

Resource availability and explicit memory largely determine evaluative conditioning effects in a paradigm claimed to be conducive to implicit attitude acquisition

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Keywords: evaluative conditioning, evaluative learning, multinomial processing tree models, automaticity

WORD COUNT: 4,995

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DECLARATION OF CONFLICT OF INTEREST:

The author(s) declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

FUNDING:

The author(s) disclosed receipt of the following financial support for the research and/or authorship of this article: Fonds de la Recherche Scientifique-FNRS under Grant(s) n° 1.A802.15F and German Research Foundation under grant HU 1978/4-1.

Abstract

In three experiments, we investigated how preventing the explicit encoding of CS-US pairings by imposing a secondary task at learning influences evaluative conditioning (EC) effects in a paradigm claimed to be conducive to implicit EC. We additionally used a multinomial processing tree model additionally to examine how the resource depletion manipulation affects explicit and implicit memory contributions to EC. In all experiments, the EC effect largely vanished when a secondary task was employed that severely reduced participants' explicit memory for the CS-US pairings. Furthermore, no evidence obtained for an implicit memory contribution to EC effects. In conclusion, the present research yields evidence for explicit learning, but no support for the contribution of implicit processes to EC, in a paradigm claimed to facilitate implicit EC.

Keywords: evaluative conditioning, evaluative learning, multinomial processing tree models, automaticity

Evaluative conditioning (EC) consists of an evaluative change in a conditioned stimulus (CS) following its pairing with an unconditioned stimulus (US; De Houwer, 2007). In attitude research, EC is classically viewed as a strong case for implicit evaluative learning (Gawronski & Bodenhausen, 2006, 2009). Recent evidence, however, questions the possibility of attitude formation independent of participants' explicit encoding of CS-US pairings in memory. For instance, both explicit memory for pairings and EC effects are reduced to non-significance when imposing a secondary task at learning (e.g., Pleyers, Corneille, Luminet, & Yzerbyt, 2009). Likewise, the EC effect does not emerge when CSs are presented at near-chance identification thresholds (Stahl, Haaf, & Corneille, 2016) or in parafoveal areas of the perceptual field (Dedonder, Corneille, Bertinchamps, & Yzerbyt, 2013).

Other evidence suggests, however, that *specific* CS-US pairing procedures may elicit implicit EC effects (Sweldens, Van Osselaer, & Janiszewski, 2010). Specifically, Hütter and Sweldens (2013; Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012) demonstrated implicit EC effects in a paradigm relying on *simultaneous* pairings involving *various* USs paired with a given CS. In such settings, the affect elicited by the processing of the US may be misattributed implicitly (without explicit memory for the pairings; Jones, Fazio & Olson, 2009) to the CS. In turn, this may produce an EC effect independently of the explicit encoding of the pairings in memory.

The present research seeks to advance our understanding of the scope of implicit EC effects by preventing an explicit encoding of the pairings in the paradigm developed by Hütter and Sweldens. This was achieved by imposing a depleting secondary task at learning. This approach conforms to recent recommendations to manipulate awareness at encoding instead of correlating the EC effect with awareness measures possibly influenced by retrieval-related effects (Gawronski & Walther, 2012).

Relying on evaluative ratings alone, however, is inconclusive for several reasons. First, the absence of residual EC effects under resource depletion conditions may be due to a lack of power. Second, the presence of residual EC effects may be attributed to the insufficiency of the secondary task (Fiedler & Hütter, 2014). Furthermore, residual EC effects under resource depletion may be attributed either to explicit or implicit processes (or both).

The multinomial processing tree (MPT) approach introduced by Hütter et al. (2012) is well-suited to examine the latter questions. This approach, based on the process dissociation procedure developed by Jacoby (1991), is tailored to a memory task and allows dissociating explicit (recollection of the pairings: the m -parameter) and implicit (acquired evaluations without explicit memory of the pairings: the a -parameter) memory. Hütter and Sweldens (2013) observed evidence for both a - and m -parameters using simultaneous pairings, whereas the a -parameter was not significant when using sequential pairings.

The latter evidence supports the view that some CS-US pairing procedures may be conducive to implicit EC effects. Unfortunately, little evidence exists to date regarding its sensitivity to resource depletion at encoding. Consistent with Jacoby's classic demonstration (e.g., Jacoby, Toth & Yonelinas, 1993), explicit memory, but not implicit memory, should decrease when participants' resources are taxed at encoding. The latter pattern would support the claim that MPT parameters can be interpreted as indicators of qualitatively different processes operating *during* learning despite being assessed *after* learning (Gawronski & Walther, 2012).

Halbeisen and Walther (2015) presented a first study that combined the MPT approach with a resource depletion manipulation. Unfortunately, their results do not inform our current research question for several reasons. First, Halbeisen and Walther (2015) compared the effect of different types of resource depletion instead of comparing the effect of taxing resources per se. That is, while different types of secondary tasks might differ in the degree of

interference as shown by Halbeisen and Walther (2015), all types may reduce both explicit and implicit learning, one of these mechanisms, or none when compared to a control condition. Second, although Halbeisen and Walther (2015) used simultaneous pairings, each CS was repeatedly paired with a single US. As discussed above, this pairing procedure may prevent implicit EC because one of the two conditions for implicit EC was not met. Finally, the MPT model was based on only a small number of observations, challenging the reliability of their results.

In conclusion, a test of the role of resource depletion in an EC paradigm claimed to be conducive to an implicit EC effect is still lacking. Investigating the impact of resource depletion on EC effects in combination with the MPT approach allows addressing several questions of importance: (1) Is the EC effect reduced by resource depletion in a paradigm assumed to be conducive to implicit EC effects? (2) Does resource depletion decrease the m -parameter, supporting the notion that m reflects explicit encoding of CS-US pairings? (3) Does resource depletion fail to influence the a -parameter, supporting the view that a reflects implicit memory processes, which are known to arise independently of resource availability at encoding (Jacoby, 1991; Sweldens et al., 2010)? (4) Does any significant residual EC effect under resource depletion more likely reflect the role of implicit or explicit memory? A significant a -parameter in combination with a non-significant m -parameter would support the notion that EC may be observed in the absence of explicit encoding of the CS-US pairings in memory.

Overview of Experiments

The experiments relied on a common procedure. Participants pre-rated the CSs before they were exposed to pairings involving either negative USs (of multiple identities) or positive USs (of multiple identities). Between participants, resources at learning were either

taxed or not. After the learning phase, participants completed the memory task tailored to the MPT approach, and only then the evaluative post-ratings that allowed for the analysis of EC.

Following Hütter and colleagues (2012), the memory task had participants report whether a given CS was paired with pleasant or unpleasant USs. Specifically, they were instructed to respond “pleasant” (“unpleasant”) if they remembered a CS was paired with positive (negative) USs. A distinct property of this task is that participants are requested to answer the memory task by drawing on their attitude toward the CS when they lack explicit memory of the pairing. That is, they select “pleasant” (“unpleasant”) for liked (disliked) CSs. In this *inclusion* condition, explicit and implicit memory lead to the same response and thus cannot be separated.

In order to dissociate explicit and implicit memory, Hütter et al. (2012) created *exclusion* conditions that reverse the responses based on one of the aforementioned processes so that explicit and implicit memory now lead to different responses. The exclusion instructions varied between experiments. In Experiments 1 and 2, participants reversed responses based on their evaluation of the CSs. In the absence of memory for the pairings, they were asked to respond “unpleasant” (“pleasant”) if they evaluated the CS *positively* (negatively). In Experiment 3, participants reversed memory-based responses, that is, they were asked to respond “unpleasant” (“pleasant”) if they remembered that the CS was paired with *positive (negative) USs*. In the absence of pairing memory, they were asked to simply report their evaluation of the CS.

The estimation of the *m*- and *a*-parameters involves comparing the frequencies of the “pleasant” and “unpleasant” responses between the inclusion and exclusion conditions. The processing trees for the attitude-exclusion and the memory-exclusion implementations are depicted in Figures 1 and 2, respectively. The variation of exclusion instructions between experiments established discriminant validity of the MPT parameters.

Effect size and statistical power

On the basis of the resource depletion effect size on EC effects (i.e., $\eta_p^2=0.11$) reported by Pleyers and colleagues (2009), using a two-tailed mixed ANOVA test with $\alpha=\beta=.05$, a sample of 62 participants is required to achieve high statistical power ($1-\beta=.95$). We systematically collected larger samples in the present experiments to accommodate for potential data loss (e.g., as we excluded participants who failed the practice trials of the MPT task). More specifically, for each experiment, we decided to collect data of at least 100 participants and ran sessions up to the day this goal was reached.

The MPT model analyses were based on 1800 (Exp.1), 2256 (Exp.2), and 2760 (Exp.3) observations, that is, 24 CSs per participant. As a rule of thumb for sufficient power, Klauer, Stahl, and Voss (2011) suggested that not more than 10% of the expected category counts should be below five. With the present sample size, the smallest expected category counts amount to 74 (Exp.1), 74 (Exp.2), and 97 (Exp.3).

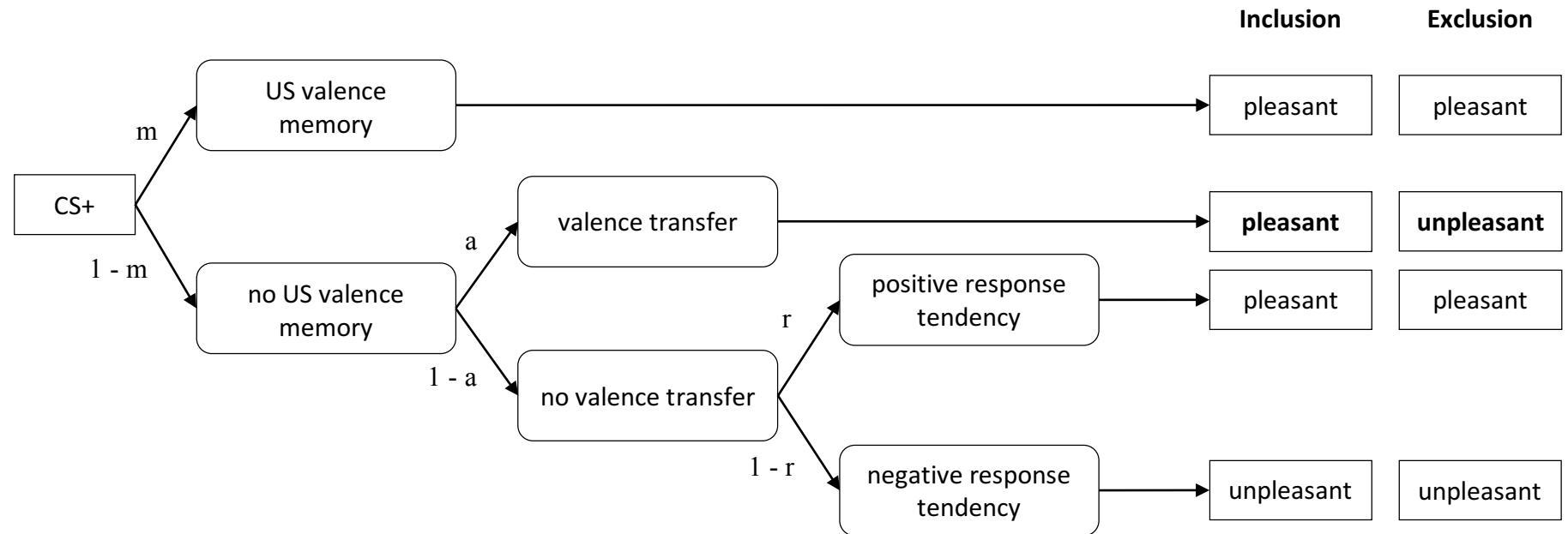


Figure 1. Processing tree model of performance in the memory task in the attitude-exclusion implementation of the MPT model. The rectangle on the left denotes the stimulus. The branches of the processing tree represent the combination of cognitive processes postulated by the model. m = probability of remembering the valence of the US; a = probability of relying on CS attitude given memory failure; r = response tendency towards “pleasant” when neither memory nor attitude are available.

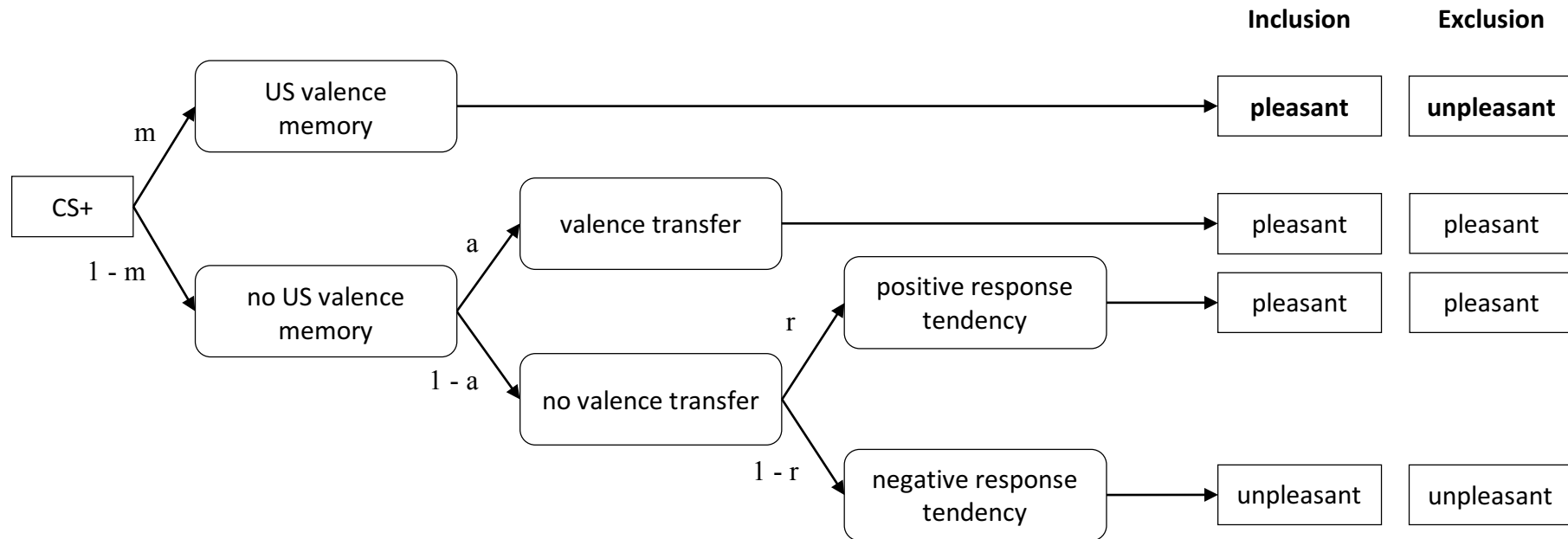


Figure 2. Processing tree model of performance in the memory task in the memory-exclusion implementation of the MPT model. The rectangle on the left denotes the stimulus. The branches of the processing tree represent the combination of cognitive processes postulated by the model. m = probability of remembering the valence of the US; a = probability of relying on CS attitude given memory failure; r = response tendency towards “pleasant” when neither memory nor attitude are available.

Experiment 1

Experiment 1 provides a first examination of the role of explicit encoding in a paradigm claimed to be conducive to implicit EC effects (Hütter et al., 2012, 2013; Sweldens et al., 2010). We relied on an auditory 2-back task for the resource depletion manipulation in order to reduce interferences with the visual processing of the pairings (Dedonder et al., 2010; Pleyers et al., 2009) and examined the influence of the resource manipulation on the *m*- and *a*-parameters of the MPT model.

Method

Participants. Of 100 undergraduate participants, 9 were excluded for technical reasons, 15 were excluded because they failed the memory-training task. The final sample consisted of 76 participants ($M_{\text{age}}=21.28$; $SD_{\text{age}}=5.13$; 70 females).

Design. A 2 (time of evaluative rating: before versus after conditioning) $\times$ 2 (US valence: positive versus negative) $\times$ 2 (Resource depletion: secondary task versus control) $\times$ 2 (memory instruction: inclusion versus exclusion) mixed design was implemented with repeated measures on the first three factors.

Materials and Procedure. The procedure combined the conditioning procedure by Hütter et al. (2012) with the distraction task used by Pleyers et al. (2009). Specifically, participants first rated 102 black-and-white portraits in a random order on a scale ranging from “unpleasant” (-100) to “pleasant” (100). Of these portraits, the 24 most neutral ones were selected as CSs. Randomly we assigned 12 CSs to positive and 12 CSs to negative US valence. During the conditioning phase, CSs were consecutively paired in a random order (though a given CS was never paired twice in a row) with eight different USs of their assigned valence, amounting to 192 pairings in total. Each picture pair was presented simultaneously for 2000ms. The inter-stimulus interval between pairs was 100ms.

The US set consisted of 50 pleasant and 50 unpleasant pictures from the IAPS (Lang, Bradley, & Cuthbert, 1999). The pleasant pictures were more positive than the unpleasant ones, $t(98) = 60.77, p < .001$. They did not differ in terms of arousal, $t(98) = -.02, p = .98$, but differed in dominance, $t(98) = 19.66, p < .001$. At the participant level, each USs was therefore presented up to twice.

During the conditioning phase, all participants wore headphones in which either neutral music (control condition) or randomly generated numbers from 1 to 9 (secondary task condition) were played. In the control condition, participants were informed that music would be played, whereas in the secondary task condition, participants were instructed to press the space bar each time they heard the same number twice intercalated by a different one (i.e., 2-back task, see Pleyers et al., 2009).

After the conditioning phase, the memory task was administered in the attitude-exclusion version described above (see Hütter et al., 2012, for a more extensive description of the procedure). An MPT model (Batchelder & Riefer, 1999) was applied to the memory task to estimate an explicit memory parameter (m -parameter), an implicit memory parameter (a -parameter), as well as a response tendency parameter (r -parameter) as displayed in Figure 1.

Before the actual trials started, participants were presented with eight hypothetical scenarios to probe for their comprehension of the instructions. If participants made an error, instructions were repeated up to two times. If participants still made errors in the third round, they were excluded from analysis.

Finally, evaluative ratings of the 24 CSs were collected a second time. After the completion of the experiment, participants were debriefed, thanked, and dismissed. No additional measures were collected.

Table 1. Mean evaluative ratings (and standard deviations) of CSs as a function of time of measurement, US valence, and resource depletion for Experiments 1, 2, and 3.

		Pre-ratings		Post-ratings	
		CSs-	CSs+	CSs-	CSs+
Experiment 1					
Control		104.00 (6.03)	103.68 (5.86)	104.83 (14.78)	113.26 (12.69)
Secondary Task		106.38 (9.69)	105.78 (10.68)	106.01 (17.87)	107.86 (16.86)
Experiment 2					
Control		102.43 (6.32)	102.71 (6.44)	97.20 (18.26)	108.71 (14.25)
Secondary Task		101.64 (4.25)	103.01 (3.84)	98.16 (14.58)	104.56 (11.27)
Experiment 3					
Control		103.78 (6.63)	102.32 (6.38)	101.86 (6.63)	112.86 (13.47)
Secondary Task		103.78 (7.77)	103.72 (7.00)	103.58 (13.72)	105.34 (13.08)

Note. US = Unconditioned stimulus; CSs = Conditioned stimuli.

Results

Evaluative Ratings. CS ratings were submitted to a 2 (US valence) by 2 (time of measurement) by 2 (Resource depletion) General Linear Model (GLM), with repeated measures on the first two factors¹. This analysis revealed a significant EC effect (see Table 1 and Figure 3), as indicated by a significant interaction between US valence and time of measurement, $F(1,74) = 13.09, p < .001, \eta_p^2 = .15$, 90% Confidence Interval (*CI*) [.05, .27], observed power = .95.² Importantly, the three-way interaction between US valence, time of measurement, and resource depletion was significant, $F(1,74) = 4.16, p < .05, \eta_p^2 = .05$, 90% *CI* [.00, .15], observed power = .52. Decomposition of this interaction by resource depletion condition revealed a significant EC effect in the control condition $F(1,41) = 14.14, p < .001$,

$\eta_p^2 = .26$, 90% *CI* [.08, .41], observed power = .96, but not in the resource depletion condition

$F(1,33) = 1.68$, $p = .20$, $\eta_p^2 = .05$, 90% *CI* [.00, .20], observed power = .24.

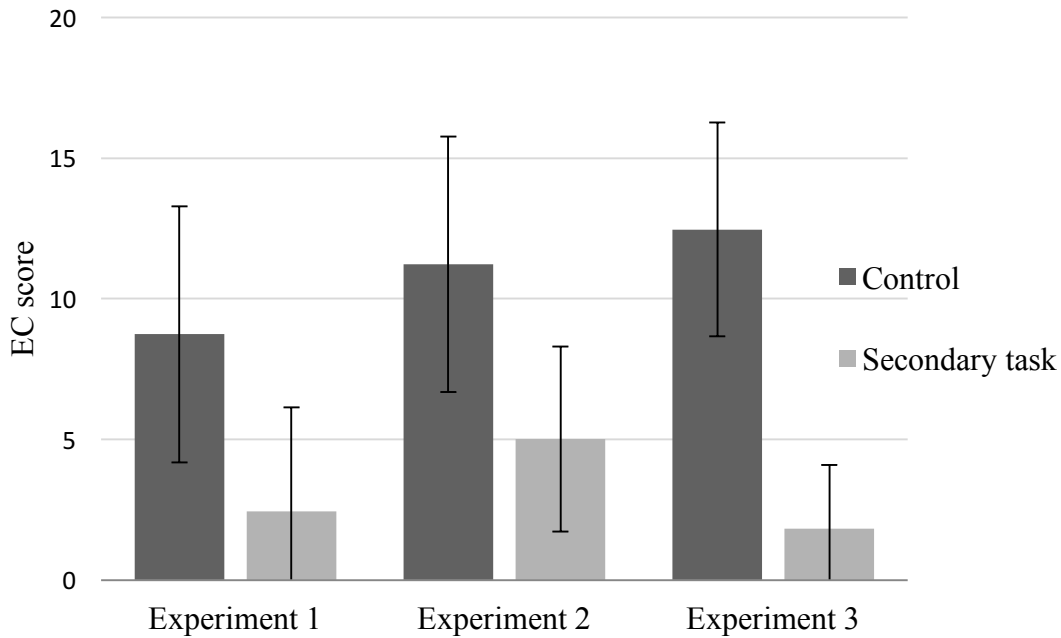


Figure 3. Mean EC effect (and 95% CIs) as a function of resource depletion (resource depletion) for Experiments 1, 2, and 3. EC score = $(CSS_{+post} - CSS_{+pre}) + (CSS_{-pre} - CSS_{-post})$.

MPT Model. The initial model contained three parameters per resource depletion condition as presented in Figure 4, $G^2(2) = 13.06$, $p < .01$. We compared the parameters across resource depletion conditions by setting them equal and observing the impact on model fit. The m -parameter was significantly smaller in the secondary task condition as compared to the control condition, $\Delta G^2(1) = 56.99$, $p < .001$. In contrast, the a -parameters, $\Delta G^2(1) = 0.00$, $p = .99$, and r -parameters, $\Delta G^2(1) = 1.64$, $p = .20$, could be set equal across conditions without loss in model fit. The final model contained two m -parameters (control: $m = .37$, 95% *CI* [.31, .43], resource depletion: $m = .02$, 95% *CI* [.00, .09]), one a -parameter ($a = .00$, 95% *CI* [.00, .06]) that did not differ from zero, $\Delta G^2(1) = 0.00$, $p = .50$,³ and one r -parameter ($r = .49$, 95% *CI* [.46, .51]) indicating no deviation from chance level (.50). However, the model had

insufficient fit, $G^2(4) = 14.70$, $p < .01$, so that the present results should be interpreted with caution.

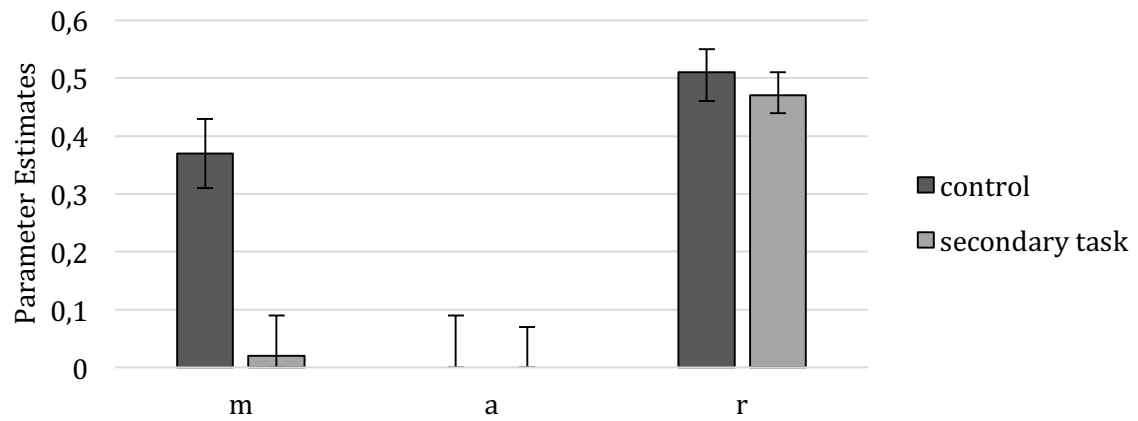
Discussion

Experiment 1 indicates that both EC and m are largely dependent on resource availability, whereas no evidence is found for implicit EC. Because the MPT model did not demonstrate good fit to the data, we realized an even closer replication of Hütter and Sweldens' (2013) original paradigm in Experiment 2.

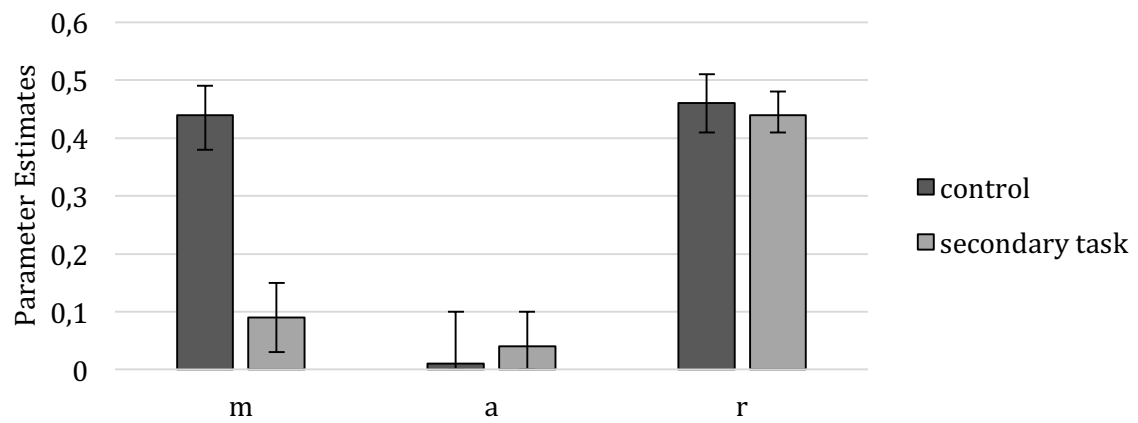
Experiment 2

Experiment 2 implemented a slight modification in the control condition. In Experiment 1, participants wore headphones and listened to neutral music whereas they did not in Hütter and colleagues' (2012, 2013) studies. Hence, Experiment 2 removed the music (and headphones) in the control condition.

a) Experiment 1



b) Experiment 2



c) Experiment 3

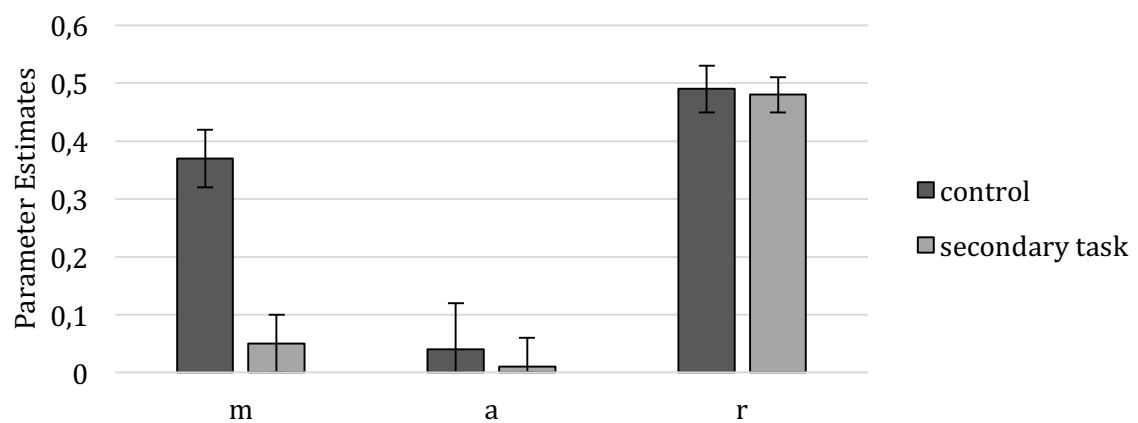


Figure 4. Estimates of the MPT model's m -, a -, and r -parameters. Error bars show the 95% confidence intervals of the parameter estimates.

Method

Participants. We recruited 101 undergraduate students. Fifteen were excluded because they failed to answer correctly in the practice phase. The final sample consisted of 86 participants ($M_{\text{age}}=20.79$; $SD_{\text{age}}=2.51$; 77 females).

Design, Material, and Procedure. The design, material, and procedure of Experiment 2 were the same as in Experiment 1, with the exception that participants in the control condition did not listen to music during the conditioning phase.

Results

Evaluative Ratings. CS ratings (see Table 1 and Figure 3) were submitted to a 2 (US valence) by 2 (time of measurement) by 2 (Resource depletion) GLM, with repeated measures on the first and second factors. We again observed a strong EC effect, as shown by the significant interaction between US valence and time of measurement, $F(1,84) = 31.27, p < .001, \eta_p^2 = .27, 90\% CI [.15, .39]$, observed power = .99, that was moderated by the resource depletion, $F(1,84) = 4.57, p < .05, \eta_p^2 = .05, 90\% CI [.00, .14]$, observed power = .56. The EC effect in the resource depletion condition, $F(1,40) = 8.94, p < .01, \eta_p^2 = .18, 90\% CI [.04, .35]$, observed power = .83, was much smaller than in the control condition, $F(1,44) = 23.57, p < .001, \eta_p^2 = .35, 90\% CI [.16, .49]$, observed power = .99, although it was significant in both conditions.

MPT Model. We fitted the model with three parameters per resource depletion condition as presented in Figure 4, $G^2(2) = 2.20, p = .33$. The m -parameter was significantly reduced by the secondary task, $\Delta G^2(1) = 74.14, p < .001$. The a -parameters, $\Delta G^2(1) = 0.18, p = .67$, and r -parameters, $\Delta G^2(1) = 0.01, p = .92$, could be set equal without loss in model fit. The final model contained two m -parameters (control: $m = .44, 95\% CI [.39, .49]$, Resource depletion: $m = .09, 95\% CI [.03, .15]$), one a -parameter ($a = .03, 95\% CI [.00, .08]$) that did

not differ from zero, $\Delta G^2(1) = 1.24$, $p = .13$, and one r -parameter ($r = .45$, 95% CI [.42, .48]).

This model constituted a good account of the memory data, $G^2(4) = 2.71$, $p = .61$.

Discussion

Consistent with Experiment 1, resource depletion decreased the magnitude of the EC effect. This time, the MPT model fit was satisfactory, and evidence obtained in Experiment 1 replicated. The m -parameter proved highly sensitive to resource depletion, yet clearly survived it – in line with the residual EC effect in the resource depletion condition. The a -parameter was again not significant. These findings support the view that EC effects were mainly driven by explicit encoding processes.

Experiment 3

Experiment 3 replicates Experiment 2 with an alternative implementation of the MPT task to achieve convergent validity. Participants now were instructed to reverse their responses based on their memory instead of their evaluation in the exclusion condition of the memory task.

Method

Participants. Of 124 undergraduate participants, nine were excluded because of poor performance in the practice phase. The final sample consisted of 115 participants ($M_{\text{age}}=19.99$; $SD_{\text{age}}=1.32$; 105 females).

Design, Material, and Procedure. The design, material, and procedure of Experiment 3 replicated Experiment 2 with the exception that exclusion instructions asked participants to reverse the responses based on memory rather than attitudes (cf. Hütter et al., 2012). Figure 2 illustrates the predictions of the parameters.

Results

Evaluative Ratings. Evaluative ratings (see Table 1) were submitted to a 2 (US valence) by 2 (time of measurement) by 2 (resource depletion) GLM with repeated measures

on the first two factors. The analysis revealed a significant EC effect, $F(1,113) = 42.28, p < .001, \eta_p^2 = .27, 90\% CI [.16, .37]$, observed power = .99, that was moderated by resource depletion, $F(1,113) = 23.39, p < .001, \eta_p^2 = .17, 90\% CI [.08, .27]$, observed power = .99. An EC effect was observed in the control condition $F(1,53) = 41.14, p < .001, \eta_p^2 = .44, 90\% CI [.26, .56]$, observed power = .99, but not in the secondary task condition $F(1,60) = 2.50, p = .12, \eta_p^2 = .04, 90\% CI [.00, .14]$, observed power = .34 (cf. Figure 3).

MPT Model. According the same analytic procedure, the model (see Figure 4) was highly consistent with the previous results, $G^2(2) = 2.09, p = .35$. While the m -parameter was sensitive to the resource depletion manipulation, $\Delta G^2(1) = 79.52, p < .001$, the a -parameters, $\Delta G^2(1) = 0.57, p = .45$, as well as the r -parameters, $\Delta G^2(1) = 0.11, p = .74$, did not differ between conditions. The final model containing two m -parameters (control: $m = .37, 95\% CI [.32, .42]$, Resource depletion: $m = 0.05, 95\% CI [.00, .10]$), one a -parameter ($a = .02, 95\% CI [.00, .06]$) that did not differ from zero, $\Delta G^2(1) = 0.78, p = .19$, and one r -parameter ($r = .48, 95\% CI [.46, .51]$), demonstrated good fit, $G^2(4) = 2.77, p = .60$.

Discussion

The findings obtained in Experiments 1 and 2 generalize to a different MPT procedure. The model fit was satisfactory and conclusions turned out to be similar to those observed in Experiment 2: the m -parameter was sensitive to resource depletion and no significant a -parameter was observed. Resource depletion weakened the EC effect, again to non-significance.

Integrative Data Analysis

Evaluative ratings. We conducted an Integrative Data Analysis (IDA; Curran & Hussong, 2009) on the aggregated data of the three experiments. This analysis allows to increase statistical power and to test whether the effects vary across experiments. We

submitted CS ratings to a 2 (US valence) by 2 (time of measurement) by 2 (Resource depletion) by 3 (Experiment) GLM with repeated measures on the first two factors.

The IDA showed that EC effect was generally strong, $F(1,271) = 79.33, p < .001, \eta_p^2 = .226$, 90% $CI [.16, .29]$, observed power = .99, independent of Experiment, $F(2,271) = .80, p = .45, \eta_p^2 = .006$, 90% $CI [.00, .02]$, observed power = .19. The overall effect of the resource depletion on EC was strong, $F(1,271) = 24.41, p < .001, \eta_p^2 = .08$, 90% $CI [.04, .14]$, observed power = .99, irrespective of Experiment, $F(2,271) = .98, p = .38, \eta_p^2 = .01$, 90% $CI [.00, .03]$, observed power = .22.

The EC effect was significant in both conditions but was much stronger in the control condition, $F(1,138) = 73.40, p < .001, \eta_p^2 = .35$, 90% $CI [.24, .44]$, observed power = .99, than in the resource depletion condition, $F(1,133) = 12.12, p < .001, \eta_p^2 = .08$, 90% $CI [.02, .16]$, observed power = .93.

MPT model. We conducted an integrative analysis across all 6817 observations of the three experiments. The fitted model with two m -parameters (control: $m = 0.40$, 95% $CI [.37, .43]$, resource depletion: $m = 0.06$, 95% $CI [.02, .09]$), one a -parameter ($a = .00$, 95% $CI [.00, .03]$) that did not differ from zero, $\Delta G^2(1) = 0.01, p = .46$, and one r -parameter ($r = .47$, 95% $CI [.46, .49]$), demonstrated satisfactory fit, $G^2(20) = 29.15, p = .08$.⁴ Based on this analysis, the residual EC effect in the resource depletion condition is likely due to residual explicit memory for the pairings.

General Discussion

In the present research, we examined how depleting participants' resources at learning influences the EC effect, as well as indicators of implicit and explicit memory, in the context of a paradigm claimed to be conducive to implicit EC effects. In three experiments, despite significant variations of a common procedure (i.e., different implementations of both the MPT instructions and the control condition), we systematically reached the same conclusion: taxing

participants' resources largely reduces both explicit memory for the CS-US pairings and the magnitude of EC effects. We found these effects although the encoding task and the secondary task did not overlap in sensory modality, demonstrating that these processes draw on a common resource.

We failed to obtain evidence for the contribution of implicit processes to EC, despite the use of high-powered experiments and a close replication of past procedures (Hütter & Sweldens, 2013; Hütter et al., 2012). The lack of replication of the a -parameter suggests a lack of robustness of past evidence pointing to the contribution of implicit memory to EC. As a consequence of this replication failure, an assessment of the a -parameter's sensitivity to resource depletion is not possible in the present research. However, the generally good fit of the model and the a -parameter's insensitivity to decreases in m supports the relevance of the MPT approach. That is, as proposed and empirically validated by Hütter et al. (2012, 2013), the a -parameter is not affected by a reduction in the m -parameter, suggesting that the two parameters represent qualitatively different processes rather than processes that differ in quantitative terms (e.g., the strength of the memory signal).

All three experiments show that EC is sensitive to opportunities of explicit encoding, with larger EC effects in the control condition than in the resource depletion condition. However, the absolute levels of EC observed in the evaluative ratings in these conditions are difficult to interpret. As there is no absolute scale for depletion (Fiedler & Hütter, 2014), one cannot know whether the two-back task used in the present research fully depleted participants' resources. Thus, the small (and often non-significant) EC effects under resource depletion could be due to processes operating implicitly or residual resources that were not taxed by the secondary task. Results from the MPT model support the latter interpretation.

The present research relied on direct evaluative measures (i.e., evaluative ratings). One could argue that EC effects assessed with indirect measures (Fazio, Jackson, Dunton, &

Williams, 1995; Payne, Cheng, Govorun, & Stewart, 2005) may have proven less sensitive to resource depletion. However, several theoretical considerations led us to focus on direct evaluations in the present research. First, the effect size of EC effects is considerably larger on direct than on indirect measures (Hofmann et al., 2010). Finding no evidence for EC effects on an indirect measure may thus have been attributed to a lack of power. Second, evidence is accumulating that questions the existence of qualitative differences between direct and indirect measures. Effects consistent with explicit encoding were obtained on indirect measures (e.g., De Houwer, 2006; Pleyers, Corneille, Luminet, & Yzerbyt, 2007; Stahl et al., 2009) and effects consistent with implicit learning were obtained on direct measures (Hütter et al., 2012; Jones et al., 2009; Olson & Fazio, 2001). Thus, the nature of the measure is not necessarily informative with regard to the type of learning underlying evaluation. The MPT measure relies on self-reports that allow for flexible responding in line with instructions and allows for keeping the task constant. Nevertheless, it is an open research question whether indirect measures of evaluation would show the same pattern of results.

The contribution of this research is manifold. In general, the experiments reported here are consistent with recent invitations to address the role of contingency awareness in EC through experimental manipulations at the encoding stage (Gawronski & Walther, 2012) and to combine experimental approaches with MPT modeling (Sweldens, Corneille & Yzerbyt, 2014). Additionally, the present research allows reaching a number of more specific innovative conclusions. First, it reveals that the detrimental impact of resource depletion extends to a paradigm thought to be conducive to implicit learning processes. Second, it shows that explicit memory for the CS-US pairings plays a large role in this paradigm. Third, it further validates the view that the m -parameter reflects encoding-related processes (as m was sensitive to an encoding-related manipulation) and that m can be varied independently of

the α -parameter. Fourth, it suggests that the estimation of the α -parameter in the present paradigm is less robust than initially thought.

Nevertheless, the current experiments should not be interpreted as revealing the general absence of implicit processing in EC. First, the question of whether an implicit process operates in the current paradigm remains open. In two unrelated studies using the same conditioning paradigm, we recently observed a significant α -parameter. We may therefore conclude that the α -parameter is obtained in the current paradigm, although it seems not to be quite robust. Furthermore, another CS-US pairing procedure may be more suitable for obtaining implicit EC effects. However, such evidence is currently scarce. For instance, subliminal EC studies generally suffered from design-related issues, lacked sensitive awareness tests, and operated under exposure conditions that have been shown to allow conscious identification (Lovibond & Shanks, 2002; Pleyers et al., 2007; Stahl et al., 2016; Sweldens, Corneille & Yzerbyt, 2014). When tightly controlled CS exposure conditions and sensitive awareness checks are used, meeting methodological requirements currently advised in cognitive psychological research (Atas, Vermeiren & Cleeremans, 2013; Pratte & Rouder, 2009; Shanks & St. John, 1994), objective identification appears to be a necessary yet insufficient condition for an EC effect to emerge (Stahl et al., 2016). As to subliminally presented affective stimuli (i.e., USs), they have recently been shown to elicit no affective response (Lähteenmäki, Hyönä, Koivisto, & Nummenmaa, 2015).

As a final comment, evidence supporting the possibility of an implicit EC effect stems from incidental learning studies by Fazio and colleagues (Jones et al., 2009; Olson & Fazio, 2001). Their paradigm involved a distracting vigilance task and an even larger number of different USs paired with the CSs. In addition, the USs used in these studies likely involved USs of lower intensity. Assuming the latter effect is robust and survives stringent awareness tests, the scope of implicit EC effects observed in the vigilance paradigm would however

exclude from the realm of implicit EC effects: backward and forward CS-US pairings, non-incidental exposures, procedures involving USs of either too weak or too high intensity, and of either too large or too small perceptual salience. Such a small scope of implicit EC would severely limit the practical and theoretical interest of dual-process models of attitude acquisition and perhaps of implicit learning in general (Shanks, 2005).

References

- Atas, A., Vermeiren, A., & Cleeremans, A. (2013). Repeating a strongly masked stimulus increases priming and awareness. *Consciousness and Cognition*, 22, 1422–1430. doi: 10.1016/j.concog.2013.09.011
- Batchelder, W. H., & Riefer, D. M. (1999). Theoretical and empirical review of multinomial process tree modeling. *Psychonomic Bulletin & Review*, 6, 57–86. doi:10.3758/BF03210812
- Dedonder, J., Corneille, O., Yzerbyt, V., & Kuppens, T. (2010). Evaluative conditioning of high-novelty stimuli does not seem to be based on an automatic form of associative learning. *Journal of Experimental Social Psychology*, 46, 1118–1121. doi: 10.1016/j.jesp.2010.06.004
- Curran, P. J., & Hussong, A. M. (2009). Integrative data analysis: the simultaneous analysis of multiple data sets. *Psychological methods*, 14, 81. doi: 10.1037/a0015914
- Dedonder, J., Corneille, O., Bertinchamps, D., & Yzerbyt, V. (2013). Overcoming correlational pitfalls: Experimental evidence suggests that evaluative conditioning occurs for explicit but not implicit encoding of CS-US pairings. *Social Psychological and Personality Science*, 5, 250–257. doi:10.1177/1948550613490969
- De Houwer, J. (2007). A conceptual and theoretical analysis of evaluative conditioning. *The Spanish journal of psychology*, 10, 230–241. doi: 10.1017/S1138741600006491
- De Houwer, J. (2006). What are implicit measures and why are we using them. *The handbook of implicit cognition and addiction*, 11–28.
- Fazio, R. H., Jackson, J. R., Dunton, B. C., & Williams, C. J. (1995). Variability in automatic activation as an unobtrusive measure of racial attitudes: a bona fide pipeline?. *Journal of personality and social psychology*, 69, 1013–1027. doi: 10.1037/0022-3514.69.6.1013

- Fiedler, K., & Hütter, M. (2014). The limits of automaticity. In J. Sherman, B. Gawronski, & Y. Trope (Eds.), *Dual process theories of the social mind* (pp. 497-513). New York: Guilford Press.
- Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: An integrative review of implicit and explicit attitude change. *Psychological Bulletin*, 132, 692–731. doi:10.1037/0033-2909.132.5.692
- Gawronski, B., & Bodenhausen, G. V. (2009). Operating principles versus operating conditions in the distinction between associative and propositional processes. *Behavioral and Brain Sciences*, 32, 183-246. doi: 10.1017/S0140525X09000855
- Gawronski, B., & Walther, E. (2012). What do memory data tell us about the role of contingency awareness in evaluative conditioning? *Journal of Experimental Social Psychology*, 48, 617–623.
- Halbeisen, G., & Walther, E. (2015). Dual-task interference in evaluative conditioning: Similarity matters! *The Quarterly Journal of Experimental Psychology*, 68, 2008-2021. doi: 10.1080/17470218.2014.1002506
- Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin*, 136, 390-421. doi: 10.1037/a0018916
- Hütter, M., & Sweldens, S. (2013). Implicit misattribution of evaluative responses: Contingency-unaware evaluative conditioning requires simultaneous stimulus presentations. *Journal of Experimental Psychology: General*, 142, 638–643. doi:10.1037/a0029989
- Hütter, M., Sweldens, S., Stahl, C., Unkelbach, C., & Klauer, K. C. (2012). Dissociating contingency awareness and conditioned attitudes: evidence of contingency-unaware

evaluative conditioning. *Journal of Experimental Psychology: General*, 141, 539–57.

doi:10.1037/a0026477

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, 30, 513–541. doi: 10.1016/0749-596X(91)90025-F

Jacoby, L. L., Toth, J. P., & Yonelinas, A. P. (1993). Separating conscious and unconscious influences of memory: Measuring recollection. *Journal of Experimental Psychology: General*, 122, 139-154. doi: 10.1037/0096-3445.122.2.139

Jones, C. R., Fazio, R. H., & Olson, M. A. (2009). Implicit misattribution as a mechanism underlying evaluative conditioning. *Journal of Personality and Social Psychology*, 96, 933–948. doi:10.1037/a0014747.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1999). International affective picture system (IAPS): Instruction manual and affective ratings. *The center for research in psychophysiology, University of Florida*.

Klauer, K. C., Stahl, C., & Voss, A. (2011). *Multinomial Models and Diffusion Models*. In A. Voss, C. Stahl, & K. C., Klauer (Eds.). *Cognitive methods in social psychology*, (pp.331-354). La Rioja: Dialnet.

Lähteenmäki, M., Hyönä, J., Koivisto, M., & Nummenmaa, L. (2015). Affective processing requires awareness. *Journal of Experimental Psychology: General*, 144, 339-365. doi: 10.1037/xge0000040.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAS. *Frontiers in Psychology*, 4. doi: 10.3389/fpsyg.2013.00863

- Lovibond, P. F., & Shanks, D. R. (2002). The role of awareness in Pavlovian conditioning: empirical evidence and theoretical implications. *Journal of Experimental Psychology: Animal Behavior Processes*, 28, 3-26. doi: 10.1037/0097-7403.28.1.3
- Olson, M. A., & Fazio, R. H. (2001). Implicit attitude formation through classical conditioning. *Psychological Science*, 12, 413-417. doi: 10.1111/1467-9280.00376
- Payne, B. K., Cheng, C. M., Govorun, O., & Stewart, B. D. (2005). An inkblot for attitudes: affect misattribution as implicit measurement. *Journal of personality and social psychology*, 89, 277-293. doi: 10.1037/0022-3514.89.3.277
- Pleyers, G., Corneille, O., Luminet, O., & Yzerbyt, V. (2007). Aware and (dis)liking: item-based analyses reveal that valence acquisition via evaluative conditioning emerges only when there is contingency awareness. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, 33, 130-44. doi:10.1037/0278-7393.33.1.130
- Pleyers, G., Corneille, O., Yzerbyt, V., & Luminet, O. (2009). Evaluative conditioning may incur attentional costs. *Journal of Experimental Psychology. Animal Behavior Processes*, 35, 279-85. doi:10.1037/a0013429.
- Pratte, M. S., & Rouder, J. N. (2009). A task-difficulty artifact in subliminal priming. *Attention, Perception, & Psychophysics*, 71, 1276-1283. doi: 10.3758/APP.71.6.1276
- Self, S. G., & Liang, K.-Y. (1987). Asymptotic properties of maximum likelihood estimators and likelihood ratio tests under nonstandard conditions. *Journal of the American Statistical Association*, 82, 605-611.
- Shanks, D. R. (2005). *Implicit Learning*. In K. Lamberts & R. Goldstone (Eds.), *Handbook of cognition* (pp.202-220). London: Sage.
- Shanks, D. R., & St. John, M. F. (1994). Characteristics of dissociable human learning systems. *Behavioral and Brain Sciences*, 17, 367-395. doi: 10.1017/S0140525X00035032

- Smithson M. (2001). Correct confidence intervals for various regression effect sizes and parameters: the importance of noncentral distributions in computing intervals. *Educational and Psychological Measurement*, 61, 605–632. doi: 10.1177/00131640121971392
- Stahl, C., Unkelbach, C., & Corneille, O. (2009). On the respective contributions of awareness of unconditioned stimulus valence and unconditioned stimulus identity in attitude formation through evaluative conditioning. *Journal of personality and social psychology*, 97, 404–420. doi: 10.1037/a0016196
- Stahl, C., Haaf, J., & Corneille, O. (in press). Subliminal evaluative conditioning? Above-chance CS identification may be necessary and insufficient for attitude learning. *Journal of Experimental Psychology : General*. doi: 10.1037/xge0000191.
- Sweldens, S., Corneille, O., & Yzerbyt, V. (2014). The role of awareness in attitude formation through evaluative conditioning. *Personality and Social Psychology Review*, 18, 187–209. doi:10.1177/1088868314527832
- Sweldens, S., Van Osselaer, S. M. J., & Janiszewski, C. (2010). Evaluative conditioning procedures and the resilience of conditioned brand attitudes. *Journal of Consumer Research*, 37, 473–489. doi:10.1086/653656

Footnotes

¹ To ensure correspondence between the MPT modelling and the evaluative ratings, participants excluded from the memory task were not included in the analyses of the evaluative ratings. The results on evaluative ratings however hold when those participants are included in the analyses. This was the case for all three experiments.

² We calculated the 90% confidence interval for the partial eta-squared following the recommendations of Lakens (2013) and Smithson (2001).

³ 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.

⁴ Complementary analyses including participants excluded due to erroneous practice trials resulted in analogous statistical outcomes in all experiments as well as the integrative data analysis, but for slightly worse model fits.