Results

In a first step, the effects of pairing on EC and awareness were analyzed. In a second step, effects of awareness on EC were analyzed.

**Evaluative ratings.** Ratings were highly consistent across the four items (Cronbach's  $\alpha = .93$ ); the mean evaluation across the four items was therefore computed as a single evaluative index. The EC effect was computed as the difference between the mean evaluative ratings for the CSs paired with positive USs and CSs paired with negative USs (see Table 1). An EC effect was observed,  $F(1, 32) = 9.93$ ,  $p < .01$ , which was not qualified by pairing ( $F < 1$ ,  $p = .42$ ).

**Evaluative priming.** In a first step, trials were excluded from analyses when response latency was above 2,000 ms (0.2%). After preliminary analyses revealed that there were no effects on accuracy, trials with incorrect responses were excluded (3.4%). Mean response latency was  $M = 624$  ms ( $SD = 187$  ms). In a second step, response latencies were log-transformed. A 2 (pairing)  $\times$  2 (congruency)  $\times$  3 (block) analysis of variance (ANOVA) of the log-transformed latencies was conducted, with repeated measures on the last two factors. An overall congruency effect was obtained,  $F(1, 32) = 12.76$ ,  $p < .001$ , indicating a strong overall EC effect on the evaluative priming measure. In addition, a nonsignificant main effect of block emerged,  $F(2, 64) = 3.41$ ,  $p = .05$ , indicating practice effects. As this influence did not interact with congruency,  $F(2, 64) = 2.06$ ,  $p = .14$ , it is not considered further in the analyses of subsets of the data reported below. There were no effects of pairing. Means and standard deviations are reported in the upper half of Table 2.

**Memory for CS-US pairings.** In the US identity memory test, 25.9% of responses fell into the *don't know* category (49.4% in the multiple-US condition and 2.4% in the single-US condition). The correct response was given in 55.0% of cases (15.3% in the multiple-US condition and 94.7% in the single-US condition), and an incorrect response was selected in the remaining 19.1% of cases (35.3% in the multiple-US condition and 2.9% in the single-US condition).

In the US valence memory test, 21.2% of responses fell into the *don't know* category in both the multiple-US and the single-US condition. The correct response was given in 65.6% of cases (60.6% in the multiple-US condition and 70.6% in the single-US condition), and an incorrect response was selected in the remaining 13.2% of cases (18.2% in the multiple-US condition and 8.2% in the single-US condition).

**Awareness effects on evaluative ratings.** EC effects for valence-aware CSs could be computed for 15 participants in the multiple-US condition and for 17 participants in the single-US condition. For valence-aware CSs, an EC effect was observed,  $F(1, 30) = 41.91$ ,  $p < .001$ . An interaction with pairing,  $F(1, 30) = 6.82$ ,  $p < .05$ , was due to the fact that the EC effect for valence-aware CSs was greater in the multiple-US condition,  $F(1, 14) = 41.66$ ,  $p < .001$ , than in the single-US condition,  $F(1, 16) = 7.51$ ,  $p < .05$ .

EC effects for valence-unaware CSs could be computed for 5 participants in the multiple-US condition and for 3 participants in the single-US condition. For valence-unaware CSs, a negative EC effect was observed,  $F(1, 6) = 27.89$ ,  $p < .01$ , such that CSs paired with negative USs were preferred over CSs paired with positive USs. This finding is again consistent with a demand explanation.

EC effects for valence-undecided CSs could be computed for 5 participants in the multiple-US condition and for 8 participants in

Table 2

Mean RTs and SDs for Congruent and Incongruent Evaluative Priming Trials and EC Effects on the Evaluative Priming Measure in Experiments 3–4

| Valence awareness | N  | Congruent |     | Incongruent |     | EC | p     |
|-------------------|----|-----------|-----|-------------|-----|----|-------|
|                   |    | M         | SD  | M           | SD  |    |       |
| Experiment 3      |    |           |     |             |     |    |       |
| Overall           | 34 | 618       | 127 | 629         | 116 | 11 | <.01  |
| Aware             | 34 | 618       | 131 | 633         | 120 | 15 | <.001 |
| Unaware           | 22 | 631       | 129 | 630         | 120 | -1 | .90   |
| Undecided         | 20 | 657       | 159 | 652         | 137 | -5 | .81   |
| Experiment 4      |    |           |     |             |     |    |       |
| Overall           | 83 | 621       | 102 | 624         | 102 | 3  | <.05  |
| Aware             | 83 | 619       | 103 | 626         | 101 | 7  | <.01  |
| Unaware           | 43 | 636       | 125 | 631         | 115 | -5 | .54   |
| Undecided         | 38 | 618       | 121 | 612         | 108 | -6 | .96   |

Note. ps refer to paired-comparison *t* tests of the log-transformed RTs. EC = evaluative conditioning effect (i.e., the difference between RT in incongruent and congruent trials); RT = reaction time.

the single-US condition. For valence-undecided CSs, EC was absent,  $F(1, 11) < 1, p = .97$ .

There was again no evidence for an inference strategy with the criteria delineated above (i.e., a tendency to indicate the wrong US valence for CSs with a negative EC effect on evaluative ratings): Out of 136 CSs with negative EC, the incorrect valence was indicated in only 32 cases (23.5%), whereas the correct valence was indicated in 69 cases (50.7%); the *don't know* category was selected in 35 cases (25.7%). Responses diverged from chance level (equal proportions of correct and incorrect responses),  $\chi^2(1, N = 101) = 13.55, p < .001$ , but this divergence reflected above-chance levels of valence awareness for CSs with negative EC, which is opposite to the pattern predicted by the inference account.

To evaluate whether identity awareness predicted evaluative ratings when valence awareness was controlled, we computed the same regression analyses as in Experiments 1 and 2; with 34 participants and 10 CSs each, there were 340 cases in the analysis. A regression model computed on all CSs with the two predictors identity awareness and valence awareness,  $F(2, 337) = 16.63, p < .001$ , revealed that identity awareness did not predict EC,  $t(337) = -1.30, p = .20, \beta = -.07$ , whereas valence awareness again significantly predicted EC,  $t(337) = 5.76, p < .001, \beta = .31$ . Similar results were obtained when valence-undecided CSs were excluded from the regression analysis. For valence-aware CSs alone, identity awareness had a negative effect on evaluative ratings,  $F(1, 221) = 4.28, p < .05, \beta = -.14$ , indicating that the magnitude of EC decreased when levels of identity awareness increased. For valence-unaware CSs, identity awareness did not predict evaluative ratings,  $F(1, 43) < 1, p = .62, \beta = .08$ . Similarly, for valence-undecided CSs, identity awareness did not predict evaluative ratings,  $F(1, 70) < 1, p = .71, \beta = .04$ .

*Awareness effects on evaluative priming.* We computed separate 2 (pairing)  $\times$  2 (congruency)  $\times$  3 (block) ANOVAs on the log-transformed latencies for each level of valence awareness. For valence-aware CSs, a significant EC effect was observed on the evaluative priming measure,  $F(1, 32) = 17.23, p < .001$ , for the main effect of congruency. We did not obtain an EC effect for

valence-unaware CSs,  $F(1, 20) < 1, p = .99$ . Similarly, EC was absent for valence-undecided CSs,  $F(1, 18) < 1, p = .75$ .

Again, there was no evidence for an inference strategy when CSs with a negative EC effect on the evaluative priming measure were considered: Out of 143 cases of negative EC, the incorrect valence was indicated in only 26 cases (18.2%), whereas the correct valence was indicated in 81 cases (56.6%); participants were undecided in 36 cases (25.2%). The distribution of responses departs from chance levels (equal proportions of correct and incorrect responses),  $\chi^2(1, N = 107) = 28.27, p < .001$ ; contrary to the predictions of the inference strategy, this departure reflects above-chance levels of valence awareness, paralleling the analysis of the evaluative ratings.

We conducted the same regression analyses as for the ratings on the evaluative priming effects (i.e., the difference in log-transformed RT between incongruent trials and congruent trials), to evaluate whether identity awareness predicted evaluative priming effects when valence awareness was controlled. Similar to the analyses conducted on evaluative ratings, the regression analyses were performed at the participant by CS level (i.e., including 340 cases). A regression model with the two predictors identity awareness and valence awareness, computed on all CSs,  $F(2, 337) = 3.58, p < .05$ , revealed that identity awareness did not predict EC,  $t(337) = 0.66, p = .51, \beta = .04$ , but valence awareness did,  $t(337) = 2.42, p < .05, \beta = .13$  (similar results were obtained when valence-undecided CSs were excluded from analyses). Similarly, in separate analyses, there were no effects of identity awareness, for valence-aware CSs,  $F(1, 221) < 1, p = .80, \beta = -.02$ , or for valence-unaware or valence-undecided CSs,  $F(1, 43) < 1, p = .48, \beta = .11$ , and  $F(1, 70) < 1, p = .25, \beta = .14$ , respectively.

#### Experiment 4

In Experiment 4, we aimed to replicate the findings from Experiment 3, and to control for possible effects of test order. Therefore, evaluative ratings preceded the evaluative priming measure, and for half the participants, awareness was probed before evaluations were assessed.

## Method

**Participants and design.** Eighty-three University of Freiburg students (61 women; mean age  $M = 24$ ) participated in exchange for a monetary compensation of €3.50 (approximately U.S.\$5). A 2 (US valence: positive vs. negative)  $\times$  2 (pairing: single US vs. multiple US)  $\times$  2 (sequence: EC measures first vs. awareness test first) design was used with repeated measures on the first factor. Participants were randomly assigned to one of the four groups resulting from the orthogonal combination of the latter two factors.

**Materials and procedure.** The same materials were used as in Experiment 3. Procedures were identical to Experiment 3, with the following exceptions: First, evaluative ratings were always administered before the evaluative priming measure. Second, we manipulated between participants whether the measures of EC or the awareness measures were administered first. In the EC measures first condition, the tasks were administered in the following order: conditioning phase, evaluative ratings, evaluative priming task, valence awareness test, identity awareness test. In the awareness test first condition, the order was as follows: conditioning phase, valence awareness test, identity awareness test, evaluative ratings, evaluative priming task.

## Results

We first analyzed the effects of pairing and sequence on EC and awareness. In a second step, effects of awareness on EC were analyzed.

**Evaluative ratings.** Ratings were highly consistent across the four items (Cronbach's  $\alpha = .93$ ); the mean evaluation across the four items was therefore computed as a single evaluative index. A significant EC effect was observed,  $F(1, 79) = 32.22, p < .001$ , which was not affected by pairing ( $F < 1, p = .41$ ; see Table 1). An interaction with sequence,  $F(1, 79) = 5.12, p < .05$ , reflected the fact that the EC effect was stronger in the awareness test first condition,  $F(1, 40) = 24.54, p < .001$ , than in the EC measures first condition,  $F(1, 39) = 8.32, p < .01$ .

**Evaluative priming.** Trials were excluded from analyses when response latency was above 2,000 ms (0.5%). Trials with incorrect responses (4.2%) were excluded after preliminary analyses revealed that there were only practice effects on accuracy (i.e., increasing accuracy across blocks). Mean response latency was  $M = 622$  ms ( $SD = 181$  ms). Response latencies were log-transformed before analysis. A 2 (pairing)  $\times$  2 (sequence)  $\times$  2 (congruency)  $\times$  3 (block) ANOVA of the log-transformed latencies with repeated measures on the last two factors revealed an overall effect of congruency (i.e., an EC effect),  $F(1, 79) = 5.08, p < .05$ . Main effects of pairing and block were also obtained,  $F(1, 79) = 9.05, p < .01$ , and  $F(2, 158) = 3.69, p < .05$ , respectively, indicating that responses were faster, overall, in the multiple-US condition and that response latencies decreased across blocks, reflecting practice effects. As these main effects did not interact with EC, we do not consider them further in the analyses of subsets of the data reported below. Table 2's lower half reports the means and standard deviations.

**Memory for CS-US pairings.** In the US identity memory test, 18.3% of responses fell into the *don't know* category (34.4% in the multiple-US condition and 2.6% in the single-US condition). The correct response was selected in 56.6% of cases (18.0% in the

multiple-US condition and 94.3% in the single-US condition), and an incorrect response was selected in the remaining 25.1% of cases (47.6% in the multiple-US condition and 3.1% in the single-US condition).

In the US valence memory test, 11.0% of responses fell into the *don't know* category (16.8% in the multiple-US condition and 5.2% in the single-US condition). The correct response was selected in 77.0% of cases (68.0% in the multiple-US condition and 85.7% in the single-US condition), and an incorrect response was selected in the remaining 12.0% of cases (15.1% in the multiple-US condition and 9.0% in the single-US condition).

**Awareness effects on evaluative ratings.** EC effects for valence-aware CSs could be computed for 40 participants in the multiple-US condition and for 42 participants in the single-US condition. For valence-aware CSs, an EC effect was observed,  $F(1, 78) = 59.48, p < .001$ , for the main effect of US valence. In addition, a Pairing  $\times$  Sequence interaction emerged,  $F(1, 78) = 4.41, p < .05$ , indicating that in the multiple-US condition, overall evaluative ratings were somewhat more negative when collected after, rather than before, the awareness test,  $F(1, 38) = 6.27, p < .05$ ; there was no effect of sequence for the single-US condition,  $F(1, 40) < 1, p = .73$ .

EC effects for valence-unaware CSs could be computed for 14 participants in the multiple-US condition and for 3 participants in the single-US condition. For valence-unaware items, an EC effect did not emerge,  $F(1, 13) < 1, p = .53$ .

EC effects for valence-undecided CSs could be computed for 11 participants in the multiple-US condition and for 5 participants in the single-US condition. For valence-undecided items, EC was not observed,  $F(1, 12) < 1, p = .41$ .

There was no evidence for an inference strategy. Out of 302 cases of negative EC, the incorrect valence was indicated in only 53 cases (17.5%), whereas the correct valence was indicated in 203 cases (67.2%), with 46 undecided cases (15.2%). Responses departed from chance (equal proportions of correct and incorrect responses),  $\chi^2(1, N = 256) = 87.89, p < .001$ , again reflecting above-chance levels of valence awareness for CSs with negative EC, a finding that is opposite to the predictions of the inference account.

We conducted the same regression analyses as above to evaluate whether identity awareness predicted evaluative ratings when valence awareness was controlled; there were 830 cases in these analyses. An overall analysis of all CSs,  $F(1, 827) = 12.45, p < .001$ , revealed that identity awareness did not predict EC,  $t(827) = -0.67, p = .51, \beta = -.02$ , whereas valence awareness again significantly predicted EC,  $t(827) = 4.95, p < .001, \beta = .18$  (similar results were obtained when valence-undecided CSs were excluded from analyses). For valence-aware CSs there was no effect of identity awareness,  $F(1, 637) < 1, p = .37, \beta = -.04$ . There was no effect of identity awareness for valence-unaware CSs,  $F(1, 98) < 1, p = .97, \beta = .004$ . Finally, for valence-undecided CSs, identity awareness did not predict evaluative ratings,  $F(1, 89) < 1, p = .40, \beta = -.09$ .

**Awareness effects on evaluative priming.** EC effects for valence-aware CSs could be computed for 41 participants in the multiple-US condition and for 42 participants in the single-US condition. A significant EC effect was observed on the evaluative priming task for these CSs,  $F(1, 79) = 8.87, p < .01$ .

EC effects for valence-unaware CSs could be computed for 24 participants in the multiple-US condition and for 19 participants in the single-US condition. EC was absent for valence-unaware CSs,  $F(1, 39) < 1, p = .41$ .

EC effects for valence-undecided CSs could be computed for 26 participants in the multiple-US condition and for 12 participants in the single-US condition. EC was also absent for valence-undecided CSs,  $F(1, 34) < 1, p = .69$ .

There was again no evidence for an inference strategy when CSs with a negative EC effect on the evaluative priming measure were considered. Out of 392 cases with negative EC on the priming measure, the incorrect valence was indicated in only 56 cases (14.3%), whereas the correct valence was indicated in 286 cases (73.0%); participants were undecided in the remaining 50 cases (12.8%). This pattern reflects above-chance levels of valence awareness (chance being equal proportions of correct and incorrect responses),  $\chi^2(1, N = 342) = 154.68, p < .001$ , which is again incompatible with an inference strategy.

Finally, we conducted the same regression analyses as in Experiment 3 on the evaluative priming effects, to evaluate whether identity awareness predicted evaluative priming effects when valence awareness was controlled. In an overall analysis of all CSs,  $F(2, 827) = 2.48, p = .08$ , identity awareness did not predict EC,  $t(827) = -0.32, p = .75, \beta = -.01$ , but valence awareness did,  $t(827) = 2.21, p < .05, \beta = .08$  (similar results were obtained when valence-undecided CSs were excluded from analyses). There were no effects of identity awareness on EC for valence-aware CSs,  $F(1, 637) < 1, p = .62, \beta = -.02$ , for valence-unaware CSs,  $F(1, 98) < 1, p = .95, \beta = -.01$ , or for valence-undecided CSs,  $F(1, 89) < 1, p = .70, \beta = .04$ .

### Discussion of Experiment 3 and 4

Experiments 3 and 4 are the first to demonstrate with an evaluative priming task (Fazio et al., 1986) that EC depends on valence awareness and is insensitive to identity awareness after valence awareness is controlled for. When valence awareness was controlled, EC effects did not increase with increasing levels of identity awareness.

This finding supports the view that the impact of valence awareness on evaluative-ratings EC effects obtained across all experiments reflects genuine valence acquisition rather than demand effects or other artifacts of the explicit evaluation process. As a matter of fact, participants were never asked to evaluate the CSs in the context of the evaluative priming task, and similar findings were obtained no matter whether the evaluative priming measure preceded or followed the evaluative ratings.

Two alternative explanations of the relation between valence awareness and EC were raised above—an inference strategy and a demand account. The evidence in support of these accounts is evaluated in turn.

The inference strategy predicts that responses on the valence memory test do not reflect true memory but instead reflect inferences based on participants' evaluations. We ruled out this possibility by investigating the prediction for CSs with a negative EC effect: If participants followed the inference strategy, they should show below-chance performance for CSs with a negative EC effect. In other words, the inference strategy can account for the relation between EC and valence awareness only to the degree to

which performance on the valence memory task was below chance given a negative EC effect. In fact, performance was never below chance; in contrast, it was even clearly and significantly above chance in Experiments 3 and 4. These findings suggest that instead of being based on an inference strategy, performance on the valence memory task reflected a mixture of memory and guessing processes that is typical for (recognition) memory paradigms.

We have just seen that the present data are inconsistent with a pure version of the inference account. But it might be argued that the inference strategy should apply to CSs with strong subjective evaluations but not to those with weak subjective evaluations. We addressed this possibility by reanalyzing valence memory for CSs with negative EC, using a median-split approach. However, contrasting the predictions of this variant of the inference account, valence memory was always at or above chance both for cases of negative EC that fell below the median as well as for those cases that were above the median.

Finally, it is possible that participants might have relied on an inference strategy only in some cases, and these cases could have been masked by a combination of memory and guessing processes operating in the remaining cases. To evaluate this sophisticated possibility, we used multinomial processing-tree modeling (see Appendix). We found that the data were fully accounted for by memory and guessing and that there was again no support for an inference account. Given these repeated failures to find support for effects of an inference strategy, we feel safe to conclude that this strategy did not underlie the present findings.

The second alternative explanation for the relation between valence awareness and EC is based on demand effects: Participants may give positive (negative) evaluative ratings for CS that were paired with positive (negative) USs, not because this reflects their true feelings but because they want to conform to what they believe to be the experimenter's expectations. As EC was restricted to valence-aware CSs on both the evaluative rating and evaluative priming measures, it is unlikely that this pattern reflects mere experimental demands. This being said, we considered it important to complete additional analyses in order to clarify the role that experimental demands may have played on evaluative ratings and evaluative priming data. This was done in the context of the following meta-analysis, with the logic delineated in the introduction: If demand effects are responsible for the observed relation of EC and valence awareness, then incorrect valence memory should lead to an evaluation that is consistent with the incorrectly indicated valence but opposite to that of the correct US valence. Thus, the meta-analysis tests the prediction that valence-unaware CSs should show negative EC.

### A Meta-Analysis

*Evaluative ratings.* Across Experiments 2–4, there were  $N = 38$  participants for which an EC effect could be computed for CSs for which the wrong US valence was indicated. We conducted an ANOVA of these EC effects with experiment as a between-subjects factor and US valence as a within-subjects factor. A significant negative EC effect was obtained,  $F(1, 35) = 7.33, p = .01$ . Neither the main effect of experiment nor its interaction with the EC effect were significant ( $F_s < 1$ ). Thus, substantial negative EC was found on the ratings measure for CSs with incorrect US memory.

What were the reasons for this finding? At this point, we can only speculate. As already mentioned in the introduction, evaluative ratings are prone to a lot of contaminations and judgmental concerns, one being demand effects. As discussed above, an account in terms of demand effects can explain the negative EC effect on evaluative ratings if we assume that the positive EC effect obtained on that measure also—at least partly—reflects demand processes.

But other strategies are also possible: Tested separately, significant negative EC effects were found only in those experiments (Exp. 3 and for a subset of CSs in Experiment 2) in which assessment of valence awareness directly followed the evaluative ratings; the negative EC effect may depend on this close temporal relation. Specifically, the effect on the valence awareness measure may have depended on participants' memory for their responses in the evaluative ratings task. Note further that both tasks were similar in that they presented the CSs as stimuli and required valence judgments as responses. Participants may have noticed this similarity and may have attempted to respond consistently on both tasks. If they followed this strategy whenever they had neither particularly strong feelings about the CS nor memory for the valence or the identity of the USs with which it was paired, this could explain the observed pattern. However, this is mere speculation and must be interpreted with caution, especially in light of the fact that the meta-analysis did not reveal an interaction with experiments.

*Evaluative priming.* Across Experiments 3 and 4, there were  $N = 65$  subjects with at least one CS for which they indicated the wrong US valence. We conducted an ANOVA of the priming effects with the between-subjects factors experiment and pairing (single US vs. multiple US), and with prime congruency (congruent, incongruent) as a within-subjects factor. This analysis did not yield any significant results. It is important to note that the effect of congruency (i.e., the EC effect) was far from reaching significance,  $F(1, 63) = 0.32, p = .58$ .

This null finding was not due to lack of statistical power. Given an alpha level of  $\alpha = .05$  and an observed correlation between repeated measures of  $r = .91$ , the statistical power to detect an effect of medium size ( $f = .25$ ) was practically perfect ( $1 - \beta > .99$ ; Cohen, 1988; Faul, Erdfelder, Lang, & Buchner, 2007). Even for a small effect ( $f = .1$ ), the statistical power was still very good ( $1 - \beta = .96$ ). Theoretically, it is possible that a very small effect of  $f = .05$  may have gone undetected by the present meta-analysis with  $\beta = .54$ . However, given  $F < 1$ , it is unlikely that more degrees of freedom would have changed the results. In fact, the probability density for the empirical  $F$  value under the null hypothesis was about three times that under the alternative hypothesis. Thus, contrasting the findings obtained with the ratings measure, we found no evidence for negative EC on the evaluative priming measure.<sup>2</sup>

To summarize, the meta-analysis yielded evidence for demand effects on the ratings measure, but not on the priming measure; the latter null finding was obtained with high statistical power. Thus, whatever process has caused negative EC effects in evaluative judgments did not affect the evaluative priming measure. Given that this measure reflects a more direct assessment of acquired stimulus valence (cf. Gawronski & Bodenhausen, 2006), we are confident that the observed relation between performance on the valence memory measure and the EC effect on the evaluative

priming measure reflects the dependence of valence acquisition and attitude formation through EC on explicit memory (i.e., awareness) for US valence.

## General Discussion

In four experiments, new attitudes toward initially neutral objects were learned through EC, but only when participants were aware of the valence of the US with which a given CS had been paired. We explored a possible explanation for discrepancies between earlier findings suggesting that EC is independent of participants' awareness (e.g., Fulcher & Hammerl, 2001; Olson & Fazio, 2001, 2002; Walther & Nagengast, 2006) and recent research showing that EC effects only emerge when participants are aware of the statistical contingency (or the spatiotemporal contiguity) between a CS and a US (e.g., Pleyers et al., 2007, 2009; Wardle et al., 2007). Whereas in previous research it was only considered whether participants could identify the specific US that a CS was paired with, we also assessed whether participants could report the valence of the US. The dissociation between identity and valence awareness was accomplished by a simple manipulation of pairing a CS not only with one US but with multiple USs of the same valence.<sup>3</sup> Awareness of US valence proved to be a necessary condition for EC effects to be observed. Hence, in previous studies in which participants showed EC effects but were unable to report the identity of the US, participants might have instead been aware of the US's valence.

This reasoning follows Shanks and St. John (1994), who argued that a mental process can seem to be independent of awareness (a) because the measures of awareness are not sensitive enough or (b) because people are aware of and use a simpler form of information. The first point was examined by Pleyers and colleagues (2007). These authors showed the importance of checking for awareness and valence at the level of CSs and not at the level of participants. Regarding the second point, we found in the present experiments that EC is observed only on valence-aware CSs. This finding was obtained across the conditioning of both semantically meaningless and semantically meaningful attitude objects, different evaluative measures (ratings and evaluative priming), and different orders of the dependent variables. As an additional insight, the present findings suggest that identity awareness may not contribute to EC effects over and above valence awareness.

<sup>2</sup> These findings did not depend on the type of analysis (i.e., controlling for the effects of multiple between-subjects factors). We also computed a paired-comparison  $t$  test to evaluate whether log-transformed reaction times in incongruent trials were larger than in congruent trials. This was not the case,  $t(64) = 0.64, p = .52$  (two tailed). At an alpha level of  $\alpha = .05$ , the statistical power to detect a medium-sized effect of  $d = .5$  was almost perfect,  $1 - \beta = .98$ , and a small-to-medium effect,  $d = .35$ , could be detected with an acceptable power of  $1 - \beta = .80$ . Theoretically, a small effect of  $d = .2$  may have gone undetected in the present meta-analysis. However, given  $t < 1$ , it again seems unlikely that more degrees of freedom would have changed the results; the probability under the null hypothesis for the empirical  $t$  value was again considerably larger than that under the alternative hypothesis.

<sup>3</sup> However, as Experiments 3 and 4 show, the same result is obtained when a standard 1 CS – 1 US pairing procedure is used; the present results are therefore not restricted to the multiple-US pairing procedure.

Valence awareness was defined here as the ability to recognize US valence that was paired with a given CS. As discussed in the introduction, this recognition measure is only a proxy for effects that occur during conditioning. Based on this operational definition of awareness, unaware EC may be observed simply because memory fails over time and longer delays lead to unaware EC. This calls for two comments. First, on-line measures of awareness would provide, in theory, better assessment of participants' conscious encoding of the CS-US contingencies. Unfortunately, on-line measures may also elicit interference effects that are detrimental to EC effects (i.e., for instance by eliciting reactance or contrast effects). Second, the present experiments suggest that valence awareness is involved in learning. Whether a specific CS-US contingency must or must not be retained in memory for an evaluative conditioning effect to be sustained is another issue, one that concerns attitude stability rather than valence acquisition.

In this context, it is also important to discuss previous studies that reported EC effects under subliminal conditions. In theory, such studies create conditions that make awareness, of valence or identity, unlikely during conditioning. Among the few studies that reported subliminal EC, however, most tended to be problematic with respect to the examination of associative processes (for a detailed discussion, see Pleyers et al., 2007). For instance, Krosnick, Betz, Jussim, & Lynn et al. (1992) and Niedenthal (1990) manipulated US valence between participants. Hence, some participants were presented with positive USs and others were presented with negative ones. As a result, nonassociative changes in affect may have been induced in these groups (Lovibond & Shanks, 2002). More recently, Dijksterhuis (2004) reported conditioning participants' self with a subliminal procedure. However, most selves are associated with both positive and negative attributes, whose level of activation may be enhanced through processes unrelated to learning. In other words, these studies may have concerned self-construal rather than learning effects. Even more problematic is the fact that five of the six studies compared a condition in which the self was paired with positive words (conditioned-self condition) with a condition in which the self was paired with neutral words (control condition). As only positive words were activated in the conditioned-self condition, this design may have resulted in mood effects. In another experiment (i.e., Experiment 2), positive words were activated in both the control and conditioned-self condition. Unfortunately, the self was activated in the latter condition only, thereby unbalancing the CS (i.e., self) presentations for the control and conditioned-self conditions.

Other subliminal EC studies failed to consistently obtain an EC effect (De Houwer, Baeyens, & Eelen, 1994; De Houwer, Hendrickx, & Baeyens, 1997), lacked an awareness check (Gawronski & LeBel, 2008), or checked for identity awareness (Rydell, McConnell, Mackie, & Strain, 2006). In Rydell et al. (2006), for instance, each of the 10 USs paired with a CS were presented 10 times under brief and masked presentation conditions. Although presentation times were short in this study, participants may have consciously identified a few of the 100 subliminally presented items (see also Dijksterhuis & Aarts, 2003). Hence, although there seems to be evidence for EC without awareness by subliminal procedures, a strong test of this notion is still lacking.

The present experiments are rather obvious in their nature, as compared with other EC paradigms in which experiments take great care to hide the true purpose of the experiments from par-

ticipants or mask the critical conditioning trials among many others (e.g., Olson & Fazio, 2001). To be sure, the relation between valence awareness and EC may turn out to be moderated by other variables such as cover stories or distraction. Thus, we want to be cautious before generalizing our results. However, the role of awareness in EC was also demonstrated in studies that reduced the overall level of awareness to about 20% (Pleyers et al., 2009), and in the present Experiment 1, the important role of valence awareness was demonstrated in the not-so-obvious procedure of conditioning meaningless letter strings.

Finally, the theoretically important case of unconscious EC may be more likely to apply to conditions where the critical dependent variable concerns participants' motivational rather than evaluative state. The difference between wanting and liking has been recently discussed by Berridge and Aldridge (2008), and it is possible that the former is conditioned through more basic processes than the latter. Recently, Aarts, Custers, and Marien (2008) demonstrated how goal pursuit and behavior might be manipulated outside of awareness (see also Aarts, Custers, & Holland, 2007). As an additional comment, a more implicit mode of affective learning may be observed in associative paradigms that are unrelated, or less clearly related, to EC (e.g., Corneille, Mauduit, Strick, & Holland, 2009).

### *Theoretical Implications*

If one reconsiders the role of awareness in the light of the present data, there are clear implications for theories of evaluative learning. Two major approaches have been proposed to account for the large body of effects often termed *associative learning*: an associative approach based on the forming of associations in a semantic network and a propositional approach based on rule-based learning (for recent reviews, see De Houwer, 2009; Mitchell, et al., 2009). Although this is probably a simplification (cf. Pacton & Perruchet, 2008), associative processes are commonly thought to be independent of cognitive resources and to occur in the absence of awareness, whereas propositional learning is thought to require awareness (e.g., Gawronski & Bodenhausen, 2006). The present research suggests an important role for valence awareness—a finding that is more easily accommodated by current propositional theories than by current associative accounts of EC. Yet, our findings are silent about the causal link between valence awareness and EC effects. This is because we did not experimentally manipulate awareness but only assessed it as a dependent variable after the acquisition phase. More precisely, we addressed awareness only in an indirect manner, using explicit memory as a proxy. The underlying mechanisms—associations or propositions—that implement this relation in the cognitive system were not directly addressed; in this sense, modified accounts based on associative processes are conceivable that can accommodate the role of awareness in EC.

With respect to the causal role of awareness, a theory of EC would need to include the temporal specificity of awareness: Although the discussed research usually assessed awareness of CS-US contingencies after acquisition, awareness during acquisition is a precondition for awareness at later stages. Because the extraction of rule-based regularities from the environment requires attention, current propositional accounts would predict that awareness at the time of acquisition is critical to support learning

processes. This notion is consistent with findings by Pleyers et al. (2009; see also Field & Moore, 2005), showing that reducing attentional resources at acquisition has similar detrimental effects on both contingency awareness and EC. It is also consistent with the finding that EC effects are sensitive to the processing goals activated in participants before their exposure to the CS-US pairings (Corneille, Yzerbyt, et al., 2009). In this view, a memory trace is formed at the time of acquisition that later supports both awareness and EC, albeit possibly via different causal paths (see also Lovibond & Shanks, 2002). Hence, a prominent goal in future research is to further specify the conditions during acquisition that later lead to EC effects and to investigate in more detail the memory representations that underlie both awareness and attitude formation.

### Applications

These considerations also have implications for the role of EC in applied research. EC has a prominent role in consumer research and marketing because it provides a general model of how and why advertising works. The usefulness of EC in this applied area is supported by our results in Experiments 2–4, as we have used common consumer products as CS. And indeed, both evaluative ratings (“How likely is it that you would buy this product?”) and response latencies in the evaluative priming task systematically varied as a function of the valence of the USs (positive or negative). Our theoretical analysis above provides factually good news for the area of advertising, as most advertisement campaigns are built on some attention-grabbing principle (e.g., the attention–interest–desire–action principle). Previous findings indicated that if people show awareness, EC effects are not found or are even reversed (e.g., Fulcher & Hammerl, 2001; Walther & Nagengast, 2006). The present findings suggest that campaigns based on establishing attention are well suited to change the evaluation of a given product. At the afferent stage, effective advertisement should create some awareness of the pairing between the product and a positive stimulus (e.g., a liked celebrity, a praising statement). At the efferent stage, the conscious retrieval of the pairing may still prove to be unnecessary, which can be considered a desirable state of affairs if the goal is to sell consumer products (as the absence of conscious retrieval may undermine conscious control strategies). Clearly, a similar reasoning may also apply when clinical and social implications of EC principles are concerned.

### Conclusions

When awareness is operationalized as performance in recognition memory tasks, EC effects depends on awareness of the CS-US relation. This finding is in line with recent research on awareness in EC (e.g., Pleyers et al., 2007, 2009; Shanks & Dickinson, 1990; Stahl & Unkelbach, 2009; Wardle et al., 2007) as well as in classical conditioning (Brewer, 1974; Lovibond & Shanks, 2002; Mitchell et al., 2009). In previous research, the discrepancy—between experiments demonstrating unaware EC and more recent studies demonstrating that EC relies on contingency awareness—has been attributed to the use of problematic designs, to the use of insensitive measures of awareness, or to the use of questionable analyses for examining the role of awareness in EC (or any combination of these). Most notable is the distinction of whether

awareness is defined at the participant level or at the CS level (Pleyers et al., 2007). The present research provided another answer for this discrepancy, namely that EC does not depend on awareness for US identity but does depend on awareness for the more basic property of US valence. The results of four experiments consistently demonstrated that when valence awareness is controlled for, identity awareness does not predict the EC outcome any longer. Thus, to advance the theoretical debate, we highly recommend that future researchers use more sensitive measures for awareness that are based on single CS-US pairings and include checks for valence awareness.

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Appendix

A Formal Account of Valence Memory Responses

The inference account proposes that participants use their evaluation of the conditioned stimulus (CS) to infer the unconditioned stimulus (US) valence in the memory task. It predicts that participants should show clear below-chance memory for CSs with US-inconsistent evaluations (i.e., CSs showing a negative EC effect) simply because they infer memory responses from their evaluations. Contrasting this prediction, we consistently observed at-chance or above-chance levels of valence memory for CSs with negative EC.

Yet, it is possible that there were some cases in which an inference process was nevertheless used in the memory task (i.e., resulting in below-chance performance for these cases); these cases could have been masked by a combination of memory and guessing in the remaining cases (i.e., exhibiting above-chance performance). Hence, responses on the memory test could reflect a mixture of memory, inference, and guessing processes, with the below-chance pattern predicted by the inference account masked by an above-chance pattern produced by memory and guessing.

In the following, we evaluate this mixture account using a formal quantitative model that fully accounts for valence memory responses for CSs with negative EC, as we have shown these are the only relevant cases to tackle the inference account. The model distinguishes between three processes: memory, inference, and guessing. This analysis yields support for an inference account if two conditions are met: Condition A is that the model can fit the

data, and Condition B is that the model's inference parameter is significantly greater than zero.

We based our analyses on the evaluative measures obtained from the evaluative priming paradigm because they tap directly into evaluative processes. As suggested by the meta-analytic results (see main text), the ratings measure is likely to be contaminated by demand effects or other strategic biases; the model-based analyses would similarly be compromised by these confounds if we relied on the ratings data.

Among the CSs with descriptively negative EC effects, there are cases in which the negative EC effect reflects a true EC-inconsistent evaluation; in other cases, it merely reflects random noise when the evaluation is neutral. Assuming that this noise is normally distributed, we can distinguish these cases, using a median split that separates CSs with stronger negative EC effects (i.e., those that are more likely to reflect true US-inconsistent evaluations) from CSs with weaker negative EC effects (i.e., those that likely reflect neutral evaluations plus random noise). As the inference account applies only to CSs for which evaluations are present, it should operate on the former but should not operate on (or should operate less so) on the latter.

The model is illustrated in Figure A1. The upper half illustrates the process model for neutrally evaluated CSs (i.e., weak negative EC). Because there is no evaluation on which an inference could be based, this part of the model does not contain an inference

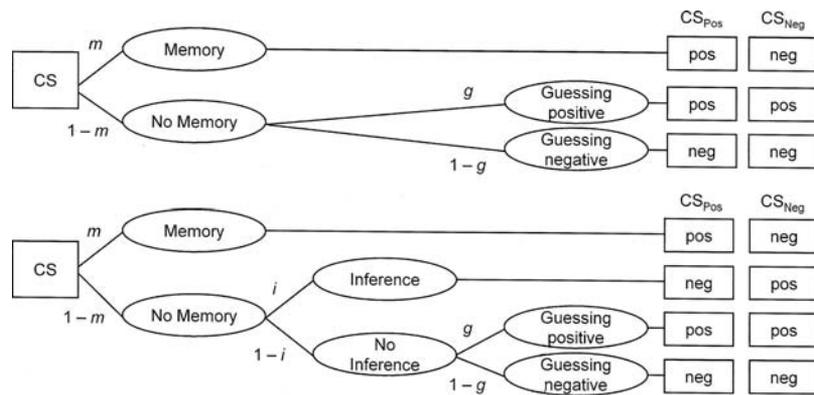


Figure A1. A multinomial processing tree model of valence memory responses. The model assumes a mixture of three processes: memory (parameter  $m$ ), inference (parameter  $i$ ), and guessing (parameter  $g$ ). Ovals represent latent cognitive states, connections represent transitions between states, and parameters represent transition probabilities. Boxes on the right represent the responses predicted by the model as a function of unconditioned stimulus (US) valence. The upper half illustrates the process model for neutrally evaluated conditioned stimuli (CSs; i.e., CSs with weak negative EC); the lower half illustrates the process model for CSs with an EC-inconsistent attitude (i.e., CSs with strong negative EC; see text for a discussion of this distinction). CS = conditioned stimulus; CS<sub>Pos</sub> = CS paired with positive USs; CS<sub>Neg</sub> = CS paired with negative USs; pos = positive response; and neg = negative response.

(Appendix continues)

parameter. The first branch represents the case that (with probability  $m$ ) participants have access to memory for US valence; in that case, US valence is reported correctly. If they lack access to US valence memory (with probability  $1 - m$ ), participants simply select a response by guessing (i.e., they respond *positive* with probability  $g$ ; second and third branch).

The lower half of Figure A1 illustrates the process model for CSs with an EC-inconsistent evaluation (i.e., strong negative EC); for these CSs, the model incorporates an inference process. The first branch again represents the case that with probability  $m$ , valence memory is available, again leading to correctly reported US valence. If participants lack access to valence memory (with probability  $1 - m$ ), they infer US valence from their evaluation of the CS with probability  $i$  (second branch). As this evaluation is inconsistent with US valence, the incorrect response is then selected. Finally, participants may again select a response by guessing (third and fourth branch).

We applied this model to the pooled data from Experiments 3 and 4 to maximize statistical power. The data yielded four empirical probabilities (i.e., proportion correct relative to the total of correct and incorrect responses, for CSs paired with positive versus negative USs, computed separately for CSs with weak vs. strong negative EC; the *don't know* responses were discarded as they are not informative for the above hypotheses). The model has three free parameters—memory ( $m$ ), inference ( $i$ ), and guessing ( $g$ ). There was 1 degree of freedom for a goodness-of-fit test; statistical power was good for detecting small effects ( $1 - \beta = .80$  for  $w = .1$ ; Cohen, 1998) and almost perfect for detecting medium or greater effect sizes ( $1 - \beta > .99$  for  $w = .3$ ). In a first step, to test whether Condition A is met (see above), the model's ability to fit

the data was evaluated with a goodness-of-fit test. The model fitted the data well,  $G^2(1) = 0.33$ ,  $p = .57$ , allowing us to use the model's parameters as quantitative estimates for the processes they represent. Specifically, this allows for a statistical test of the inference hypothesis: If there were cases in which an inference strategy was used, this would be reflected by a nonzero estimate of the inference parameter (Condition B, see above). Parameter estimates (and 95% confidence intervals) were  $m = .63$  (.55, .71),  $i = .00$  (- .20, .20), and  $g = .48$  (.37, .58). It is important to note that as already evident from the parameter value of  $i$ , the probability for an inference process was not greater than zero,  $\Delta G^2(1) < 0.001$ ,  $p > .99$ . Thus, Condition B was not met: There was no evidence for inference-based responses.

To summarize, we have put forward a complete quantitative account of responses on the valence memory test that allowed for the possibility of an inference process, along with memory and guessing. The model was applied to the data from Experiments 3 and 4 to test the prediction of the inference account, namely that participants infer US valence from their attitudes toward the CSs. Concerning our conditions formulated above, the results are clear: (a) the model fitted the data very well, and the precondition for a test of the inference account was therefore met, and (b) the inference parameter was equal to zero, and the analysis thus failed to find evidence for inference-based responses. In other words, a model including only memory and guessing can fully account for the data; there was no support for an inference account.

Received September 16, 2008

Revision received March 10, 2009

Accepted March 13, 2009 ■

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