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# Evaluative Learning With Single Versus Multiple Unconditioned Stimuli: The Role of Contingency Awareness

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Evaluative conditioning (EC) is obtained when an initially neutral conditioned stimulus (CS) becomes evaluated positively (negatively) after being paired with an evaluatively positive (negative) unconditioned stimulus (US). Most EC studies have paired a given CS with a single US, but EC has also been obtained when a CS was paired with multiple USs of the same valence. This study compares how both variants of CS–US pairing affect awareness for CS–US pairings and ultimately EC effects. EC was assessed directly and indirectly, using evaluative ratings and the Extrinsic Affective Simon Task. Memory for US identity and US valence was assessed to investigate effects of awareness. The multiple-US condition showed attenuated EC effects compared with the single-US condition. The direct measure showed EC effects when awareness of US valence or US identity was present. The indirect measure showed EC effects only when awareness of US identity was present. Results are discussed with regard to the role of contingency awareness in EC.

*Keywords:* evaluative conditioning, contingency awareness, Extrinsic Affective Simon Task, multinomial model



Evaluative conditioning (EC) refers to the change in valence of initially neutral stimuli (conditioned stimuli, or CSs) that is a result of their pairing with evaluatively positive or negative stimuli (unconditioned stimuli, or USs). Since its initial discovery (Levey & Martin, 1975), the EC phenomenon has instigated considerable amount of research (for recent reviews, see De Houwer, 2007; De Houwer, Thomas, & Baeyens, 2001; Lovibond & Shanks, 2002). EC is of theoretical importance because of its central role in dual-process models of human evaluative learning and attitude formation (e.g., Gawronski & Bodenhausen, 2006). The present research compares the pairing of a given CS with multiple USs of the same valence (e.g., Stuart, Shimp, & Engle, 1987) with the standard procedure of pairing a CS repeatedly with the same US. This manipulation is used to shed light on the role of US–CS contingency awareness for the emergence of EC effects.

Despite the phenomenon's theoretical importance, much is still unknown about EC (e.g., De Houwer, 2007). A central question is whether EC is a form of classical, or Pavlovian, conditioning or whether it represents a distinct form of evaluative learning (e.g., Baeyens De Houwer, 1995). Baeyens and Colleagues (1995) have taken the latter position, arguing that EC is a referential learning process, whereas Pavlovian conditioning arises from signal learning (cf. Rescorla & Wagner, 1972). In this debate, the issue of *contingency awareness* plays a central role. Contingency awareness refers to a participant's explicit knowledge about the US with which a given CS has been paired. It has been argued that Pavlovian conditioning effects are not found without awareness, whereas EC effects can be found in the absence of awareness (e.g., Baeyens, Eelen, & Van den Bergh, 1990; Walther & Nagengast, 2006; but see Lovibond & Shanks, 2002). Recently, however, findings with improved methodology have raised serious doubts about whether EC occurs in the absence of awareness (Pleyers, Corneille, Luminet, & Yzerbyt, 2007). The present work presents evidence relevant to this debate.

In a typical EC study, a CS is paired with a single US, and this pairing is presented repeatedly (e.g., Baeyens et al., 1990; Levey & Martin, 1975). However, EC effects have also been obtained when a single CS was paired with different USs of the same valence during the acquisition phase (e.g., Stahl & Degner, 2007; Stuart et al., 1987). To illustrate, in single-US pairing, a CS is paired with a single US and presented $k$ times. In contrast, in multiple-US pairing, a CS is paired with $k$ different $US_m$, $m = 1 \ldots k$, of the same valence. This research is the first to systematically manipulate stimulus pairing and compare its effects on EC. We use this manipulation to investigate the role of contingency awareness in EC.

Pairing a given CS with single versus multiple USs should affect awareness of co-occurrences, as participants' memory for single CS–US pairs increases with the number of repeated presentations (Baeyens, Eelen, Crombez, & Van den Bergh, 1992). Awareness can therefore be expected to be reduced in the multiple-US condition as compared with the single-US condition. If EC depends on awareness, a reduced EC effect is predicted for the multiple-US condition. If awareness is the factor underlying the effects of the pairing manipulation on EC, effects of condition should disappear when awareness is controlled for.

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In this research, we consider two different types of awareness—awareness for the CS–US identity contingency (*identity awareness*) and awareness for the CS–US valence contingency (*valence awareness*). Identity awareness, that is, memory for the specific US with which the CS was paired, is expected to be a function of the number of repetitions; it is expected to be higher in the single-US case than in the multiple-US case. Predictions for valence awareness, that is, memory for the valence the CS was paired with, are less clear: If information is stored in an integrated memory trace and memory retrieval is all or nothing, then valence should be retrieved only when US identity is retrieved. This implies that valence and identity awareness are at comparable levels. In contrast, if partial retrieval from memory is possible, US valence may sometimes be retrieved even when sufficient details for an identification of the correct US are lacking. Thus, participants may have valence awareness without identity awareness, allowing for levels of valence awareness above those of identity awareness. Hence, levels of valence awareness in the multiple-US condition are expected to be above levels of identity awareness in that condition, but below the level of awareness in the single-US condition.

The role of awareness in EC has received much attention (e.g., De Houwer et al., 2001; Hammerl & Fulcher, 2005; Lovibond & Shanks, 2002). The early debate, however, suffered from two major problems. First, some studies demonstrating EC effects without awareness had design flaws (e.g., Baeyens et al., 1990), which made the demonstrated EC effects questionable (cf. Field & Davey, 1999, for a detailed critique). Second, studies demonstrating EC effects unambiguously used insensitive measures for awareness. Thus, participants might have been aware, but the test failed to capture that awareness (cf. Shanks & St. John, 1994). By now, however, measures of awareness have improved considerably, and the designs used leave no doubt that EC is a genuine phenomenon, rendering much of the earlier criticisms obsolete.

However, the results regarding awareness are still inconclusive. Walther and Nagengast (2006) introduced a forced-choice recognition test to measure whether participants could select the appropriate US from a set of four choices (i.e., pictures) for a given CS. On the basis of performance on this test, participants were classified as aware or unaware, and it was found that EC effects emerged only for unaware participants. Pleyers et al. (2007) also observed EC effects for participants classified as unaware when mean EC effects computed for each participant were collapsed across all CSs, regardless of participants' awareness for the specific CS. However, when separate EC effects were computed for aware and unaware CSs for each participant, EC effects emerged only for those CSs for which participants showed awareness. This suggests that Walther and Nagengast's (2006) finding of EC for unaware participants might have been driven by awareness for some of the CSs in those participants; however, this analysis cannot account for the absence of EC for aware participants in that study.

Thus, although both studies used sensitive measures to assess awareness for single CS–US pairs, Walther and Nagengast (2006) analyzed effects of awareness on EC at the participant level, whereas Pleyers et al. (2007) compared EC for aware and unaware CSs within participants. According to the criteria established by Shanks and St. John (1994), when multiple CSs are used in a study, awareness assessment at the level of the single CS–US pair is preferable to an assessment at the participant level. Following this guidance, we assessed and analyzed awareness on the level of the CS–US pairs, using a memory test similar to that used by Pleyers et al. (2007).

A possible solution for these seemingly contradictory results lies in the idea that two separate systems may underlie human evaluative learning (e.g., Gawronski & Bodenhausen, 2006): an explicit, propositional system that is responsible for extracting declarative knowledge from rule-based regularities in the environment and an implicit, associative system that registers co-occurrences and establishes associations between concepts in memory (see also Clark, Manns, & Squire, 2002). If there are two different processes underlying EC, they might be differentially affected by the pairing manipulation investigated here.

Explicit declarative learning processes are captured by evaluative ratings, a standard dependent variable in EC research (De Houwer et al., 2001). To tap into associative processes, we assessed CS valence indirectly, using the Extrinsic Affective Simon Task (EAST; De Houwer, 2003) in addition to evaluative ratings. Similar to the Affective Priming task (Fazio, Sanbonmatsu, Powell, & Kardes, 1986), this measure yields indirect estimates of a CS's valence by assessing performance costs in a condition in which CS valence is task incongruent as compared with a condition in which CS valence is task congruent. The EAST is set up as follows: Words are presented and classified according to different rules in two separate tasks. In the first task (the valence task), words are classified as positive or negative, using two keys labeled *positive* and *negative*. In the second task (the color task), valence is task irrelevant, and words are classified according to their ink color (e.g., blue or green), using the same responses as in the first task (e.g., by pressing *positive* for blue words and *negative* for green words). In the critical color task, a trial is congruent when a *positive* response is required for a positive stimulus (i.e., when it is presented in blue) or a *negative* response is required for a negative stimulus (i.e., when it is presented in green). A trial is incongruent when a *negative* response is required for a positive stimulus (i.e., when a positive stimulus is presented in green) or when a *positive* response is required for a negative stimulus (i.e., when a negative stimulus is presented in blue). Increased response latencies and/or error rates in the incongruent condition as compared with the congruent condition indicate interference resulting from the task-irrelevant stimulus valence (De Houwer, 2003). Both the EAST and the Affective Priming task have been successfully used to assess EC effects (e.g., Hermans, Vansteenwegen, Crombez, Baeyens, & Eelen, 2002; Pleyers et al., 2007; Stahl & Degner, 2007). Here, we used the EAST because a validated measurement model is available for this task, providing an index of CS valence that is uncontaminated by strategic processes or response biases (Stahl & Degner, 2007).

We conducted two experiments, Experiments 1A and 1B, with almost identical procedures, that are reported together. In both experiments, the CSs were either paired with one US (i.e., the 1US condition) or five USs of the same valence (i.e., the 5US condition). EC effects on CS valence were assessed by using evaluative ratings and the EAST. Finally, a memory test probed participants' awareness for CS–US identity contingency (identity awareness) and for CS–US valence contingency (valence awareness).

If the number of USs per CS is relevant for EC, there should be a difference between EC effects obtained in the 1US and 5US conditions. If this effect is mediated by participants' awareness of the CS–US contingency, the effect of condition should disappear when awareness is taken into account. If awareness of US identity is a necessary condition for EC, significant EC effects would be expected only for CSs with identity awareness; if awareness of US valence is sufficient, an EC effect should also obtain for CSs with valence awareness.

## Method

### *Participants*

Thirty-two University of Freiburg (Freiburg, Germany) students (26 women; mean age = 24) participated in Experiment 1A and 32 additional University of Freiburg students (19 women; mean age = 22) participated in Experiment 1B; participants received a monetary refund of €3.50.

### *Design*

A 2 (US valence: positive vs. negative) × 2 (pairing: 1US vs. 5US) × 2 (CS set: Set A–positive vs. Set B–positive) design was used with repeated measures on the first factor. In the EAST, two additional factors were counterbalanced: color assignment (blue–positive vs. blue–negative) and word set assignment (Set A–color task vs. Set B–color task).

### *Materials and Procedure*

Materials were taken from Stahl and Degner (2007). 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 International Affective Picture System pictures were used as USs (Lang, Bradley, & Cuthbert, 2005). Mean evaluative ratings were 7.9 for the set of positive pictures and 2.5 for the set of negative pictures, $t(48) = 117.80$, $p < .001$. Assignment of CS sets to USs was counterbalanced.

In the conditioning phase, participants passively watched 100 CS–US pairs that appeared on screen for 2,000 ms each. In the 1US condition, the same US was always paired with a given CS, and each pairing was repeated 10 times. In the 5US condition, each CS was paired with five different USs of the same valence, and each pairing was presented twice.

After the conditioning phase, the EAST task was administered. Procedures closely followed those of Experiment 3 in Stahl and Degner (2007). For the valence task, stimuli were presented in white on a black screen; for the color task, stimuli were presented in blue or green. Participants were instructed to respond with a *positive* or a *negative* key to the valence of the words presented in white and to respond with the same keys to the color of the words presented in blue or green. Two sets (words A and words B) of clearly positive and negative words were used as stimuli for the valence task and as control targets in the color task; assignment of word set to task was counterbalanced. The CSs were presented as targets on the color task. Each CS was presented equally as often in the congruent and the incongruent colors.

Practice blocks of 20 trials each were run for the valence task and for the color task. Four blocks of 44 trials followed in which both tasks were mixed. Order of trials was randomized, except that a mixed block always started with four valence trials. Of the remaining 40 trials, 20 were valence trials (10 positive and 10 negative) and 20 were color trials (10 positive and 10 negative). Within a mixed block, each stimulus in the color task appeared once in each color. A trial started with a 350-ms presentation of a fixation cross that was replaced by the stimulus, presented for 200 ms. In the case of an incorrect response, an error message was displayed for 400 ms. The next trial commenced 1,200 ms after a response was registered or after the offset of an error message.

In the rating phase, participants were presented with each of the CSs that were presented in random order and intermixed with the target words from the EAST task. Participants evaluated each item on a scale ranging from 1 (*very unpleasant*) to 8 (*very pleasant*).

In the memory test, the CSs were presented again, and two questions had to be answered. First, participants indicated whether the CS had been paired with pleasant or unpleasant USs. After a response was given, six pictures from the set of USs of the indicated valence were presented, and participants had to decide which of these pictures had been presented with the CS in the conditioning phase. In Experiment 1A, if US valence was incorrectly indicated, all of these pictures were lures. If US valence was correctly indicated, one of the response options was always a target US. In the 5US condition, each CS was presented five times, once with each of the different USs as a target.

In Experiment 1B, after participants had indicated whether the CS had been paired with pleasant or unpleasant USs, they were always presented with six USs from the correct valence, independent of the valence they indicated. Thus, whether valence was indicated correctly or not, one of the response options on the identity memory test was always a target US. This allowed participants to report identity memory even when unable to correctly report US valence. This change addressed a problem of the memory test in Experiment 1A: In principle, valence may be incorrectly identified for a CS for which US identity can be correctly indicated. If such a response pattern occurs frequently, memory for US identity should be higher in Experiment 1B than in Experiment 1A; however, this was not the case (see the Results section). Thus, the possibility of identity memory without valence memory proved negligible.

Furthermore, memory in Experiment 1B for each CS in the 5US condition was probed only once. This modification avoids biased responses resulting from feedback learning that were made possible by the first change: By always presenting USs of the correct valence on the US-identity trials, participants were indirectly informed about the correct valence. Therefore, performance on subsequent trials probing for US valence memory that would have followed in the 5US condition might have been biased. In Experiment 1B, each CS was probed only once, and one out of the five USs was randomly selected to serve as the target on the US-identity trial in the 5US condition. Only the data from the first identity trial were analyzed to ensure comparability across experiments.

### *Analysis of EAST Data*

The EAST data were analyzed with a multinomial model (Stahl & Degner, 2007) that expresses the frequencies for correct responses and errors for congruent and incongruent trials as a function of three latent parameters—automatic effects of stimulus valence (parameter a), controlled task-relevant processing (parameter c), and guessing (parameter b; see Stahl & Degner, 2007). We used the HMMTree software (Stahl & Klauer, 2007) to obtain maximum likelihood estimates for these parameters, as well as the $G^2$ statistic to evaluate the model's goodness-of-fit. Hypotheses were tested by imposing restrictions on model parameters and comparing goodness of fit of the restricted model with that of the unrestricted model; significant reductions in model fit indicate that the hypothesis must be rejected. In multinomial modeling of aggregated data, the assumption is made that parameters are homogeneous across participants; this assumption was tested and found to be violated. However, when we applied a hierarchical model (Klauer, 2006) to control for effects of parameter heterogeneity, the results obtained from the aggregated data that are reported below were replicated. Additional detail can be obtained from Christoph Stahl.

## Results

No significant effects emerged when experiment (1A or 1B) was included as a factor. The results are therefore reported collapsed across experiments. In a first step, effects of the pairing manipulation on EC and awareness were analyzed. In a second step, the role of awareness on EC effects was investigated.

### *Evaluative Ratings*

We computed an EC effect as the difference between the mean evaluative ratings for the CSs paired with positive USs and those paired with negative USs. An EC effect was observed, $F(1, 60) = 71.08$, $p < .001$, that was affected by condition, $F(1, 60) = 6.19$, $p < .05$. Significant EC effects were observed in the 1US condition, $t(31) = 6.48$, $p < .001$, and in the 5US condition, $t(31) = 5.46$, $p < .001$, but the EC effect was smaller in the 5US condition ($M = 1.27$) than in the 1US condition ($M = 2.33$), $t(62) = 2.48$, $p < .05$.

### *EAST Effects*

Model fit was good, $G^2(3) = 0.58$, *ns*, demonstrating that the model provided an adequate account of the data. The parameters measuring effects of valence were significantly different from zero for target words, $\Delta G^2(1) = 90.76$, $p < .001$. This shows that the EAST task adequately captured the valence of those words. The parameters measuring effects of CS valence did not differ across conditions, $\Delta G^2(1) = 1.03$, *ns*, and they did not differ from zero, $\Delta G^2(1) = 1.33$, *ns*. Thus, there were no effects of the valence of CSs on the EAST measure in either condition. In short, we obtained no overall EC effect in the EAST.

### *Memory for CS–US Pairings*

There was a significant effect of condition on memory for US identity, $F(1, 60) = 53.70$, $p < .001$: In the 1US condition, the US was correctly assigned in 85% of cases, whereas in the 5US condition, it was correctly assigned in only 34% of cases. By chance alone, one would expect 17% correct assignments (i.e., one out of six). This effect was paralleled by a significant effect of condition on memory for US valence, $F(1, 60) = 14.89$, $p < .001$: In the 1US condition, the correct valence was remembered in 85% of cases; in the 5US condition, it was correctly remembered in only 69% of cases. Here, 50% of correct assignments would have been expected by chance alone. Memory for US identity and memory for US valence were above chance in both conditions (all *p*s $< .001$).

### *Role of Awareness in EC Effects*

What caused the difference in EC between conditions? We evaluated the possibility that the difference in EC magnitude between pairing conditions could be attributed to differences in awareness. Although memory for CS–US pairings was impaired in the 5US condition as compared with the 1US condition, there were above-chance levels of correct memory for US identity even in the 5US condition. If memory for US identity is necessary and sufficient for an EC effect to occur, there should be an EC effect for identity-aware CSs in the 5US condition and no effect of condition if only identity-aware CSs are analyzed. Similarly, if memory for US valence is necessary and sufficient for an EC effect to occur, there should be an EC effect for valence-aware CSs in both conditions and no effect of condition if only valence-aware CSs are analyzed.

### *Awareness Effects on Evaluative Ratings*

We computed EC effects on evaluative ratings for identity-aware, for valence-aware, and for unaware CSs. A given CS was classified as identity aware for a participant when US identity was correctly assigned. EC effects for identity-aware items could be computed for 18 participants in the 5US condition and 28 participants in the 1US condition. For identity-aware items, an EC effect was observed, $F(1, 42) = 36.46$, $p < .001$. As predicted, this effect was not affected by pairing condition, $F(1, 42) = 1.58$, *ns*.

A CS was classified as unaware when participants were unable to correctly report both US identity and US valence. EC effects for unaware items could be computed for 23 participants in the 5US condition and for 10 participants in the 1US condition. Replicating Pleyers et al. (2007), no EC effects were found for unaware items, $F(1, 29) < 1$ *ns*.

The remaining CSs for which the correct valence was reported but the identity of the US was incorrectly reported were classified as valence aware. Supporting the notion that memory for US valence may be available even in the absence of memory for US identity, we were able to compute EC effects for 28 participants in the 5US condition and 5 participants in the 1US condition. A significant EC effect was observed for valence-aware trials, $F(1, 29) = 8.17$, $p < .05$; this effect was not qualified by pairing condition, $F(1, 29) < 1$, suggesting that memory for US valence is sufficient for an EC effect.

### *Awareness Effects on the EAST*

In a second model-based analysis, we compared EAST effects for identity-aware, valence-aware, and unaware CSs. The goodness of fit of the model was good, $G^2(7) = 7.49$, *ns*, demonstrating that the model adequately described the data. There was no effect of condition on the valence parameters, $\Delta G^2(3) = 5.2$, *ns*. Thus, the following effects on CS valence were independent of whether CSs were paired with one US or five USs. For identity-aware CSs, an EAST effect was observed, $\Delta G^2(1) = 4.84$, $p < .05$, reflecting the valence acquired by the CSs during the acquisition phase. There was no effect on the valence parameters for unaware CSs,

$\Delta G^2(1) = 1.55$, *ns*, nor was there an EAST effect for valence-aware CSs, $\Delta G^2(1) < 0.01$, *ns*. In sum, we obtained EC effects in the EAST for CSs for which participants had identity awareness, but not for valence-aware or unaware CSs.

## Discussion

We compared EC effects across two variants of CS–US pairing: A CS was paired with either one US or five USs. EC effects were assessed directly, using evaluative ratings, and indirectly, using the EAST. Memory for US identity and US valence was assessed to investigate effects of awareness. Replicating previous findings, EC effects were found in both the single-US and multiple-US conditions. This study is the first to compare both conditions, and we observed that EC effects were of smaller magnitude in the multiple-US condition.

Simultaneously, the pairing manipulation affected awareness. As predicted, awareness of US identity was strongly reduced in the multiple-US condition. Awareness of US valence was also reduced, but to a lesser degree. More important, there were some CSs for which US valence memory was found, but not US identity memory, supporting the notion that partial memory traces can contain information about valence but not identity.

In this study, awareness and EC were found to coincide. In line with the findings by Pleyers et al. (2007), but in contrast to Walther and Nagengast (2006), we obtained significant EC effects only for CSs for which awareness was available; evidence for EC was not obtained for unaware CSs. In contrast to previous reports, EC effects on evaluative ratings were obtained for CSs for which valence awareness was present but identity awareness was lacking. Previous failures to find such an effect were most likely because of a lack of power, as only a small proportion of CSs is usually classified as valence but not identity aware (e.g., Pleyers et al., 2007). In the present study, valence-aware CSs were found for a small proportion (5 out of 32) of participants in the 1US condition, but for the majority (28 out of 32) of participants in the 5US condition. A significant EC effect was obtained on evaluative ratings for these stimuli.

EC was not obtained for valence-aware stimuli on the EAST measure. There are two possible reasons: First, the discrepancy may reflect a genuine difference, suggesting that different underlying processes may be responsible for the effects obtained with the different measures. For example, evaluative-ratings EC may have resulted from rule-based propositional processes, whereas EC in the EAST task may be a result of associative processes. However, given that this study is the first to report such a discrepancy for valence-aware CSs, we hesitate to interpret this finding as evidence for different underlying processes and prefer an explanation in terms of the EAST's sensitivity: Note that the EC effect on evaluative ratings was considerably larger for identity-aware CSs than for valence-aware CSs, and it was also considerably larger than the EC effect for identity-aware CSs in the EAST. The lack of a significant EC effect for valence-aware CSs may thus simply reflect the lack of sensitivity of the EAST measure.

Alternative explanations for the observed EC effect for valence-aware CSs are conceivable. For instance, participants may have noticed that they liked (disliked) a specific CS and inferred from this liking that it must have been paired with positive (negative) USs (see Pleyers et al., 2007). If participants had followed this strategy, then a specific pattern should be observed for CSs in which participants consistently assigned the wrong valence in the memory test: For these CSs, a negative EC effect should be found (i.e., a CS paired with negative USs would be evaluated more positively than a CS paired with positive USs). Such cases were observed for 10 participants in the 5US condition and 8 participants in the 1US condition. However, negative EC effects were not observed for these CSs, $F(1, 16) < 1$. The account would also predict that erroneous classifications of US valence would be associated with negative EC effects. Contrary to this prediction, negative EC effects were equally frequent for CSs for which US valence judgments were consistently erroneous (19 out of 320) and for CSs for which participants consistently remembered the correct US valence (14 out of 320). In sum, there is little evidence that participants' valence memory responses were inferred from their evaluations of the CSs.

## Conclusions

The present study replicated recent findings by Pleyers et al. (2007): When awareness and EC were assessed at the level of the specific CS–US pairing (as opposed to the participant level), EC was found for CSs with US-identity awareness but not for CSs without awareness. The results go beyond previous work by demonstrating that awareness of US valence is sufficient for EC. However, this is likely not the last word on this issue. In our view, much can still be learned about EC from such procedural manipulations as CS–US pairing.

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