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Does attitude acquisition in evaluative conditioning without explicit CS-US memory reflect implicit misattribution of affect?

Adrien Mierop[a], Mandy Hütter[b], Christoph Stahl [c] and Olivier Corneille[a†]

[a]Université catholique de Louvain, Louvain-la-Neuve, Belgium; [b]Eberhard Karls Universität Tübingen, Tübingen, Germany; [c]Universität zu Köln, Köln, Germany

ABSTRACT
Research that dissociates different types of processes within a given task using a processing tree approach suggests that attitudes may be acquired through evaluative conditioning in the absence of explicit encoding of CS-US pairings in memory. This research distinguishes explicit memory for the CS-US pairings from CS-liking acquired without encoding of CS-US pairs in explicit memory. It has been suggested that the latter effect may be due to an implicit misattribution process that is assumed to operate when US evocativeness is low. In the present research, the latter assumption was supported neither by two high-powered experiments nor by complementary meta-analytic evidence, whereas evocativeness exerted an influence on explicit memory. This pattern of findings is inconsistent with the view that CS-liking acquired without encoding of CS-US pairs in explicit memory reflects an implicit misattribution process at learning. Hence, the underlying learning process is awaiting further empirical scrutiny.

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When a neutral stimulus (conditioned stimulus; CS) is paired with a positive or negative stimulus (unconditioned stimulus; US), the CS may acquire the US valence. This attitude formation phenomenon, coined "evaluative conditioning" (Martin & Levey, 1978), has been studied extensively (e.g. Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). An intensely debated question is whether this simple attitude learning mechanism can occur independently of the encoding of CS-US pairings in explicit memory.

Experimental and correlational research has typically provided conflicting answers to that question (for a recent review, see Corneille & Stahl, 2017; Sweldens, Corneille, & Yzerbyt, 2014). Experimental studies that prevented the explicit encoding of CS-US pairings in memory generally found weak evidence for memory-independent EC. This conclusion was supported in experiments that failed to obtain a significant EC effect when participants' cognitive resources were taxed at learning (e.g. Davies, El-Deredy, Zandstra, & Blanchette, 2012; Dedonder, Corneille, Yzerbyt, & Kuppens, 2010; Kattner, 2012; Mierop, Hütter, & Corneille, 2017; Pleyers, Corneille, Yzerbyt, & Luminet, 2009) or when participants were exposed to briefly presented (e.g. Hofmann et al., 2010; Stahl, Haaf, & Corneille, 2016; see however Greenwald & De Houwer, in press), parafoveally presented (Dedonder, Corneille, Bertinchamps, & Yzerbyt, 2014), or visually suppressed (Högden, Hütter, & Unkelbach, in press) stimuli.

Turning to correlational evidence, studies that relied on item-based analyses of CS-US memory generally found EC effects only for CSs that were successfully related to their associated US identity (e.g. Pleyers, Corneille, Luminet, & Yzerbyt, 2007) or US valence (e.g. Stahl, Unkelbach, & Corneille, 2009) in a later memory task. This finding was obtained in various sensory modalities (Wardle, Mitchell, & Lovibond, 2007) and was supported using psychophysiological measures (Dawson, Rissling, Schell, & Wilcox,

CONTACT Adrien Mierop Adrien.mierop@uclouvain.be
[†]AM, MH, CS, and OC planned and discussed the research and wrote the manuscript; AM and MH conducted the studies and analyzed the data.

2007). In contrast, however, studies relying on a more refined processing tree approach using multinomial processing tree (MPT) modeling, found evidence for EC in the absence of explicit memory for the pairings (Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012). The present research is the result of an adversarial collaboration that examined the role of implicit affective misattribution as a driver of the latter implicit learning evidence, by manipulating one of its moderators: US evocativeness.

The contribution of implicit affect misattribution to EC without CS-US memory

Hütter et al. (2012) noted that when participants report the valence of a US paired with a CS, both valence memory ("I remember this image was paired with a positive image") and inferences ("I like this image, so it must have been paired with a positive image") may contribute to US valence responses. A process dissociation approach (Jacoby, 1991) allows disentangling the contribution of these independent processes. This is achieved by contrasting an "inclusion" to an "exclusion" instruction condition, where these two processes produce convergent or divergent responses, respectively. As explained below (see Methods section), data generated under these conditions may then be modeled to yield separate estimates for memory-dependent (recollection of the CS-US pairings: the *m*-parameter) and memory-independent (acquired evaluations without explicit memory of the pairings: the *a*-parameter) effects in EC.

Hütter et al. (2012) showed that the estimate of the explicit memory component, parameter *m*, was larger than zero, suggesting that participants successfully encode a substantial proportion of the CS-US pairings in explicit memory. More importantly, they also found that the estimate of memory-independent EC effects, parameter *a*, was larger than zero, suggesting that participants may acquire CS liking consistent with US valence in the absence of explicit CS-US memory. Of critical interest, Hütter and Sweldens (2013) further predicted and found the EC effect on the *a*-parameter to be obtained in simultaneous, but not in sequential CS-US pairing settings.

These authors explained that the latter finding is consistent with the operation of an implicit affective misattribution (IM) process (Jones, Fazio, & Olson, 2009; Jones, Olson, & Fazio, 2010). That is, given simultaneous CS-US pairings, participants may be confused about the source of their affect at learning: they would implicitly and mistakenly attribute their affective response to the CS instead of the US. As a result of this IM process, the CS may acquire the US valence in the absence of encoding of the CS-US pairing in explicit memory. Presumably, this would result in a memory-independent EC effect that is captured by the *a*-parameter.

While temporal contiguity is considered a particularly relevant and critical factor to IM by Jones et al. (2009), simultaneous versus sequential pairings, however, are also potentially relevant for other processes contributing to EC. That is, the temporal proximity of the CS and US might foster a multitude of attitude acquisition processes. In particular, the *a*-parameter might also represent associative learning of mere referential relations (Baeyens, Eelen, Crombez, & Van den Bergh, 1992) or the formation of a holistic representation (Martin & Levey, 1978). Hence, it is possible that other such processes conceptualised as driving EC effects in the absence of explicit memory also profit from simultaneous over sequential presentations. The reasoning that a multitude of different processes may be affected by temporal contiguity also receives support from variation of the *m*-parameter in Hütter and Sweldens (2013) study, which was larger when CS-US pairs were presented simultaneously rather than sequentially. As a consequence, a temporal contiguity manipulation does not allow for a conclusive evaluation of the discriminant validity of the *a*-parameter (Campbell & Fiske, 1959).

Yet, it may still be the case that the EC effect reflected in the *a*-parameter partly reflects IM in a simultaneous CS-US pairing paradigm. This possibility can be addressed by manipulating other factors that are relevant to IM and that are uniquely postulated by that account. In the present research, we chose to manipulate US evocativeness, which is considered another critical determinant of IM. US evocativeness was examined as a moderator of IM in an experiment conducted by Jones et al. (2009). These authors paired CSs with USs that were pretested to be rated as more intense on an evaluative dimension and categorised faster as "positive" or "negative" in a dichotomous categorisation task (strongly evocative USs) *versus* to be rated as relatively milder and categorised slower as "positive" or "negative" (weakly evocative USs).

In that experiment, low evocativeness decreased pairing memory, yet *increased* EC effects. Presumably, low evocativeness enhanced source confusability, thereby boosting the operation of IM in EC. Importantly, this proposed pattern is unique to the IM account. Even if one would allow for an influence of US evocativeness on memory-independent processes as conceptualised in the referential (Baeyens et al., 1992) and holistic accounts (Martin & Levey, 1978), one would expect that lower evocativeness would *decrease* EC effects as learning effects are assumed associative in nature and thus reflective of the properties of the US.

In the present adversarial collaboration, we examined the latter hypotheses in two experiments that relied on the same CS material, conditioning procedure, and memory task as in Hütter et al. (2012). US evocativeness was manipulated between-participants in Experiment 1 and within-participants in Experiment 2. If low evocativeness facilitates IM, and if the *a*-parameter reflects IM, then it should be the case that a greater *a*-parameter is obtained for CSs simultaneously paired with weakly as compared to strongly evocative USs. In contrast, obtaining a lower or an equivalent *a*-parameter in the low evocativeness condition as compared to the high evocativeness condition would challenge the claim that the memory-independent contribution to EC reflects the operation of an IM process. As to the *m*-parameter, its estimate may be found to be lower for CSs paired with weakly than strongly evocative USs (Jones et al., 2009).

Experiment 1

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. The data from the experiment as well as from the pilot study for the selection of the USs are publicly available on Open Science Framework (osf.io/6bjvy).

Method

Participants

The sample size of this experiment was estimated on the basis of Hütter and Sweldens (2013), who relied on 77 participants. We collected six more participants to accommodate potential data loss (participants are excluded if they fail the training stage). Among the 83 initial participants, seven were excluded because they failed the practice trials preceding the memory task three times in a row. The final sample was therefore composed of 76 participants ($M_{age} = 21.21$; $SD_{age} = 2.24$; 62 female). The number of observations collected respects the "rule of thumb" for sufficient power suggested by Klauer, Stahl, and Voss (2011), who recommended that not more than 10% of the expected category counts should be below five.

Design

A 2 (time of evaluative rating: before versus after conditioning) × 2 (US valence: positive versus negative) × 2 (US evocativeness: low versus high) × 2 (memory instruction: inclusion versus exclusion) mixed design was implemented with repeated measures on the first two factors.

Procedure

The procedure was identical to Hütter et al. (2012; Experiment 2a), but for the USs used. Specifically, the USs were 200 affective pictures (all coming from the *International Affective Picture System*, IAPS, Lang, Bradley, & Cuthbert, 1999, see Appendix) that were selected on the basis of a pilot study. These 200 USs were composed of 50 USs of each of four (valence × evocativeness) categories. Consistent with the evocativeness criteria used by Jones et al. (2009, Experiment 5), we measured both the self-reported liking and the time needed to categorise each US as "positive" or "negative". The stimuli of low and high evocativeness (see Table 1) differed both in (absolute value) ratings, $F(1,198) = 6.34$, $p = .013$, $\eta_p^2 = .03$, and in the amount of time needed to categorise them as positive or negative, $F(1,198) = 244.59$, $p < .001$, $\eta_p^2 = .55$. They, however, differed neither in categorisation accuracy nor in arousal ($Fs < 1$). The effect size of the evocativeness manipulation (at least for the direct evaluative ratings) was modest, but the mean values closely followed the mean ratings of the stimuli selected by Jones et al. (2009).

The CSs were 24 black-and-white portraits selected on a participant level. They were the most neutral portraits for each participant among 102 that were prerated in a random order on an evaluative scale ranging from "very unpleasant" (−100) to "very pleasant" (100).

The CSs were randomly assigned to USs of positive (12 CS+) or negative valence (12 CSs−). A given CS was paired with eight different USs of their assigned valence during the conditioning phase, amounting to 192 pairings in total. Each picture pair was presented simultaneously for 2000 ms with an interstimulus interval between pairs of 100 ms.

After the conditioning phase, participants performed the memory task. They were randomly assigned to the inclusion or the exclusion condition. The task of the participants was, for each CS, to

Table 1. Mean evaluative ratings, categorisation time, categorisation accuracy, and arousal ratings for the positive and negative USs of low and high evocativeness.

	Low evocative USs		High evocative USs	
	Negative	Positive	Negative	Positive
Experiment 1				
Ratings (1–9)	3.4 (.8)	6.5 (.6)	3.1 (.6)	6.9 (.8)
RT (ms)	986.5 (137.2)	1053.6 (141.4)	786.5 (51.0)	790.9 (22.1)
Accuracy (0–1)	.8 (.2)	.8 (.1)	.9 (.1)	.9 (.1)
Arousal (1–9)	5.2 (.9)	4.5 (.9)	5.3 (.9)	4.5 (.9)
Experiment 2				
Ratings (1–9)	4.0 (.5)	5.9 (.3)	2.5 (.2)	7.4 (.3)
RT (ms)	1034.5 (165.9)	1109.9 (177.0)	787.1 (48.2)	794.0 (20.9)
Accuracy (0–1)	.7 (.2)	.8 (.1)	.9 (.1)	1.0 (.1)
Arousal (1–9)	4.9 (1.0)	4.2 (.9)	5.6 (.8)	4.7 (1.0)

Note: USs = Unconditioned stimuli; CSs = Conditioned stimuli. RT = response time (i.e. time in milliseconds to categorise a stimulus as "positive" or "negative").

report whether it had been paired with pleasant or unpleasant pictures by selecting one of the two answer boxes ("pleasant" and "unpleasant"). Participants in the inclusion condition were instructed to respond in accordance with their memory. In the exclusion condition, participants were instructed to reverse their responses according to their memory of the pairings (e.g. by selecting the "pleasant" answer if a CS was paired with unpleasant USs). Importantly, participants in both conditions were also instructed to report their attitude toward the portrait (without reversing their response) when they did not remember the pairings. Participants were never instructed to guess.

Before the actual memory task started, participants were trained with eight hypothetical scenarios to probe for the comprehension of the instructions. If participants made errors, instructions were repeated up to two times. Participants who still made errors in the final repetition were excluded from the analysis in accordance with Hütter et al. (2012) and Hütter and Sweldens (2013). Finally, evaluative ratings of the 24 CS faces were obtained a second time. After the completion of the experiment, participants were thanked and dismissed.

Results

Evaluative ratings

Evaluative ratings of the CSs were submitted to a 2 (US valence) by 2 (time of measurement) by 2 (US evocativeness) ANOVA, with repeated measures on the first and second factors. This analysis revealed an EC effect, as indicated by a significant interaction between US valence and time of measurement, $F(1, 74) = 81.16$, $p < .001$, $\eta_p^2 = .52$. Positively paired CSs were rated more positively than negatively paired CSs in the postratings, $F(1, 74) = 86.66$, $p < .001$, $\eta_p^2 = .54$, but not in the preratings, $F(1, 74) = .09$, $p = .76$, $\eta_p^2 = .00$. The three-way interaction between US valence, time of measurement, and evocativeness condition was not significant, $F(1, 74) = .06$, $p = .81$, $\eta_p^2 = .00$. The full pattern of means is reported in Table 2.

Memory task

We modeled the frequency data of the memory task (see Table 3) using the HMMtree software (Stahl & Klauer, 2007). We adapted the MPT model proposed by Hütter et al. (2012) by expressing the level of memory-independent EC in the high-evocativeness

Table 2. Mean evaluative ratings (and standard deviations) of CSs as a function of time of measurement, US valence, and US evocativeness.

	Preratings		Postratings	
	CSs−	CSs+	CSs−	CSs+
Experiment 1				
Mild USs	103.08 (6.72)	102.30 (6.15)	95.05 (15.04)	108.82 (13.28)
Intense USs	102.49 (3.94)	103.54 (4.43)	98.20 (10.70)	114.60 (10.49)
Experiment 2				
Mild USs	103.61 (8.82)	104.37 (8.76)	101.64 (18.21)	112.98 (19.15)
Intense USs	104.35 (8.76)	103.50 (8.51)	100.17 (19.15)	113.40 (16.72)

Note: USs = unconditioned stimuli; CSs = conditioned stimuli.

Table 3. Observed frequencies of "pleasant" (+) and "unpleasant" (–) responses under inclusion and exclusion instructions in the different conditions of Experiments 1 and 2.

	Inclusion		Exclusion	
	+	–	+	–
Experiment 1				
Low evocativeness				
CSs+	181	83	60	132
CSs–	50	214	133	59
High evocativeness				
CSs+	164	52	73	167
CSs–	53	163	175	65
Experiment 2				
Low evocativeness				
CSs+	342	162	180	240
CSs–	157	347	279	141
High evocativeness				
CSs+	357	147	146	274
CSs–	128	376	321	99

Note: CSs = conditioned stimuli.

condition as a proportion f of the memory-independent EC in the low-evocativeness condition (i.e. $a_{\text{high-evocativeness}} = f^{*}a_{\text{low\_evocativeness}}$). If high US evocativeness indeed harms memory-independent EC as predicted by the IM account, parameter f should be significantly smaller than 1. The parameters of interest were therefore a (reflecting the level of memory-independent EC) and f (reflecting the effects of the evocativeness manipulation on the a-parameter). In addition, for each evocativeness condition, the model estimated one m-parameter (reflecting explicit memory) for each US valence (positive, negative) to allow for valence asymmetries, and one r-parameter (reflecting the tendency to guess "pleasant").

Restricting the a-parameter to zero tests the hypothesis that no memory-independent EC effect is present. The hypothesis is rejected if this restriction leads to significant reduction of the model's goodness of fit. The hypothesis that memory-independent EC effects were absent must be rejected based on the fact that a could not be fixed at zero, $\Delta G^2(1) = 7.01$, $p = .004$.[1]

Restricting parameter f to a constant value of 1 tests the hypothesis that memory-independent EC is *not* affected by US evocativeness (i.e. is of the same magnitude with low- and high-evocative USs). The hypothesis is rejected if this restriction leads to significant reduction of the model's goodness of fit. The parameter $f = .71$, 95% CI [.00, 1] could be fixed at 1 without reducing goodness of fit, $\Delta G^2(1) = 0.20$, $p = .33$. The null hypothesis that US evocativeness does not affect memory-independent EC could be retained ($a_{low} = .11$, 95% *CI* [.00, .22]; $a_{high} = .08$, 95% *CI* [.00, .19]).

Retaining the null hypothesis raises the issue of power and sensitivity. We conducted power analyses using multiTree (Moshagen, 2010) and found that the memory-independent EC effect (i.e. $a > 0$) had an effect size of $w = .06$ (Cohen, 1988)[2], and given our sample sizes ($N = 76$) and the observed level of explicit memory, the present studies were sufficiently sensitive to detect effects of this magnitude with alpha = .05 and power = .75. In contrast, the effect of US evocativeness on memory-independent EC was much smaller ($w = .01$). To detect such a very small effects in the present design, we would have needed 71,154 observations or 2965 participants. Thus, we cannot exclude the possibility of very small effects of US evocativeness on EC. In the present study, however, that was sufficiently powered to detect small effects, US evocativeness failed to reduce the MPT estimate of memory-independent EC substantially.

Next, we assessed the moderation of the m-parameters by evocativeness condition. The m-parameter for positively paired CSs was not influenced by evocativeness, such that memory was comparable between the low-, $m_{low\_pos} = .37$, 95% *CI* [.29, .46], and high-evocativeness conditions, $m_{high\_pos} = .46$, 95% *CI* [.37, .54], $\Delta G^2(1) = 1.83$, $p = .18$. Evocativeness also did not influence memory for negative pairings, $\Delta G^2(1) = 0.11$, $p = .18$. The m-parameter for CSs– in the low-evocativeness condition amounted to $m_{low\_neg} = .50$, 95% *CI* [.42, .58], and $m_{high\_neg} = .48$, 95% *CI* [.40, .56] in the high-evocativeness condition. When equated across evocativeness conditions, the resulting m-parameters for positive, $m_{pos} = .41$, 95%

CI [.36, .47], and negative pairings, $m_{neg} = .49$, 95% *CI* [.44, .55], demonstrated a marginal difference, $\Delta G^2(1) = 3.52$, $p = .06$.

Finally, we explored effects of evocativeness on guessing. The *r*-parameters differed significantly between evocativeness conditions, $\Delta G^2(1) = 4.07$, $p = .04$. While the *r*-parameter in the low-evocativeness condition did not differ significantly from .50, $r_{low} = .52$, 95% *CI* [.46, .58], $\Delta G^2(1) = 0.00$, $p = .99$, for the high-evocativeness condition the *r*-parameter indicated a negative response tendency, $r_{high} = .43$, 95% *CI* [.37, .49], $\Delta G^2(1) = 5.09$, $p = .02$.

Discussion

To summarise the results of Experiment 1, the memory-independent parameter (*a*) was not dependent on the evocativeness condition. However, as the null-effects on both the explicit memory-parameter (*m*) and the evaluative ratings suggest, our manipulation of evocativeness might not have been strong enough in the present experiment.

Experiment 2

The fact that we did not obtain effects of US evocativeness in Experiment 1 may be due to a lack of statistical power and/or a lack of strength of the evocativeness manipulation. To address this possibility, Experiment 2 increased statistical power by using a within-participants design and doubling the sample size, and strengthened the evocativeness manipulation.

Experiment 1 used 200 USs with 50 USs in each group that had relatively large variability in their evocativeness. Furthermore, the contrast between mild and intense USs was perhaps too weak because of the between-participants evocativeness manipulation. It is also possible that our set of "weakly evocative" USs were in fact still too high in absolute evocativeness. For these reasons, we conducted a second experiment that made use of more differentiated US sets and manipulated US evocativeness within-participants.

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. The data from the experiment as well as from the pilot study for the selection of the USs are publicly available on Open Science Framework (osf.io/6bjvy).

Method

Participants

One hundred and seventy-eight subjects participated in this experiment. Twenty-four were excluded because they failed the memory-training task three times in a row. The final sample was therefore composed of 154 participants ($M_{age} = 20.64$; $SD_{age} = 2.94$; 139 female).[3]

Design and procedure

Design and procedure were identical to the first experiment with the only exception that the US evocativeness manipulation was performed within-participants and that only the mildest half of the low-evocativeness and the strongest half of the high-evocativeness USs were kept in the EC procedure. Hence, each participant was exposed to the same number of CS-US pairs as in the first experiment (i.e. 192 pairings).

We selected 25 USs per category (valence × evocativeness) resulting in 100 USs (all coming from the *International Affective Picture System*, IAPS, Lang et al., 1999, see Appendix). The stimuli of low and high evocativeness differed both in (absolute value) ratings, $F(1,98) = 83.53$, $p < .001$, $\eta_p^2 = .46$, and in the amount of time needed to categorise them as positive or negative, $F(1,98) = 125.36$, $p < .001$, $\eta_p^2 = .56$. They differed neither in categorisation accuracy nor in arousal ($Fs < 1$). As compared to Experiment 1, the stimuli of low and high evocativeness now differed strongly in valence ($\eta_p^2 = .46$), while the effect on the categorisation measure remained strong ($\eta_p^2 = .56$).

A 2 (time of evaluative rating: before versus after conditioning) × 2 (US valence: positive versus negative) × 2 (US evocativeness: low versus high) × 2 (memory instruction: inclusion versus exclusion) mixed design was implemented with repeated measures on the first three factors.[4]

Results

Evaluative ratings

Evaluative ratings of the CSs were submitted to a 2 (US valence) by 2 (time of measurement) by 2 (US evocativeness) repeated-measures ANOVA. This analysis revealed a significant EC effect, as shown by a significant interaction between US valence and time of measurement, $F(1, 153) = 86.68$, $p < .001$, $\eta_p^2 = .36$. The three-way interaction between US valence, time of measurement, and evocativeness was statistically significant, $F(1, 153) = 5.16$, $p = .025$, $\eta_p^2 = .03$.

However, the effect size of the interaction was small and the analyses on the level of the two evocativeness conditions demonstrated significant EC effects which were comparable in size in both the high evocativeness condition, $F(1, 153) = 70.58$, $p < .001$, $\eta_p^2 = .32$, and the low evocativeness condition, $F(1,153) = 59.25$, $p < .001$, $\eta_p^2 = .28$. The full pattern of means is reported in Table 2.

Memory task

We used the same adapted MPT model as in Experiment 1 to model the frequency data obtained (see Table 3). As in the last experiment, the parameter *a* could not be fixed at zero, $\Delta G^2(1) = 8.39$, $p = .002$. Thus, the hypothesis that memory-independent EC was absent must be rejected. To assess whether memory-independent EC was affected by US evocativeness, we tested whether the parameter *f* ($f = .27$, 95% *CI* [0, 1]), could be fixed at 1 without reducing goodness of fit. This was indeed the case, $\Delta G^2(1) = 1.74$, $p = .19$, so that the null hypothesis stating that memory-independent EC is not affected by US evocativeness could be retained ($a_{\text{low}} = .09$, 95% *CI* [.03, .15]; $a_{\text{high}} = .03$, 95% *CI* [.00, .10]).

The memory-independent EC parameter had an effect size of $w = .05$ (i.e. $a > 0$), and given our sample size ($N = 154$) and the level of explicit memory, the present study was sufficiently sensitive to detect effects of this magnitude with alpha = .05 and power = .83. In contrast, the effect of US evocativeness on memory-independent EC was much smaller, $w = .02$. Detecting such a small effect in the present design with alpha = .05 and power = .80 would have required 16,630 observations, which is equivalent to 693 participants. Thus, again we cannot exclude the possibility of very small effects of US evocativeness on memory-independent EC.

However, in this study, we obtained evidence that the lack of an effect on the a-parameter cannot be explained by a weak or unsuccessful manipulation of US evocativeness as its effectiveness was ensured by careful pretesting. Moreover, the evocativeness manipulation affected explicit memory for US valence (i.e. the *m*-parameter). For positively paired CSs, the *m*-parameter was larger for the high-evocativeness condition, $m_{\text{high\_pos}} = .36$, 95% *CI* [.30, .42], than the low-evocativeness condition, $m_{\text{low\_pos}} = .25$, 95% CI [.19, .31], $\Delta G^2(1) = 6.22$, $p = .01$. The estimates for the low-, $m_{\text{low\_neg}} = .35$, 95% CI [.29, .41], and high-evocativeness conditions, $m_{\text{high\_neg}} = .51$, 95% *CI* [.03, .15], also differed for negatively paired CSs, $\Delta G^2(1) = 14.01$, $p = .0002$. Within both the low-, $\Delta G^2(1) = 5.34$, $p = .02$, and high-evocativeness conditions, $\Delta G^2(1) = 12.69$, $p = .0004$, memory parameters were larger for CSs− than for CSs+. In Experiment 2, the *r*-parameters for the low-, $r_{\text{low}} = .53$, 95% *CI* [.49, .56], and high-evocativeness conditions, $r_{\text{high}} = .53$, 95% *CI* [.49, .57], were equal in size, $\Delta G^2(1) = 0.01$, $p = .92$.

Discussion

In this second experiment, we strengthened the US evocativeness manipulation by selecting the most differentiated USs from Experiment 1 and by relying on a within-participant manipulation. We observed that the evocativeness manipulation affected explicit memory for the CS-US contiguity (the *m*-parameter): CS-US pairs with intensely evocative USs were better remembered than CS-US pairs with mildly evocative USs. Finally, we again observed that although the *a*-parameter was overall significantly different from zero, it was not affected by the evocativeness manipulation.

Although the null hypothesis (that there is no difference in the magnitude of the *a*-parameter due to the evocativeness manipulation) was not rejected, at this point we cannot conclude it has to be accepted. In the following section, we report a meta-analysis on the two experiments reported here as well as previously published experiments using a similar EC procedure that reported an estimate of the *a*-parameter. We did so to determine the statistical heterogeneity[5] (see Higgins & Thompson, 2002) between experiments and so to examine whether the variation between the *a*-parameters obtained in the experiments reported here is above the variation that can be expected from sampling error.

Meta-analysis

The present analysis includes all published experiments in which an estimate of the *a*-parameter was obtained and in which the material as well as the EC procedure was comparable. The criteria for the material were: (i) black-and-white human faces as CSs, and (ii) IAPS pictures as USs. The criteria for the EC procedure were: (i) simultaneous pairing of the CS-US pairs, and (ii) CSs paired with USs that shared the valence but differed in identity (i.e. "one-to-many" pairings). Eight published data sets met these criteria. Three data sets were from the original paper by Hütter et al. (2012; Experiments 2a, 2b and 3), three were comprised by the control conditions from Mierop et al. (2017), one consisted of the "simultaneous pairings" condition from Hütter and Sweldens (2013), and one consisted of the "experienced pairings" condition from Hütter and De Houwer (2017).

We conducted a meta-analysis (see Figure 1) on the estimates of the *a*-parameters and their precision (i.e. confidence intervals) using RStudio (RStudio Team, 2015) and the "meta" package (Schwarzer, 2007). By doing so, we were able to approximate the overall magnitude of the *a*-parameter and, perhaps more important for our current purpose, the degree of heterogeneity between experiments. If the estimates of the *a*-parameters obtained in our experiments fall into the distribution of the *a*-parameters from the referent experiments and do not increase the heterogeneity, we might conclude that different evocativeness conditions should not be thought of as influencing the size of the *a*-parameter. By contrast, if they do increase the heterogeneity between experiments, then differences should not be seen as resulting from chance. The R script for the meta-analysis is publicly available via the Open Science Framework (osf.io/6bjvy).

The random effects analysis revealed a mean *a*-parameter of $a = .07$, 95% *CI* [.04, .11]. The experiments also had substantial heterogeneity ($I^2 = 56\%$), indicating that 56% of total variation in the estimates of the *a*-parameter is due to heterogeneity between experiments rather than chance (Higgins & Thompson, 2002).

Interestingly, the heterogeneity between the experiments was lower when we included the estimates from the two experiments reported here ($I^2 = 56\%$) than when the present experiments were excluded from the meta-analysis ($I^2 = 68\%$). This reduction in heterogeneity implies that the present data fail to provide evidence for assuming that evocativeness has a noticeable effect.

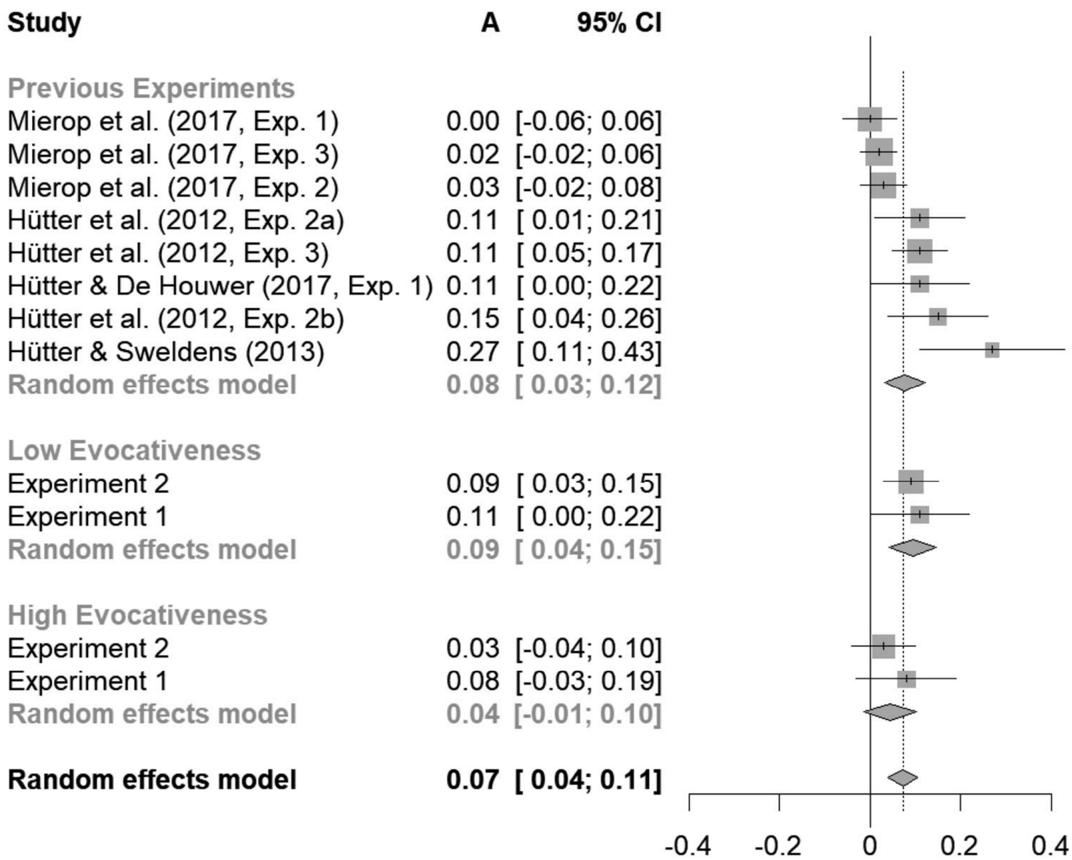

Figure 1. Forest plot depicting the *a*-parameter estimates as well as their respective uncertainties. The estimates are displayed separately for the original/published experiments (top), the low evocativeness conditions (middle), and the high evocativeness (bottom) conditions observed in the two experiments reported here. As can be seen, the low and high evocativeness conditions show values that fall in the middle of the distribution of estimates.

General discussion

To test the hypothesis that memory-independent EC, as measured by the multinomial model, reflects implicit misattribution, we investigated whether it is affected by US evocativeness (Jones et al., 2009). In two high-powered studies, which relied (i) on between and within-participants manipulations of US evocativeness, (ii) on procedures, materials and analyses closely similar to Hütter et al. (2012), and (iii) on various levels of US evocativeness (mild to strong in Exp. 1, and even milder to even stronger in Exp. 2), we consistently found evidence for a memory-independent EC effect (as reflected by the *a*-parameter) that was not moderated by US evocativeness. In a meta-analysis, we observed that adding the estimates of the *a*-parameters from the experiments reported here to those from comparable published experiments does not increase the statistical heterogeneity between experiments. We therefore conclude that US evocativeness does not impact the magnitude of the *a*-parameter, at least under conditions observed here, which are thought to facilitate implicit learning effects.

This lack of support for the IM account is unlikely due to an insufficiently effective manipulation of US evocativeness, as this manipulation (i) was duly pretested on evaluative ratings and response times in Experiment 1 and 2, (ii) was further strengthened in Experiment 2, and (iii) impacted the explicit memory parameter *m* in Experiment 2, thereby replicating the effects on the memory measure reported by Jones et al. (2009).

The absence of an effect on the *a*-parameter may be interpreted in at least four different ways: (i) the *a*-parameter may not reflect IM-driven EC, (ii) IM may play no role in the EC paradigm considered in the present studies, (iii) IM in the specific paradigm implemented here may be insensitive to evocativeness effects, (iv) evocativeness does not influence the likelihood of IM counter to what has been claimed by Jones et al. (2009). In the remainder of this discussion, we elaborate on why answers to these questions are central to current theorising in attitude formation and point to important directions for future research.

Whereas experimental studies that decreased participants' ability to encode CS-US pairings in explicit memory found little evidence for memory-independent attitude formation in EC, processing tree studies have supported the view that attitudes may be acquired independently of explicit memory for the CS-US pairings. The fact that an EC effect on the *a*-parameter was observed only in simultaneous (but not sequential) CS-US settings also seemed consistent with the notion that this parameter captures the operation of an IM process. According to the IM account, people sometimes end up attributing the affective response elicited by the US to the CS. This typically happens when CS and US are presented simultaneously (Jones et al., 2009). Evidence for a significant *a*-parameter in simultaneous but not in sequential CS-US pairing settings (Hütter & Sweldens, 2013) has been considered strong evidence for the existence of dual-attitude learning (e.g. Sweldens et al., 2014). As discussed in the introduction, however, the manipulation of temporal contiguity does not allow assessing the discriminant validity of the *a*-parameter (see also Corneille & Stahl, 2017). Consistent with this observation, the present two experiments manipulated US evocativeness, but did not find evidence for the sensitivity of the *a*-parameter to the latter factor, which is considered another critical moderator of the IM process.

In recent research that crossed the processing tree approach with a cognitive load manipulation at encoding, Mierop et al. (2017) expected and found the explicit *m*-parameter to be largely sensitive to the load manipulation, but failed to obtain evidence for an EC effect on the memory-independent *a*-parameter. The present research replicates earlier evidence for the existence of EC effects on the memory-independent parameter. Along with Mierop et al. (2017), it also reveals that the *m*- and *a*-parameters are differently sensitive to encoding manipulations, which further validates the view that these parameters reflect independent contributions to EC. Yet, it must be noted that the *a*-parameter is often weak and, perhaps even more critically, that it remains difficult to interpret. This state of affairs is further supported by recent studies showing that EC effects on the *a*-parameter are observed in instruction-based EC (i.e. in the absence of actual CS-US pairings), and that they vary as a function of manipulations implemented at retrieval (Hütter & De Houwer, 2017). Hence, the *a*-parameter does not entirely reflect processes occurring at the learning stage. To the extent that it does, we believe it is unlikely to reflect IM based on the present empirical evidence.

Therefore, more research is needed on the conditions under which this parameter is observed and on the processes that may produce it. Importantly, such research should not only focus on the memory-dependency and awareness of learning, but also on other operating conditions and operating principles. Operating conditions refer to features of automaticity, which are manifold and include processing characteristics such as controllability and intentionality (Bargh, 1994; Moors & De Houwer, 2006). These features have played only a minor role in EC research and might even prove more conclusive with regard to the dual-process view (Hütter & Sweldens, in press).

Operating principles refer to the exact nature and the situational constraints of a cognitive process. However, only few theories of evaluative conditioning specify the operating principles of cognitive processes. The IM account by Jones and colleagues (2009, 2010) constitutes a prime example for the concrete conceptualisation of a process and its operating principles. Specifically, the IM process is conceptualised to depend on source confusion that is instigated by situational factors such as temporal contiguity of CS and US, US evocativeness, and frequent eye-gaze shifting. Only such clearly specified theories allow for stringent tests of their influence on evaluative learning as performed in the present line of research. Moreover, investigating operating principles might be most informative in identifying the cognitive process (es) contributing to the EC effect in a specific situation as they allow for the strongest tests of discriminant validity. We thus conclude that more such conceptually driven research is needed to advance our understanding of the role of implicit learning processes in the evaluative conditioning paradigm, which is usually considered offering the best support for theorising on dual-learning of attitudes.

Notes

1. Note that the null hypothesis of this test ($a = 0$), is on the boundary of the parameter space (a being a probability cannot be negative). Therefore, the appropriate reference distribution is an equal mixture of a chi-square distribution with zero degrees of freedom and one with one degree of freedom (Self & Liang, 1987). The *p*-values reported are based on this distribution.
2. Cohen's *w* is an estimate of the size of an effect for associations among categorical variables. Cohen's rule of thumb for w is that $w = .1$ indicates a "small" effect size, $w = .3$ a "medium" effect size and $w = .5$ a "large" effect size.
3. We initially collected data of 83 participants. We collected a second batch of 95 data sets to increase the power of our study. Data collection, however, was not contingent on the "favorableness" of the results.
4. In the exclusion condition, we instructed participants to reverse their memory-based responses and we trained participants to follow these instructions during a practice phase. However, upon the first completion of the memory task, it turned out that the software mistakenly instructed participants to reverse their attitude-based responses. Because all data were collected over two days of scheduled sessions, the experimenter provided oral instructions to participants in this condition about the programming error and further asked each participant after the session which of their responses they reversed. All participants reported to have reversed their memory-based responses. The first data set was discarded and replaced by a new participant.
5. "Statistical heterogeneity exists when the true effects being evaluated differ between studies, and may be detectable if the variation between the results of the studies is above that expected by chance." (Higgins & Thompson, 2002, p. 1539).

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ORCID

Christoph Stahl http://orcid.org/0000-0002-9033-894X

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Appendix

IAPS Numeric Labels of the US Pictures

USs −		USs +	
Mild	Intense	Mild	Intense
1080, 1090, 1110, 2399, 2682, 2691, **2750**, **2900(1)**, 3022, **3220**, 5971, 6010, 6020, **6200**, 6210, 6211, **6213**, **6230**, 6241, **6242**, **6243**, 6244, **6311**, **6312**, **6135**, **6370**, 6410, **6530**, **6570 (1)**, **9000**, 9001, 9010, 9080, 9110, 9120, **9280**, **9340**, 9341, **9342**, **9421**, 9440, 9472, 9530, **9600**, **9620**, **9830**, **9910**, **9911**, 9913, **9920**	**1019**, **1030**, 1274, **1302**, **1932**, 2095, 2141, **2220**, **2681**, 2683, **2690**, **2692**, **2694**, 2715, **2722**, **2780**, **2810**, **3280**, 3500, 3530, 3550(1), **5120**, **5130**, **5970**, **5972**, **6000**, **6190**, 6212, 6360, 6561, **6836**, 6838, 9041, 9050, **9090**, 9220, **9230**, **9390**, 9452, 9470, 9471, 9495, 9520, 9611, 9621, 9622, 9630, 9635, **9700**, **9912**	1450, **1460**, 1603, 1722, **1731**, **1999**, **2071**, **2224**, **2304**, **2345**, **2370**, **2387**, **2388**, 2501, 2655, 2791, 2900(2), 4531, 4536, **4599**, 4601, **4614**, 4625, **4626**, **5551**, **5600**, **5621**, **5623**, 5731, **5779**, **5830**, 5870, 5875, 5890, **5891**, 5994, 7282, 7283, 7325, **7350**, 7351, 7360, **7580**, 8031, 8032, **8120**, **8200**, 8280, **8350**, 9531	**1121**, **1333**, 1340, 1500, 1510, **1560**, 1660, 1900, **1942**, 2299, **2320**, 2344, 2391, **2435**, **2616**, **2620**, **2635**, 2650, **4537**, **4571**, 4653, **5250**, 5260, 5270 **5390**, 5611, **5622**, 5628, **5661**, **5740**, **5900**, 7250, 7270, **7286**, **7352**, 7430, 7470, **7510**, 7545, 7570, **7600**, **7820**, 8170, **8191**, 8193, 8300, **8311**, **8320**, 8497, 8500

Note: IAPS = International Affective Picture System; USs = unconditioned stimuli. USs used in Experiment 2 are in bold font.