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Evaluative conditioning and conscious knowledge of contingencies: A correlational investigation with large samples

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Evaluative conditioning (EC) is a change in the valence of a stimulus that results from pairing the stimulus with an affective stimulus. Two high-powered studies (total $N = 1{,}161$) investigated the nature of the relationship between EC and contingency awareness measured as contingency memory. Stronger EC occurred among people with more accurate and more confident memory of the pairings. Awareness was a necessary condition for EC, but EC was not necessary for awareness. Supporting a propositional account of EC, we found evidence for intentional reliance on the contingency for the evaluation of stimuli. We also found evidence that contingency memory was based both on the actual contingency and on preexisting attitudes.

Keywords: Evaluative conditioning; Propositional learning; Associative learning; False memory.

When people are repeatedly exposed to a neutral stimulus that appears in temporal proximity to an affective stimulus, their subsequent evaluation of the neutral stimulus often becomes more similar to the valence of the affective stimulus. This effect is called evaluative conditioning (EC; De Houwer, 2007; De Houwer, Thomas & Baeyens, 2001; Martin & Levey, 1978). EC is considered a form of Pavlovian conditioning in that it refers to a change in behaviour that is due to the pairing of stimuli (see De Houwer, 2007). The neutral stimulus corresponds to the conditioned stimulus (CS), the affective stimulus corresponds to the unconditioned stimulus (US), and the change in valence of the CS can be seen as the conditioned response. For over 20 years, one of the main questions regarding EC has been whether it can occur without the learner's awareness of the CS–US contingency. Because a considerable number of reports claimed to have found EC

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without contingency awareness, EC is also highly relevant to the broader discussion about whether any learning can occur without the learner's awareness (e.g., Mitchell, De Houwer, & Lovibond, 2009; Shanks, 2010; Shanks & St. John, 1994). We took advantage of access to very large samples to investigate various possible relationships between EC and contingency awareness, including the possibility of an EC with no contingency awareness.

The present research tested the following specific questions: (a) Are contingency awareness and EC related? We went beyond previous research on this question by examining also the causal nature of the relation between awareness and EC. More specifically, we investigated (b) whether people intentionally use their memory of the CS–US contingencies when they report about their attitudes toward the CSs, either because the pairing with the US is considered relevant information for evaluation, or because of perceived experimental demand. (c) We also collected evidence about the possibility of the opposite causal link: from EC to (false) contingency awareness. We tested whether, when there is no actual pairing, false contingency memory forms as a result of a preexisting attitude and whether, when there is pairing, memory accuracy is affected by the match between the US valence and the preexisting attitudes toward the CS. (d) We also tested whether awareness and EC can be unrelated by examining whether contingency awareness can occur without EC and whether EC can occur without contingency awareness. (e) Finally, we examined the effect of the number of pairings on EC.

Previous investigations that examined the relationship between contingency awareness and EC investigated mainly whether EC can occur without awareness and produced mixed results (e.g., De Houwer, Baeyens, & Hendrickx, 1997; De Houwer et al., 2001; Field, 2000; Lovibond & Shanks, 2002; Shanks & St. John, 1994). Several researchers concluded that EC can occur without contingency awareness (Baeyens, Eelen, & Van den Bergh, 1990; Hammerl & Grabitz, 2000; Olson & Fazio, 2001, 2002, 2006; Walther, 2002; Walther & Nagengast, 2006). For instance, Olson and Fazio (2001, 2002, 2006; Jones, Fazio, & Olson, 2009) found significant EC in a sample that showed no recognition of which CS–US pairs were presented during the conditioning. In another line of work, Walther and Nagengast (2006) found EC only among participants who could not recognize the US that was paired with each CS.

In contrast with these findings, other investigations found EC only among participants who showed awareness of the contingencies (Dawson, Rissling, Schell, & Wilcox, 2007; Field, 2000; Pleyers, Corneille, Luminet, & Yzerbyt, 2007; Pleyers, Corneille, Yzerbyt, & Luminet, 2009; Stahl & Unkelbach, 2009; Stahl, Unkelbach, & Corneille, 2009; Wardle, Mitchell, & Lovibond, 2007). For instance, when measuring the awareness for each CS separately, Pleyers et al. (2007) found EC only for CSs for which the contingency with the US was accurately remembered. In another line of work, using a trial-by-trial measurement of awareness, Dawson et al. (2007) found EC only when participants were able to predict which US would appear after each CS.

We sought to further the research about the relation between EC and contingency awareness in two ways: (a) improving on the sensitivity and reliability of experimental effects by increasing statistical power, and (b) using this power not only to examine whether the relationship exists, but also to investigate the possible causes of this relationship.

Improving statistical power

One reason for the past contradictory results with regard to the relationship between contingency awareness and EC may be low statistical power. Low statistical power may produce both failures to find EC in the absence of contingency awareness and failures to find a significant relation between EC and contingency awareness. Simultaneously, there might be a reporting bias, by which researchers are more likely to report studies that found EC without contingency awareness. Studies in which neither EC nor contingency awareness were found might have been dismissed as being due to low power and never reported, indicating a prejudice against the null hypothesis (Greenwald, 1975). To remedy these problems and to enable powerful tests of numerous conditions and specific sample subsets, this research comprises of two large-scale studies, with sample sizes of 570 and 591 participants, respectively. With such samples, tests with very specific subsets still have high statistical power. We examined whether people who did not show EC still showed contingency awareness and whether people who did not show contingency awareness still showed EC.

Causal relationships between contingency awareness and attitude

Going beyond the prior research, we examined not only whether there exists a relation between contingency awareness and EC, but also the reasons why such a relation would occur. The primary aim of our studies was to investigate the hypothesis that contingency awareness may cause EC through propositional processes—more specifically, because people intentionally use knowledge about CS–US contingencies to form and evaluate propositions about their liking of the CSs (De Houwer, 2007; De Houwer, Baeyens, & Field, 2005). Participants might use such a strategy if they believe that knowledge about CS–US contingencies provides a valid source of information for evaluating propositions about their liking of the CSs. For instance, the fact that a CS is consistently followed by a negative US might be seen as a negative property of the CS and thus as a reason for endorsing the proposition "the CS is negative".

The assumption that EC results from the fact that people intentionally use their knowledge of CS–US contingencies in this manner has not been directly tested before, and some researchers have contended that this assumption makes little sense. According to Shanks (2007), "it is hard to see why a set of cognitive operations would yield such an outcome [EC]: There is nothing rational about such transfer of affect" (p. 295). Similarly, Baeyens, Vansteenwegen, and Hermans (2009) contended that "there is no causal connection at all between entertaining the propositional belief 'CS refers to (dis)liked US' and (dis)liking a CS" (p. 199). Putting these assertions into test, the present research examines the possibility that people sometimes do intentionally rely on the contingency when they rate the CSs and that EC can result from the use of this strategy.

Propositional processes are conscious by nature, and people should thus be able to report them under certain conditions (De Houwer, 2009). Therefore, we searched for evidence that contingency awareness affects attitudes toward CSs by asking participants whether they intentionally used their knowledge of the CS–US contingencies (i.e., their contingency knowledge) as a basis for rating their liking of the CSs. If intentional use of contingency knowledge contributes to EC, and if participants are able to accurately report their use of contingency knowledge, then we should observe stronger EC in participants who report using their knowledge of the CS–US contingencies. Also, the strength of the relation between contingency awareness and EC should depend on whether participants report using contingency knowledge when rating their liking of the CSs. Although self-reports sometimes fail to provide an accurate reflection of the psychological processes underlying behaviour (Nisbett & Wilson, 1977), research has shown that self-reports of psychological processes are often in line with observed behaviour and can provide useful insights in the processes underlying behaviour (Smith & Miller, 1978; Vandorpe, De Houwer, & Beckers, 2005). As De Houwer (2009) pointed out, self-report data can be particularly useful to study the conscious propositional processes that are thought to underlie EC.

In line with most previous studies on the relation between EC and contingency awareness, we assessed contingency awareness by measuring contingency memory. We asked participants to report their knowledge of the CS–US contingencies after all CS–US pairs were presented. A secondary aim of our studies was to examine whether contingency memory reflects not only the actual contingencies but also the liking of the CSs. This is an important issue because it would show that contingency memory is not an exclusive measure of contingency awareness (Reingold & Merikle, 1988). Stahl et al. (2009) recently tested this possibility by examining whether people with reverse EC show inaccurate contingency memory. The rationale was that if memory is the result of the liking of CSs, then people who prefer a negative CS (CSneg; i.e., a CS paired with a negative US) over a positive CS (CSpos; i.e., a CS paired with a positive US) should incorrectly infer that the CSneg was paired with USs of positive valence and the CSpos was paired with USs of negative valence. Examining the CSs that showed reverse EC, Stahl et al. found no evidence for inaccurate contingency memory and therefore no support for the impact of the liking of CSs on contingency memory. The present research repeats these tests with more statistical power and a more sensitive measure of contingency memory.

As a second way to examine the possibility that attitudes lead to false contingency memory, we tested whether contingency memory is related to attitudes when participants did not experience CS–US pairings. We included a between-subjects condition with no contingency pairings (Experiment 1) and control stimuli that were presented but were not paired with USs (Experiment 2). We tested the hypothesis that although no pairing occurred, people would tend to report that liked control stimuli were paired with positive US more than were disliked control stimuli. Finally, we also examined whether preexisting attitudes toward the CSs would affect the contingency memory accuracy. That is, we tested whether people would show more accurate contingency memory when the CS was paired with a US that matches the preexisting attitude toward that CS.

Overview of the experiments

In two experiments, after an EC procedure, we measured attitudes and then contingency memory. In Experiment 1, the number of pairings (0, 12, 22, or 32) of the CS and US was manipulated on a between-subject basis. In Experiment 2, the CS and US were paired 4, 8, or 12 times. We manipulated the number of pairings because causal relationships in EC might depend on the number of pairings. For instance, perhaps intentional processes occur only when the pairings are very salient, as might happen in the 32-pairings condition. This manipulation also enabled a statistically powerful study of the effect of number of pairings on EC, a factor that was rarely researched in the past (see Baeyens, Eelen, Crombez, & Van den Bergh, 1992, for an exception). The two studies also used different memory measures and different control conditions with no pairing.

EXPERIMENT 1

Method

Participants

The participants in both studies were volunteers at the Project Implicit research website (https://implicit.harvard.edu; see Nosek, 2005, for more information). Registered participants were randomly assigned to these studies from a large pool of available studies. Once assigned to a study, that participant would never again be assigned to the same study on future visits to the Virtual Laboratory. A total of 939 participants completed Experiment 1, but we removed 37 participants who made too many mistakes in the conditioning task (see below). Additionally, some people did not respond to all the memory and attitude items. The substantive results are almost identical if we do not remove these participants. However, following the present norm to include only participants who completed all the measures, we removed the 193 participants who did not respond to all the questions (mostly people who skipped some memory questions). That left us with 746 participants (64% women, 35% men, 1% unknown; M age = 30.64, SD = 12.51).

Design

For each participant, one CS was paired with positive valence (CSpos), and one was paired with negative valence (CSneg). The assignment of positivity or negativity with CSs was manipulated between subjects, as was the number of CS–US pairings: 0 (no pairing), 12, 22, and 32 pairings. The design was 2 (CS type: positive, negative; within subjects) × 2 (CS–US assignment: CS1 assigned to positive and CS2 to negative USs or vice versa; between subjects) × 4 (number of pairings: 0, 12, 22, 32).

Procedure and materials

CSs. In a pretest, 655 participants evaluated 12 cartoon characters (Pokemons) that had been used in prior EC research (Olson & Fazio, 2001), using the same 9-point attitude scale that was administered in both studies (see below). In choosing the two CSs, two criteria were important: There should not be a strong preexisting preference for one CS over the other, and the two CSs should be rated as close as possible to the neutral point. For each participant, 66 difference scores were computed, one for each two-character difference. The average absolute difference in liking between the two characters (*Ruriri* and *Jigglypuff*) that served as the CSs in both studies ($M = 1.63$, $SD = 1.49$; for the nonabsolute difference, $M = 0.16$, $SD = 2.21$) was the fourth smallest difference of the 66 differences, but the other three pairs with smaller average difference were not nearly as close to the neutral point as these two characters ($M = 4.72$, $SD = 1.92$, for Ruriri; $M = 4.88$, $SD = 1.86$, for Jigglypuff).

The stimulus image included the name of the character. The same image was presented in the procedure and in the attitude and memory measures.

USs. A total of 10 positive and 10 negative images were taken from the International Affective Picture System (IAPS) CD-ROM (Lang, Bradley, & Cuthbert, 1999), a set of normed affective stimuli. We also used 6 positive words (*Paradise, Pleasure, Cheer, Wonderful, Splendid, Love*) and 6 negative words (*Bomb, Abuse, Sadness, Pain, Poison, Grief*).

NS. A total of 9 neutral IAPS images, 9 Pokemons, and 6 words (*Table, Chair, Lamp, Room, Door, Window*) were the neutral filler stimuli (NS). Another Pokemon (always the same one, *Diglett*) was used as the target stimulus (see *Learning Procedure*).

Learning procedure. In the consent form, participants were told that the study may help us understand how people think and provide an educational, engaging experience. They then read the instructions for the learning procedure, presented as the *hit* task because participants had to hit the space bar when they saw the target stimulus (see later). We adapted the *surveillance conditioning procedure* used by Olson and Fazio (2001, 2002, 2006; Jones et al., 2009). We chose this procedure because according to the published reports, it has almost always produced EC without awareness and because it is relatively short, making it more appropriate for a web study. In the procedure, pairs of stimuli were presented simultaneously next to each other, side by side on the screen. Each pair included one of the following two stimuli: two NSs, an NS and the target, or a CS with a US. The locations (left or right) of the two stimuli were randomly assigned in each trial. Each pair was presented for 1,200 ms (in comparison to 1,500 ms in the original procedure). The next pair appeared as soon as the previous pair disappeared (i.e., the trials were presented in succession without an interval between them). Participants were instructed to hit the space-bar every time a target stimulus appeared (the Pokemon character Diglett). This character was never used as a CS or US. The target stimulus was more similar to the CSs than to the USs because like them it was a cartoon character with its name printed on its picture and because it was rated as relatively neutral in the pretest. This might have increased the attention paid to the CSs and filler Pokemon stimuli in comparison to the affective and neutral IAPS stimuli.

In the practice block, the target stimulus and each of the two CSs appeared twice together with a US (except for the *no-pairing* condition, described separately below). The CSpos appeared with positive USs (USpos) and the CSneg with negative USs (USneg). After each stimulus pair that included a CS or the target, between 2 and 6 NS–NS pairs appeared. The exact number was determined randomly on each occasion.

Two identical critical blocks came after the practice block. The target stimulus appeared 10 times in each critical block. Each CS appeared 5, 10, or 15 times in each block, depending on the number of pairings condition. This was in addition to the 2 pairings in the practice block, resulting in 12, 22, and 32 pairings in the entire task. The number of filler NS–NS pairs that appeared after each CS–US pair varied (randomly) from 1 to 20 with the goal to present 90–100 trials in each block. The stimuli for USs and NSs were selected randomly until the list of stimuli was exhausted, and then they were selected randomly again so that each participant never saw a CS appearing with the same US more than twice. To summarize in another way, in the 32-pairings condition, 64 (32%) of about 200 trials included one of the CSs. In the 12-pairings condition, 24 (12%) of about 200 trials included one of the CSs.

In the no-pairing condition, each CS appeared 22 times throughout the procedure (twice in the practice block, 10 times in each block), always with one of the 24 NSs. In that condition, in each block, appeared 10 NS–USpos and 10 NS–USneg pairs. The NSs were selected randomly from the list of 24 NSs. On average, each NS was paired once with a USpos and once with a USneg.

Attitude measure. The two CS Pokemons, 3 NS Pokemons, and the target (NS) Pokemon were presented together on the same screen in a randomized order. Participants rated each Pokemon on a 9-point scale with the following instructions: *Please provide your immediate feelings (your very first gut reaction), how warm or cold you feel toward the following characters (0 = coldest feelings, 4 = neutral, 8 = warmest feelings).*

Manipulation awareness. After the evaluation of the stimuli, participants were asked: *For some participants, during the first task, there was one character that always appeared with positive images and words and one that always appeared with negative images and words, do you think it happened in your case?* The question gave participants the impression that pairing might or might not have occurred in the learning procedure. The response options were *No, I did not notice if that happened in my task* and *Yes, that happened in my task*.

Contingency memory. In the next screen, participants were presented with the images and names of the two CSs, and they responded to two specific contingency memory items. In one memory question participants indicated which of the two CSs was the CSpos, and in a second item they indicated which was the CSneg: (a) *During the first task, which of the two characters was consistently presented with positive images and words?* and (b) *Which of the two characters was consistently presented with negative images and words?* There were six response options: *Jigglypuff (certainly), Jigglypuff (probably), Jigglypuff (guess), Ruriri (guess), Ruriri (probably), Ruriri (certainly*). The six response options were coded from −2.5 to 2.5 with 1 point difference between each option on the scale. The items were coded such that higher values indicated greater confidence in the accurate association and were then averaged. For example, if Jigglypuff was the CSpos, and Ruriri was the CSneg, *Jigglypuff (certainly)* was scored as 2.5, and the response *Ruriri (certainly)* was scored −2.5 for the first item and vice versa for the second item. In summary, higher scores indicated better memory (i.e., more accurate and confident).

The memory score for each participant was the mean score of the two memory items. To illustrate, the minimum memory score of people who answered the two memory questions correctly was 0.5 (if they indicated guessing in both responses). A score of 0 means that the respondent had one correct and one wrong response with an equal confidence level. We defined accurate memory as any score larger than 0.

Perceived effects of the pairings. After the memory questionnaire, we asked whether people thought they used the pairings as information when they rated the CSs: *When asked how much you like the characters, did you intentionally take into account whether the character often appeared with positive or negative words or images?* with the response options *Definitely no* (coded as −2), *Probably no* (−1), *Not sure* (0), *Probably yes* (1), *Definitely yes* (2).

A second question measured the participants' perceived demand compliance: *When I rated the characters, I thought that this research might want me* *to like the character that was paired with positive items and dislike the character that was paired with negative items, so that is exactly what I did.* The responses were on a 6-point scale from *Strongly agree* (coded as 2.5) to *Strongly disagree* (coded as −2.5).

To summarize the overall procedure, the experiment started with the learning task, followed by the attitude measurement, a question about the manipulation awareness, the contingency memory questionnaire, and then the measurement of people's perception of the effect of the pairing on their attitude.

Results and discussion

Performance in the learning procedure

On average, participants correctly hit the space-bar after almost all 20 appearances of the target in the two blocks ($M = 19.64$, $SD = 1.55$). They usually did not hit the space-bar after stimuli other than the target ($M = 2.21$, SDs $= 9.31$). The minimum appropriate performance was set as at least 15 correct hits and less than 7 false alarms; this removed less than 5% of the sample.

Overall effects

EC occurred and was unaffected by the number of pairings. As an index of EC, we subtracted the attitude rating for the CSneg from the attitude rating for the CSpos. The average preference for CSpos was 0.53 ($SD = 2.36$), which was significantly larger than 0 (which indicates no preference), $t(570) = 5.35$, $p < .0001$, $d = 0.23$.[1] EC did not vary across the number of pairings conditions. As detailed in Table 1, the effect appeared smallest in the 22-pairings condition, but the difference between the number of pairings conditions in an analysis of variance (ANOVA) was not significant, $F < 1$.

Manipulation awareness was low, and it moderated EC. In the experimental conditions (those that presented CS−US pairing), most people (72%) reported that they did not notice that pairing occurred in the learning procedure. This was not moderated by the number of pairings, $F < 1$ (in an ANOVA with number of pairings as a predictor of manipulation awareness). Some participants (15%) in the control condition reported noticing pairing (although pairing did not occur), suggesting that the response was sometimes based on guessing or false contingency detection. Still, participants in the experimental conditions were more likely than control participants to report that they noticed the pairing, $\chi^2(1, N = 570) = 11.85$, $p = .0006$, suggesting that at least some participants noticed the contingency manipulation, or inferred it from their attitude change. People who reported manipulation awareness ($N = 158$) showed EC of moderate scale ($M = 1.42$, $SD = 2.74$), $t(157) = 6.49$, $p < .0001$, $d = 0.52$, whereas people who did not report noticing any pairing ($N = 413$), showed very small and marginally significant EC ($M = 0.19$, $SD = 2.10$), $t(412) = 1.83$, $p = .07$, $d = 0.09$. These results suggest that noticing or inferring the pairing was important for reliable EC.

Contingency memory was good and was unaffected by the number of pairings. The memory score ($M = 0.67$, $SD = 1.18$) was positive for most people (68%) and was significantly above zero (chance), $t(570) = 13.57$, $p < .0001$, $d = 0.57$. The number of pairings did not affect memory, $F < 1$ in a single factor (number of pairings) ANOVA.

EC was related to contingency memory. Stronger EC (i.e., more preference for CSpos) was related to better memory (i.e., more accurate and more confident) for the contingencies, $r(570) = .36$, $p < .001$. The number of pairings did not moderate this relationship, as revealed by the results of a regression with EC as dependent variable and contingency memory, number of pairings, and their interaction as predictors. The regression did not reveal an interaction or a significant effect of

[1] The effect sizes of the EC reported by Olson and Fazio (2001, 2002, 2006; Jones et al., 2009) were usually around $d = 0.30$, ranging from $d = 0.14$ (Jones et al., 2009, Study 1) to $d = 0.37$ (Olson & Fazio, 2001, Experiment 1, measured with an Implicit Association Test). The EC effect sizes in our experiments were within this range.

Table 1. *The effect of contingency on attitude and memory as a function of number of pairings*

	No. of pairings	*N*	*EC*	*Memory accuracy*
Experiment 1	0	176	n/a	n/a
	12	187	$.59_{a}$** (2.18)	$.60_{a}$** (1.14)
	22	203	$.36_{a}$** (2.60)	$.67_{a}$** (1.18)
	32	180	$.64_{a}$** (2.25)	$.76_{a}$** (1.24)
	Overall	570	.53** (2.36)	.67** (1.18)
Experiment 2	4	210	$-.02_{a}$ (2.18)	$.14_{a}$** (0.66)
	8	191	$.29_{ab}$ (2.34)	$.21_{a}$** (0.70)
	12	190	$.49_{b}$** (2.21)	$.37_{b}$** (0.77)
	Overall	591	.26* (2.21)	.24** (0.71)

Note: (a) Within each experiment, the subscripts indicate values that are not significantly different; (b) EC is the difference between the evaluations of CSpos and CSneg, each on a 9-point scale, when positive values indicate EC consistent with training; (c) memory accuracy is the average of the level of confidence that CSpos was paired with positive valence and that CSneg was paired with negative valence, each on a scale that ranged from −2.5 to 2.5; positive values indicate accurate memory on average; values in parentheses are standard deviations. EC = evaluative conditioning. CSpos = a CS paired with a positive US. CSneg = a CS paired with a negative US. CS = conditioned stimulus. US = unconditioned stimulus.
$^{*}p < .05$. $^{**}p < .01$.

number of pairings, *t*s < 1. It only revealed the relationship between memory and EC, β = .43, $t(570) = 3.69$, $p < .0001$. Now that we have established the presence of a relation between EC and contingency memory, we investigate possible causal links that may explain this relationship.

Memory affected EC through intentional processes

To test the possibility of a causal effect of contingency memory on EC through intentional processes, we examined whether reported reliance on contingency memory moderated the relation between EC and contingency memory and whether the magnitude of EC differed between participants who reported using contingency memory and those who reported not using contingency memory. Then, we tested the role of demand compliance by repeating the same tests with reported demand compliance instead of the reported contingency memory reliance. Finally, we examined whether reported reliance on contingency memory was related to EC even among people who did not think that they complied with experimental demand.

Reported reliance on contingency memory moderated the memory–EC relationship. Most participants (69%) responded *Probably no* or *Definitely no* when asked whether they took into account the contingencies when evaluating the CSs. A total of 14% replied *Not sure*, 12% reported *Probably yes*, and 5% reported *Definitely yes*. The EC–memory relationship was weakest for those reporting that they did not rely on the contingencies and strongest for those reporting that they did. This conclusion was supported by the results of a regression analysis with EC as an outcome and contingency memory accuracy, reported contingency reliance, and their interaction as predictors. The interaction was significant, β = .14, $t(566) = 2.54$, $p = .009$, reflecting moderation of the memory–EC relationship depending on the self-reported intentional use of the contingencies. To illustrate this moderation, the attitude/memory correlation among participants who reported that they probably or definitely did not rely on the contingencies when evaluating the CSs was $r(396) = .25$, $p < .0001$, in comparison to $r(174) = .40$, $p < .0001$ in the rest of the sample. Reported contingency reliance was also a significant predictor of EC, β = .12, $t(566) = 2.21$, $p = .03$, indicating a stronger EC among those who reported more reliance on the contingencies. As found earlier, memory was another significant predictor of EC in that regression, β = .34, $t(566) = 7.35$, $p < .0001$.

We also examined the relationship between reported contingency reliance and EC after partialling the memory score (because both were positively related to memory). The partial correlation was significant, $r(570) = .21$, $p < .0001$, suggesting that the relationship between EC and reported contingency reliance cannot be explained completely by memory accuracy and confidence. This rules out the possibility that better memory exclusively caused both stronger EC and more reported reliance on memory. Instead, those who reported more reliance on the memory for the evaluation showed stronger EC even when memory was equated. This supports the assumption that people who reported reliance on contingency memory when rating the CSs indeed relied on memory and showed EC as a result of that.

To illustrate the contribution of reported contingency reliance to the overall EC, we compared EC between people who did not report reliance and people who reported reliance. People who reported that they definitely or probably did not use their memory of the contingencies did not show EC ($M = 0.12$, $SD = 2.08$), $t(396) = 1.14$, $p = .22$, $d = 0.06$, whereas people who reported that they definitely or probably used the contingency memory showed large EC ($M = 2.07$, $SD = 2.75$), $t(94) = 7.32$, $p < .0001$, $d = 0.75$. Among people who had accurate memory, EC was found even when people reported definitely or probably not relying on the contingencies ($M = 0.60$, $SD = 2.16$), $t(243) = 4.31$, $p < .0001$, $d = 0.27$. Hence, people who remember the pairing accurately show EC even if they believe that they did not use their memory of the pairing. Note, however, that this effect was much smaller than the effect shown by the 84 participants who had accurate contingency memory and reported reliance on memory, $d = 0.82$.

EC was related to perceived demand compliance. We repeated the same analyses with reported demand compliance. A total of 7% of the participants moderately or strongly agreed with the statement that the desire to follow the researchers' expectations caused them to report liking of the CSpos more than the CSneg; another 12% slightly agreed with the statement, and the rest (81%) disagreed with this statement (slightly, 12%; moderately, 16%; or strongly, 53%). That is, some people perceived such demand and thought that they followed it. We tested whether these reports were related to the actual EC–memory relationship. Although participants who reported not basing their behaviour on experimenter demand showed correlation between EC and memory, $r(462) = .26$, participants who (slightly, moderately, or strongly) agreed with this statement showed a stronger correlation, $r(108) = .58$. This increase was significant, as revealed in a multiple regression analysis with EC as the outcome and the predictors contingency memory score, reported demand compliance, and their interaction. A significant interaction effect, $\beta = .25$, $t(566) = 4.37$, $p < .0001$, suggested stronger EC–memory relationship for those trying to follow the experimenter's expectations. In that regression, memory also predicted EC, $\beta = .49$, $t(566) = 9.07$, $p < .0001$, but perceived demand compliance did not, $\beta = .03$, $t < 1$.

To illustrate the contribution of perceived demand compliance to EC, people who (slightly, moderately, or strongly) disagreed with the demand compliance statement showed a small EC ($M = 0.27$, $SD = 2.18$), $t(462) = 2.68$, $p = .008$, $d = 0.12$, which was stronger among the subset that had accurate memory ($M = 0.71$, $SD = 2.24$), $t(299) = 5.50$, $p < .0001$, $d = 0.32$. In comparison, the rest of the sample, people who reported demand compliance, showed a much larger effect ($M = 1.62$, $SD = 2.75$), $t(108) = 6.13$, $p < .0001$, $d = 0.59$ (which was even larger among the 84 participants who reported demand compliance and had accurate contingency memory, $d = 0.83$). This indicates that although perceived demand compliance is not the sole contributor to EC, it is an important one.

EC was related to reported contingency memory even when participants reported no demand compliance. Compliance with perceived demand implies that contingency memory is used to rate the CSs. Therefore, it is not surprising that reports of reliance on memory and reports of demand compliance were positively related, $r(746) = .44$, $p < .0001$. The propositional account that we tested in this research contends, however, that people rely on their contingency memory not because of perceived demand but because they believe that the CS–US contingency provides relevant information about the valence of CSs. If that is correct, then reporting contingency reliance should moderate EC even among participants who reported that they did not comply with perceived demand.

We examined this assumption using the data of the 305 participants (54% of the participants not including the control group with no contingency pairings) who strongly disagreed with the demand compliance statement, reporting that they did not follow perceived demand. Among this subset, a regression analysis showed that contingency reliance was a significant predictor of EC, $\beta = .17$, $t(303) = 3.03$, $p < .01$. To illustrate, in this subset participants who reported that they probably or definitely did not rely on contingency memory ($N = 262$), showed no EC ($M = 0.05$, $SD = 2.01$), $t < 1$, $d = 0.02$, whereas the rest of the participants in this subset showed significant EC ($M = 1.05$, $SD = 2.77$), $t(42) = 2.48$, $p = .01$, $d = 0.38$. Hence, more reported reliance on the contingency memory was related to stronger EC even when this reliance was not perceived by the participants as resulting from demand compliance.

Attitudes can affect contingency memory

We next examined suggestive evidence that EC may affect contingency memory. We did that by testing whether preexisting attitudes caused false memory in the no-pairing condition and whether preexisting attitudes also affected memory when contingencies occurred.

False contingency memory. In the control, no-pairing condition, we computed memory and attitude measures by arbitrarily choosing one of the CSs (Jigglypuff) to be the CSpos. We found that the attitude and memory scores were related, $r(176) = .33$, $p < .0001$, suggesting a causal link from attitude to memory because there was nothing to remember.

One might argue that when guessing in the memory question, it is sensible to use the attitude as information and thus to guess about memory based on attitude. However, the memory–attitude relationship was not limited to people who guessed. A total of 59 participants in the *no pairing* condition (i.e., no contingency exposure in reality) indicated *probable* or *certain* confidence in their contingency memory. This subgroup still showed an attitude–memory relationship, $r(57) = .44$, $p = .0006$. This suggests that the attitude did not only affect guessing in the memory question, it also affected the experience of memory, causing people to believe that they witnessed a pairing that did not occur.

This false memory confidence was related to attitude extremity. We computed an attitude extremity index for each CS, as the distance between the evaluation and the midpoint of the evaluation scale. The participant's attitude extremity index was the average of the attitude extremity index for the two CSs. The certainty index and attitude extremity index were correlated, $r(176) = .29$, $p < .0001$. That is, people who had stronger attitudes towards the CSs were more certain about their (false) contingency memory.

A sceptic might argue that people sometimes just happen to acquire false contingencies memory while encoding the pairing during the learning task and that this false memory caused the attitude and not vice versa. However, the same 59 participants in the no-pairing condition who indicated that they felt *probable* or *certain* confidence about their memory tended to remember that Jigglypuff was paired with positive stimuli and that Ruriri was paired with negative stimuli ($M = 1.70$, $SD = 3.04$), $t(57) = 4.23$, $p < .0001$, $d = 0.56$. There is no reason that a random, incidental pairing would cause this memory bias. It is more reasonable to assume that despite our attempt to choose equally liked CSs, there was still a slight overall preference for one stimulus over the other, which caused this false memory bias.

Attitude affected memory also in the pairing conditions. Following the same rationale, we also tested for memory bias in conditions that had pairings. If preexisting attitudes did not affect contingency memory, then people should show an equally accurate memory regardless of the pairing condition. Yet, people were more accurate and confident in their memory when Jigglypuff was paired with positive valence, and Ruriri was paired with negative valence ($M = 0.84$, $SD = 1.11$) than when the opposite pairing occurred ($M = 0.52$, $SD = 1.23$), $t(600) = 3.35$, $p < .001$, $d = 0.27$. Notice that the memory bias in the no-pairing condition (with different participants) also suggested a preference for Jigglypuff over Ruriri.

Attitudes were not the sole cause for contingency memory. Repeating Stahl et al.'s (2009) test of the inference-from-attitude account, we examined whether participants who showed preference for the CSneg over the CSpos also showed a reversed contingency memory. Replicating Stahl et al.'s (2009) null effect in a more statistically powerful test, the memory accuracy of these reverse-EC participants was not different from zero ($M = 0.11$, $SD = 1.09$), $t(174) = 1.32$, $p = .19$, $d = 0.10$. This indicates that although the previous tests found that attitudes affected contingency memory, attitudes were not influential enough to reverse the contingency memory when the actual contingencies were in the opposite direction to the CS preference.

Evidence for direct link from pairing to contingency awareness or EC

Although we found a relationship between contingency memory and EC, and evidence for a causal relationship between the two, it does not rule out the possibility that contingency pairings could sometimes cause one without the other. In this large sample many people did not show accurate memory, and many people did not show EC. This enabled highly reliable tests of EC without accurate memory and accurate memory without EC.

There was no standard EC without accurate contingency memory. We tested EC among the subsample of participants who had inaccurate memory for the contingencies and found reverse EC: a preference for the CSneg over CSpos ($M = -0.54$, $SD = 1.78$), $t(187) = -4.16$, $p < .0001$, $d = -0.30$. A similar reverse effect was also observed by Stahl et al. (2009). An ANOVA with the number of pairings as a three-level factor and the preference for the CSpos as a dependent measure showed no effect, $F(2, 184) = -2.48$, $p = .09$, $\eta^2_p = .02$, indicating no moderation of the reverse EC by the number of pairings.

Participants who did not show EC still showed accurate contingency memory. A total of 55% of the participants did not show EC: They either preferred CSneg over CSpos or rated the two as equally likable. These participants still remembered, on average, that the CSpos was paired with positive stimuli and that the CSneg was paired with negative stimuli ($M = 0.63$, $SD = 1.15$), $t(326) = 9.85$, $p < .0001$, $d = 0.55$. Of those, examining only the participants who rated their memory confidence as *probable* or *certain*, they showed even more accurate memory ($M = 1.12$, $SD = 1.32$), $t(175) = 11.23$, $p < .0001$, $d = 0.85$. These findings probably reflect the fact that the pairing manipulation affects memory much more than it affects attitude. It may also suggest that memory is not sufficient for EC and that, as reported earlier, a robust EC emerges only when people actively use this memory when they evaluate the CSs.

EXPERIMENT 2

The first experiment found evidence for a relationship between contingency awareness and EC, for a causal link from awareness to EC through intentional processes, sometimes because of perceived demand compliance, for a causal link from preexisting attitudes to false and real contingency awareness, and no evidence for EC without contingency awareness. Because we were surprised by the lack of evidence of EC without awareness, we conducted a second experiment to see whether these findings would replicate with a few procedural modifications. The main change was that we reduced the number of pairings to 4, 8, or 12. Perhaps with fewer pairings, the contingency would be less easy to detect, and EC without accurate contingency memory would be more likely. We also modified the memory questions about the CSs, to make them less dependent one on the other. Finally, we added memory probes about the filler Pokemons (i.e., the Pokemons that were never paired with USs), to examine whether people would show false contingency awareness and whether this false awareness would be related to preexisting attitudes toward each filler.

Method

Participants

A total of 673 participants completed the experiment. Of those, we removed 19 participants who made too many mistakes in the conditioning task. Another 61 participants were not included in the analyses because they did not respond to all the questions in the questionnaire (like in Experiment 1, the test results are virtually identical with these participants). That left us with 591 participants (88% of the sample, 69% women, 30% men, 1% unknown; *M* age = 30.37, *SD* = 11.72).

Design

The design was 2 (CS type: positive, negative; within subjects) × 2 (CS−US assignment: CS1 assigned to positive and CS2 to negative USs or vice versa; between subjects) × 3 (number of pairings: 4, 8, 12; between subjects).

Procedure and materials

The materials were the same as those in Experiment 1. The learning procedure was similar, only without presenting the CSs in the practice block. In each of the two critical blocks, each CS was paired 2, 4, or 6 times, out of the approximately 100 pairings in the block. The attitude measure was the same as that in Experiment 1 (and included the filler Pokemons).

The memory questionnaires were modified. The manipulation awareness question was the same as before, but with six response options (instead of two): from *It did not happen in my task (certainly)* to *Yes, that happened in my task (certainly)*. Between these two extreme options, participants could choose the same two statements but with *(probably)* or *(guess)* at the end of the statement, instead of *(certainly)*. The six response options were coded from −2.5 (certainty that there was no pairing) to 2.5 (certainty that there was pairing).

In the contingency memory questionnaire, participants indicated whether each Pokemon (the two CSs and the three fillers) was a CSpos or a CSneg. Participants were instructed to indicate their contingency memory about the same Pokemons from the attitude measure: *For each of the following characters, please indicate whether it was consistently (i.e., always) presented with positive or negative images and words?* The six response options ranged from *With positive images and words (certainly)* to *With negative images and words (certainly)*, with *(probably)* and *(guess)* options for each in between the extremes. Like Experiment 1, responses to the CSs were coded so that higher values indicated greater memory accuracy, and they were coded from −2.5 to 2.5 with 1 point difference between each option on the scale. The responses to the two CS items (Ruriri and Jigglypuff) were averaged. Like in Experiment 1, an average score of 2.5 indicates perfectly accurate memory, and an average score of −2.5 indicates completely inaccurate memory.

The measures of perceived effect of the pairings on the liking rating were identical to those in Experiment 1.

Results

The findings mostly replicated the results of Experiment 1, with a few minor changes, usually related to the fact that there was no significant EC when the number of CS−US pairings was smaller than 12.

Overall effects

EC occurred and was affected by the number of pairings. Because we reduced the number of pairings substantially, the overall EC effect was very small ($M = 0.26$, $SD = 2.21$), $t(591) = 2.93$, $p = .004$, $d = 0.12$ (Table 1). A regression analysis showed that EC was significantly larger with more pairings, $\beta = .09$, $t(589) = 2.15$, $p = .03$. Specifically, there was no EC in the 4-pairings condition ($M = -0.02$, $SD = 2.18$), $t(210) < 1$, small and nonsignificant EC in the 8-pairings condition ($M = 0.29$, $SD = 2.34$), $t(191) = 1.70$, $p = .09$, $d = 0.12$, and larger and significant EC in the 12-pairings condition ($M = 0.49$, $SD = 2.21$), $t(190) = 3.01$, $p = .003$, $d = 0.22$.

Manipulation awareness was low, and it moderated EC. Only 18% of the participants reported that pairing probably or certainly occurred in the learning task. Another 25% of the participants reported guessing that it occurred. The other 57% of the participants said that it did not occur with different levels of certainty. These reports moderated EC, $\beta = .09$, $t(589) = 2.35$, $p = .02$. In fact, EC was significant only among participants who reported that pairing probably occurred ($M = 0.61$, $SD = 2.53$), $t(80) = 2.16$, $p = .03$, $d = 0.24$, or that it certainly occurred ($M = 1.72$, $SD = 0.56$), $t(25) = 3.06$, $p = .005$, $d = 3.07$. All the rest of the sample did not show EC ($M = 0.10$, $SD = 2.17$), $t(486) = 1$, $p = .32$, $d = 0.05$ ($d = 0.04$, $t < 1$, among participants who reported guessing that pairing did occur).

Contingency memory was poor and was affected by the number of pairings. Most people (61%) did not show accurate memory, with most of them (42%) showing a memory score of 0, thinking that both CSs were paired with the same valence. But, because there were more people who remembered the correct pairing (39%) than the opposite pairing (19%), the memory score was significantly accurate (larger than zero) even in the 4-pairing condition, $t(210) = 2.99$, $p = .0031$, $d = 0.21$. Memory improved when the number of pairings increased, as revealed in the regression in which memory score was predicted by number of pairings, $\beta = .09$, $t(589) = 2.15$, $p = .03$ (Table 1).

Notice that people were generally more accurate in Experiment 1 than in Experiment 2 (see Table 1). The reason was probably the difference between the memory measures that were used in each experiment. In Experiment 1, one memory question forced participants to decide whether Jigglypuff or Ruriri was the CSpos. The other question forced participants to decide which of these two stimuli was the CSneg. That is, the questions suggested that one of these two was paired with USpos and the other with USneg. Because of that, there was a strong negative relationship between the two items, $r(746) = -.81$, $p < .0001$. In contrast, in Experiment 2, participants had to indicate for each stimulus whether it was paired with positive or negative stimuli. Therefore, in Experiment 2, participants were not led to believe that one CS was paired with positive stimuli and the other with negative stimuli. In line with that, in Experiment 2, there was no relationship between the contingency memory for Jigglypuff and the contingency memory for Ruriri, $r(591) = -.06$, $p = .13$. Additionally, in Experiment 2, there was no pairing in the first practice block, which might have made the pairing less noticeable.

The number of pairings did not affect EC when memory was accurate. There was no moderation of the number of pairings on EC when only participants with accurate contingency memory were included in the analysis, $F < 1$. To illustrate, among participants with accurate memory, EC was virtually identical in the 4 pairings ($M = 0.99$, $SD = 2.11$) and the 12 pairings ($M = 0.92$, $SD = 2.60$) conditions. This may suggest a relationship between the effects of the number of pairings on EC and on contingency memory. For instance, one effect may mediate the other.

EC was related to contingency memory. Like in Experiment 1, stronger EC was related to better contingency memory, $r(591) = .36$, $p < .001$. The number of pairings did not moderate this relationship, as revealed by a regression that predicted EC with contingency memory, number of pairings, and their interaction. The regression did not find a significant interaction, $\beta = -.19$, $t(587) = -1.82$, $p = .07$, nor was there a significant effect of number of pairings, $\beta = .06$, $t(587) = 1.57$, $p = .12$. Only the contingency memory score was a significant predictor of EC, $\beta = .53$,

$t(587) = 5.12$, $p < .0001$. This indicates that contingency memory and EC relationship were similarly related regardless of the number of pairings.

Memory affected EC through intentional processes

Reported reliance on contingency memory moderated the memory–EC relationship. Most participants (76%) reported responded *Probably no* or *Definitely no* when asked whether they took into account the contingencies when evaluating the CSs. A total of 14% replied *Not sure*, 8% reported *Probably yes*, and 2% reported *Definitely yes*. As in Experiment 1, reported reliance on memory moderated the relationship between contingency memory and EC. This was indicated by a significant interaction effect, in a regression that predicted EC with contingency memory, $\beta = .39$, $t(587) = 8.64$, $p < .0001$, reported reliance, $\beta = .05$, $t(587) = 1.18$, $p = .24$, and their interaction, $\beta = .11$, $t(587) = 2.29$, $p = .02$. When the interaction term between the number of pairings, the memory score, and the reported reliance was added to the same regression, this interaction term was a significant predictor of EC, $\beta = .24$, $t(586) = 2.20$, $p = .03$, and the memory by reported reliance interaction term was no longer significant, $\beta = -.12$, $t(586) = -1.09$, $p = .28$. The reason was revealed when we repeated the regression analysis separately for each number of pairings condition. We found that the reported reliance moderated the memory–EC relationship only in the 12-pairings condition, $\beta = .27$, $t(186) = 3.38$, $p = .001$, and not in the 4- and 8-pairings conditions, ts < 1. This was probably because of reduced statistical power caused by the low number of participants who reported relying on contingency memory in the 4 and 8 pairing conditions. For instance, in the 4-pairings condition, none of the participants reported a definite reliance on the contingencies, and in the 8-pairings conditions, only 4 people reported definite reliance. The 12-pairings condition had 10 people who reported definite reliance.

To illustrate the contribution of reported reliance to overall EC, participants in the 12-pairings condition who reported that they definitely or probably did not use their memory of the contingencies (72% of the 12-pairings group) showed a small nonsignificant EC, $t(135) = 1.75$, $p = .08$, $d = 0.15$, and people who reported probable of definite reliance (13% of the participants in the 12-pairings group) showed large EC, $t(24) = 3.21$, $p = .004$, $d = 1.01$. The rest of the participants in the 12-pairings group reported being unsure whether they intentionally relied on the contingencies.

The memory–EC relationship was moderated by perceived demand when there were more than 4 pairings. A total of 7% of the participants moderately or strongly agreed with the statement that the desire to follow the researchers' expectations caused them to report liking of the CSpos more than the CSneg; another 13% slightly agreed with the statement, and the rest (80%) disagreed with this statement (slightly, 11%; moderately, 13%; or strongly, 56%). This is comparable to what was observed in Experiment 1. Participants who reported not basing their behaviour on experimenter demand (i.e., they slightly, moderately, or strongly disagreed with the demand statement) still showed correlation between EC and memory, $r(470) = .30$, which seemed smaller than the correlation shown by participants who (slightly, moderately, or strongly) agreed with this statement, $r(121) = .49$. But, this difference was not significant, as was revealed in a multiple regression analysis with EC as the outcome and the predictors contingency memory score, $\beta = .39$, $t(587) = 8.68$, $p < .0001$, reported demand, $\beta = .06$, $t(587) = 1.30$, $p = .19$, and their interaction, $\beta = .08$, $t(587) = 1.73$, $p = .08$. The lack of interaction does not support the moderation hypothesis, but this was due to the 4-pairing condition. Without participants in that condition, the interaction was a significant predictor, $\beta = .14$, $t(377) = 2.44$, $p = .02$. Perceived demand contributed to the EC effect when the number of pairings ranged from 8 to 12 (and between 12 and 32 in Experiment 1), but not when there were only 4 pairings per CS. Probably, participants in that condition were less likely to notice the pairing and infer the experimenter expectation than were the other participants.

EC was related to reported contingency memory even when participants reported no demand compliance. Like in Experiment 1, it was important to examine whether reporting contingency reliance moderated EC even among participants who report that they did not follow perceived demand to prefer the CSpos over the CSneg. We examined this assumption with the 329 participants (56% of the sample) who strongly disagreed with the demand compliance statement. Among this subset, a regression analysis showed that contingency reliance was a significant predictor of EC, $\beta = .14$, $t(327) = 2.54$, $p = .01$. To illustrate, participants who reported that they probably or definitely did not rely on contingency memory ($N = 287$), showed no EC ($M = -0.10$, $SD = 2.30$), $t < 1$, $d = -.04$, whereas the rest of the participants in this subset showed a stronger sign of EC ($M = 0.69$, $SD = 2.09$), $t(40) = 1.93$, $p = .06$, $d = 0.33$. Because these results are similar to those found in Experiment 1, it bolsters the conclusion that more reported reliance on the contingency memory was related to stronger EC even when this reliance was not perceived by the participants as resulting from demand compliance.

The effect of attitudes on contingency memory

False contingency memory. The average correlation between the contingency memory and attitude for the three fillers (for which there were no contingencies) was $r(590) = .34$, $p < .0001$, similar to the average correlation for the CSs, $r(590) = .33$, $p < .0001$. The average correlation between certainty in the contingency memory about each filler and the extremity of the attitude toward that filler was $r(590) = .21$, $p < .0001$, in comparison to $r(590) = .18$, $p < .0001$, for the CSs. Because there was no contingency pairing for the filler stimuli, and thus no experience to create the memory, this correlation implies a causal relationship from attitude to contingency memory.

To build support that this correlation was caused by preexisting attitudes and not by random false memory, we examined whether for each of the three fillers there was a memory bias among people who indicated that they did not guess the contingencies for that filler stimulus. We found that one of the fillers was typically remembered as being paired with positive stimuli, $M = 1.59$, $SD = 1.57$, $t(178) = 13.50$, $p < .0001$, $d = 1.01$, and the other two were typically remembered as being paired with negative stimuli (Ms = −0.63, −1.11, SDs = 1.58, 1.39), $t(118, 145) = -4.32, -9.65$, ps < .0001, ds = 0.40, 0.80. These memory biases matched the average evaluation of the three fillers in the pilot pretest study that surveyed people's evaluation of each stimulus. In that pretest ($N = 655$), the filler stimulus that was often remembered as being paired with positive stimuli in this experiment was rated as significantly more likeable than the neutral point on the scale, $d = 1.37$; the two other filler stimuli were significantly less likeable than the neutral point, ds = −0.35, −0.95. Therefore, we conclude that the evaluation of the three fillers was the cause of the contingency memory.

Attitude also affected the CS contingency memory. Following the same rationale we also tested for memory bias regarding the CSs. We chose the CSs because they were both rated close to neutral (4.72 and 4.88, for Ruriri and Jigglypuff, respectively, on a scale between 0 and 8), yet they were still rated slightly above neutral (ds = 0.37, 0.49). In line with that, people showed a memory bias, remembering, on average, that these stimuli were paired with positive USs (Ms = 0.34, 0.28, SDs = 1.11, 0.94), $t(591, 591) = 7.38, 7.21$, ps < .0001, ds = 0.31, 0.30. This suggests that preexisting attitudes affected contingency memory even for stimuli that were actually paired with USs and supports the speculation that attitudes that were produced by EC may also affect contingency memory.

Attitudes were not the sole cause for contingency memory. Repeating the tests of Stahl and colleagues (2009) for the inference-from-attitude account yielded interesting results. The 12-pairings condition replicated our findings from Experiment 1 and also Stahl and colleagues' findings: Participants who showed preference for the CSneg over the CSpos did not show a reversed contingency memory ($M = 0.11$, $SD = 0.74$), $t(57) = 1.17$, $p = .25$, $d = 0.15$. However, participants in the 4-pairings condition almost showed a significant reverse memory ($M = -0.13$, $SD = 0.58$), $t(75) = -1.89$, $p = .06$, $d = -0.22$. The 8-pairings condition was between the two other conditions, but not significantly different than zero ($M = -0.06$, $SD = 0.61$), $t(70) < 1$, $d = -0.10$. A regression analysis with number of pairings as a predictor of contingency memory, including only participants who preferred the CSneg over the CSpos, revealed that this decline in accurate contingency memory was significant, $\beta = .15$, $t(200) = 2.11$, $p = .04$. We understand these results as describing the mutual influence of attitudes and actual contingency on the contingency memory. When there are enough pairings for noticing the pairing, preference for the CSneg may damage contingency memory but not reverse it. However, when there are only a few pairings, the effect of the actual contingencies on the contingency memory weakens, and, in Experiment 2, the attitudes were almost strong enough to induce contingency memory that is opposite to the actual contingency that occurred in the task.

The memory–attitude relationship was not due to individual differences in response style. The attitude and memory ratings of five different stimuli enabled a test of whether the relationships found in this research between attitude extremity and memory certainty were due to individual differences in how people use such scales. For instance, perhaps people who tend to use the middle of the scale in the attitude measure also did that in the memory measure. If that is the case, then the attitude–memory relationship should be similar regardless of whether the attitude and the memory pertain to the same stimulus or to a different stimulus. That is, if this relationship is simply due to scale usage, then the reported confidence in one's memory toward one CS should be equally related to the extremity of the reported attitude toward that CS and toward the other CS. To test that hypothesis, we looked at the 25 correlations between the five attitude extremity and five memory confidence scores (i.e., the absolute score of the attitude responses and of the memory responses pertaining to each of the two CSs and three fillers). The five strongest correlations were the correlations between the memory and the attitude measure that pertained to the same stimulus (e.g., the extremity of the memory response to Jigglypuff and the extremity of the attitude toward Jigglypuff). If individual differences in scale usage were the only reason for the relationship between attitude extremity and memory certainty, then the probability that the five strongest correlations in the memory–attitude extremity matrix would be the five relationships that shared the same stimulus would have been smaller than $p = .0001$. Therefore, it is clear that individual differences in scale usage were not the reason for the relationship observed in our research between the extremity of the attitude toward each stimulus and the confidence in the contingency memory regarding that stimulus.

Evidence for a direct link from pairing to contingency awareness or EC

There was no EC without accurate contingency memory. Like in Experiment 1, participants with inaccurate contingency memory showed a reverse EC, matching their memory, not the actual contingencies ($M = -0.31$, $SD = 2.07$), $t(361) = -2.87$, $p = .004$, $d = -0.15$. This time, however, the reverse EC was moderated by the number of pairings. A regression revealed that it was smaller when there were more pairings, $\beta = .13$, $t(359) = 2.45$, $p = .01$. The reverse EC was significant in the 4-pairings condition ($M = -0.54$, $SD = 2.03$), $t(138) = -3.15$, $p = .002$, $d = -0.26$, and in the 8-pairings condition ($M = -0.44$, $SD = 2.13$), $t(116) = -2.23$, $p = .03$, $d = -0.21$, but not in the 12-pairings condition ($M = 0.12$, $SD = 2.01$), $t(107) < 1$, $d = 0.06$. This change might be explained by the fact that among these inaccurate participants, the inaccuracy was marginally stronger in the 4- and 8-pairings conditions (Ms $= -0.22$, -0.22, SDs $= 0.35$, 0.33) than in the 12-pairings condition ($M = -0.15$, $SD = 0.29$), $t(359) = 1.76$, $p = .08$, $d = 0.22$.

Participants who did not show EC still showed accurate contingency memory. Participants who did not prefer the CSpos over the CSneg showed a very small yet significantly accurate memory ($M = 0.08$, $SD = 0.64$), $t(355) = 2.44$, $p = .02$, $d = 0.08$. This was moderated by the number of pairings, $\beta = .15$, $t(353) = 2.78$, $p = .006$, reflecting the fact that memory score was better than chance among people who showed no EC only in the 12-pairing condition ($M = 0.23$, $SD = 0.71$), $t(106) = 3.26$, $p = .002$, $d = 0.32$ (4 pairings, $d = -0.02$; 8 pairings, $d = 0.09$). This may reflect the importance of contingency awareness in EC because, as reported earlier, the 12-pairing condition was the only condition that showed significant EC.

GENERAL DISCUSSION

In two experiments, pairing neutral CSs with valenced USs caused changes in liking and accurate memory of the CS–US contingencies. These effects were moderated by the number of pairings, but with an asymptote at 12 pairings beyond which more pairings did not affect EC or the accuracy of contingency memory. Despite the overall EC and above-chance contingency memory, many participants did not show preference for the CSpos over the CSneg, and many did not show accurate contingency memory. The variation in EC and memory was related. People who showed more accurate and more confident contingency memory also showed stronger EC. The evidence also suggested that contingency awareness affected EC and that intentional processes contributed to that effect. We also found evidence that preexisting attitudes affected contingency memory, suggesting that contingency memory is not exclusively affected by awareness of the pairing during the task. Finally, we found no evidence for EC without awareness, but contingency awareness was observed even without EC. We now discuss each of these four sets of findings in more detail and end with a discussion of the implications of our findings for models of EC.

Overall effects

In both experiments, we observed significant EC and contingency awareness. Because we manipulated the number of CS–US pairings, our experiments provide information about the impact of the number of CS–US pairings on EC. As reviewed by De Houwer et al. (2001), a few studies found an increase in the magnitude of EC when the number of pairings increased (Baeyens et al., 1992; Sachs, 1975; Staats & Staats, 1959), but others found no effect (Martin & Levey, 1978; Stuart, Shimp, & Engle, 1987). One study even suggested that EC effects decrease in magnitude after the number of pairings passes 20 (Baeyens et al., 1992).

The present research found that EC was stronger and contingency memory more accurate when the number of pairings increased but only up to 12 pairings. Beyond that, no increase was observed with additional pairings. Further, among those who remembered the contingencies, the number of pairings did not change the magnitude of EC. When contingency memory was accurate, EC was equally strong in the 4-pairings ($d = 0.47$) and in the 12-pairings ($d = 0.35$) conditions. This may suggest that repetition of the pairings is unnecessary for EC after people already remember the contingencies. The reasons why memory would be important for EC might be related to the nature of the causal relationships between them. This is discussed in the next sections.

Direct effects of the contingencies

We found virtually no evidence that EC can occur without accurate memory of the contingency. Therefore, we do not have any evidence that CS–US pairings can directly affect EC without the mediation of contingency awareness. The fact that we did not find evidence for EC without contingency awareness is surprising considering past evidence to the contrary, and the fact that we modelled our procedure on previous research in which people showed EC without accurate contingency memory (Jones et al., 2009; Olson & Fazio, 2001, 2002, 2006). Based on that literature, we expected that with a sample size as large as ours, we would find EC with and without contingency awareness. In using large samples we aimed to ascertain that a null finding could not be easily attributed to lack of power. The fact that our results were replicated in two separate experiments further decreases the likelihood of such a possibility.

Assuming that past demonstrations of EC in the absence of contingency awareness are not due to statistical "flukes", one might argue that differences in certain procedural elements were responsible for the divergent results. One important difference might be the measurement of contingency awareness. The present research measured valence awareness (Stahl & Unkelbach, 2009), in which participants were questioned about the valence of the US with which a CS was paired rather than the specific identity of the US. In comparison, in their studies, Olson and Fazio (2001, 2002) used an identity memory test, in which participants were questioned about specific identity of the US with which a CS was paired. The fact that Olson and Fazio found EC without accurate memory, and we did not, is in line with recent findings showing that identity memory is not necessary for EC, whereas valence awareness is necessary (Stahl & Unkelbach, 2009; Stahl et al., 2009).[2]

Another possible factor that may affect the role of contingency awareness in EC is the evaluative strength of the USs (Jones et al., 2009). Jones and colleagues argued that contingency awareness is necessary for EC only when the USs are strongly evocative. In line with this claim, some (but not all) of the stimuli in our experiments were similar to those identified as strongly evocative by Jones and colleagues. However, these stimuli were the same as those used as USs in the other demonstrations of EC without accurate contingency memory (Olson & Fazio, 2001, 2002, 2006). Therefore, more research is warranted before one can be confident that the strength of the evaluative reaction to the USs is a critical parameter that determines the role of contingency awareness in EC. It is, however, difficult to exclude the possibility that our failure to find EC in the absence of contingency awareness is due to other subtle aspects of our procedure. Nevertheless, because of the large power of the statistical tests, our data do provide a genuine failure to observe EC in the absence of contingency awareness. This demonstrates that EC in the absence of contingency awareness may be observed only under certain conditions. Maintaining the claim that EC can occur in the absence of contingency awareness will require delineating the conditions under which such effects can be observed.

The effect of contingency memory on EC

An important new finding of our studies was that some participants reported to have intentionally used the CS–US contingencies as a basis for evaluating the CSs. These people also showed a stronger relationship between contingency awareness and EC, and, more generally, they showed stronger EC effects. Without these people, EC was not significant in either of the experiments. This evidence is based on self-report. However, people do not always attribute their behaviour to the correct causes (Nisbett & Wilson, 1977). Therefore, an alternative account of these findings—a *retrospective inference* account—is that when contingency memory and attitudes were more similar, people inferred that they must have used the contingencies as a source for the evaluation of the stimuli. That is, they observed the memory–EC relationship and inferred (rather

[2] Olson and Fazio (2001) also examined whether participants who did not choose the correct US in the identity memory test at least chose the US of the same valence. They found EC even without participants who showed this kind of awareness. Still, this is not the same valence awareness measure used by us and by Stahl et al. (Stahl & Unkelbach, 2009; Stahl et al., 2009). That is, Olson and Fazio did not ask the participants directly what valence was paired with each CS. Additionally, Jones et al. (2009) reported that they removed from their analyses participants who showed valence awareness in their response to an open-ended postexperimental question regarding the rules they noticed in the learning procedure. But of course, a question in an open-ended format is not the same as the valence awareness measure used by us and by Stahl and colleagues. Notice also that we probed for participants' awareness of the rules of stimuli presentations in a multiple-choice format (the manipulation awareness) and found no EC without manipulation awareness.

than experienced) that EC is the result of deliberate reliance on the observed contingencies when evaluating the CSs.

We judge the *reliance on memory* account as more likely than the *retrospective inference* account for the two following reasons. First, in Nisbett and Wilson's (1977) studies, people failed to attribute their behaviours to causes that correlated with the measured effect (across participants) and reported causes that did not actually correlate with the effects. In our studies, contingency memory and EC correlated, and participants who reported remembering indeed showed stronger memory–EC correlation. Therefore, a self-misattribution process in our experiments would be more extreme than those found in the past: It would require the participants to correctly detect a correlation but then confuse the cause with the effect by claiming an intentional process that actually never happened. Our interpretation is the more simple assumption that although people have limited self-knowledge, there are many processes about which they can report correctly (Smith & Miller, 1978) and that intentionally relying on contingencies memory when rating the CSs is one such process.

The second argument for our conclusion that contingency memory affected EC is based on a simple line of reasoning: (a) The finding that people tended to show accurate contingency memory even when they did not prefer the CSpos over the CSneg suggests a genuine memory of the pairings (i.e., not inferred based on EC); and (b) the finding that some people reported using the contingencies for evaluating the CSs suggests that they thought that contingencies were a basis for evaluation. Therefore, there is little reason to assume that people who had this belief and also remembered the contingencies did not put their belief into practice and actually relied on the contingencies when evaluating the stimuli.

Further evidence suggests that some participants relied on the contingency because they thought that the researchers expected them to do so. Reporting demand was related to stronger memory–attitude relationship and stronger EC. Therefore, it seems that some people noticed the contingency and believed that the expected behaviour in this study was to evaluate the CSs according to the contingency. This is a disconcerting artefact of the experimental settings and does not reflect the kind of attitude formation that most researchers who use EC procedure wish to study. Our results illustrate how important it is that researchers always carefully assess whether participants show demand compliance.

The effect of attitudes on contingency memory

We found that preexisting attitudes affected contingency memory. In the control conditions, stimuli that were not paired with valenced USs were still remembered by some people as if they have been paired. Importantly, this false contingency memory was related to the attitude that people had toward those stimuli. We think that this relationship was not due to false memory shaping the attitudes because the memory was biased. That is, people tended to remember that one set of stimuli were paired with positive USs and that another set of stimuli were paired with negative USs. Specifically, people tended to remember that liked stimuli were paired with positive USs, and disliked stimuli were paired with negative USs. A similar memory bias in the conditions that did pair the two CSs with valenced USs suggested that preexisting attitudes affect contingency memory in that case as well.

These findings suggest that like other memory tasks (Johnson, Hashtroudi, & Lindsay, 1993), contingency memory is prone to confabulation and source errors (see also Tomarken, Mineka, & Cook, 1989). Additionally, and most important to EC research, it suggests that attitudes are a source for memory report and thus contaminate the most commonly used measurement of awareness. Although our research could not test this directly, it is reasonable to assume that in addition to preexisting attitudes, attitudes that are the result of EC can also affect contingency memory. In fact, this may happen even if the EC is the result of intentional usage of contingency memory, as found in the present investigation. In that case, the newly formed attitude can serve as another cue to help people remember the contingency.

It is obvious, however, that not all contingency awareness in our research was caused by EC. Even people who showed no EC still showed significantly accurate contingency memory. This suggests that they had actually noticed the pairing and did not confabulate it based on their attitudes. Related to that, people who showed preference for the CSneg over the CSpos did not show a reversed contingency memory. Finally, considering our findings about the intentional reliance on memory, it seems unlikely that EC caused false contingency awareness that then caused people to believe that they intentionally used their contingency knowledge in order to evaluate the CS. Nevertheless, it might be the case that we, and others, have failed to find EC without contingency awareness because EC sometimes causes accurate contingency memory that is then interpreted as contingency awareness.

Implications for models of EC

Until recently, EC was most often explained in terms of the automatic formation of associations in memory between the representation of the CS and (certain elements of) the representation of the US (e.g., Baeyens, Eelen, & Crombez, 1995; Jones et al., 2009; see Martin & Levey, 1978, for a related account). These association formation models have been challenged by propositional models according to which EC is mediated by the formation of propositions about the CS–US relation (De Houwer, 2007, 2009; De Houwer et al., 2005; Mitchell et al., 2009; Pleyers et al., 2007). Unlike CS–US associations, propositions about CS–US relations are formed in a conscious, controlled manner. Therefore, whereas association formation models of EC predict that EC can occur automatically, propositional models lead to the prediction that EC is nonautomatic in that it requires the presence of contingency awareness, processing resources, goals, and time (see De Houwer, 2009, for details).

Recent studies provide support for the nonautomatic nature of EC in showing that the EC occurs only in the presence of contingency awareness (e.g., Dawson et al., 2007; Pleyers et al., 2007; Stahl et al., 2009), attention resources (Pleyers et al., 2009), and appropriate processing goals (Corneille, Yzerbyt, Pleyers, & Mussweiler, 2009). The fact that we also failed to find EC in the absence of contingency awareness supports the conclusion that EC is based on nonautomatic processes and thus adds to the evidence for propositional models of EC. As noted above, our results go beyond previous failures to observe unaware EC in that the lack of unaware EC in our study cannot be attributed to a lack of power.

Another novel finding that supports the idea that EC depends on contingency awareness is the observation in Experiment 2 that the impact of the number of pairings on EC was modulated by contingency memory. An increase in the number of pairings increased the magnitude of EC but only if all participants were included in the analyses. When the analysis included only participants who accurately remembered the contingencies, this increase was not observed. This is in line with the hypothesis that a CS–US contingency has an effect on liking only after participants become aware of the contingencies. The number of times that a CS is paired with a US of a certain valence seems to have an effect only by increasing the likelihood that participants become aware of the CS–US contingency. In support of this conclusion, in Experiment 1, larger number of pairings (32 in comparison to 12) did not lead to better contingency memory, and it also did not cause stronger EC (see Table 1).

The main theoretical contribution of our research is, however, the evidence it provides for one possible way in which propositions about CS–US contingencies can lead to EC effects. Some researchers (Baeyens et al., 2009; Shanks, 2007) have criticized propositional models of EC by pointing out that these models do not specify a plausible mechanism by which propositions about CS–US relations can lead to EC.

De Houwer et al. (2005) argued that participants might intentionally use such propositions in order to justify their evaluation of the CSs. For example, the fact that a CS repeatedly goes together with a negative US might be seen as a negative property of the CS and thus as a valid reason for disliking the CS. Our data provide the first evidence to support this idea. First, the fact that a significant proportion of the participants indicated that they did use their memory of the CS–US contingencies for determining the liking of the CSs shows that it is not unreasonable to assume that participants regard knowledge about CS–US contingencies as a source of information for determining their evaluation of the CSs. Second, the fact that the magnitude of EC was related to self-reports about reliance on memory is difficult to explain without the assumption that participant actually used their knowledge of the contingencies when evaluating the stimuli.

Our results, however, do not allow for the conclusion that all instances of EC are due to the intentional use of contingency knowledge. In addition to the fact that it is difficult to prove such general statements, we observed significant EC in participants who reported that they did not base their evaluations on knowledge of the CS–US contingencies, but exhibited accurate contingency memory. Although one could argue that people sometimes fail to verbalize their conscious knowledge, this observation does suggests that intentionally using contingency knowledge is not necessary in order to obtain EC. It is important to realize, however, that propositional models are not incompatible with the idea that propositions can lead to EC in an unintentional manner. The core of these models is the assumption that EC is mediated by the nonautomatic *formation* of propositions about CS–US contingencies. This implies that CS–US pairings can influence the liking of a CS only after a conscious proposition has been formed about the CS–US contingency. It does not imply, however, that the effect of the proposition on the liking of the CS is intentional. Once a proposition has been formed, it could in principle influence the liking of the CS also unintentionally—that is, independent of whether participants have the goal to take the proposition into account when evaluating the CSs. For instance, merely endorsing the proposition that a CS was paired with positive stimuli might be sufficient to result in a liking of that CS even when there is no intention to change the liking of the CS on the basis of that proposition. Future research is necessary to determine whether propositions about CS–US contingencies can have these unintentional effects. Our data do show, however, that at least in some cases, EC results from an intentional use of conscious propositional knowledge about CS–US contingencies.

CONCLUSION

Our data allow for three conclusions. First, they confirm the conclusion that EC is related to contingency awareness. Our data add to previous evidence on this issue by demonstrating the absence of EC in the absence of contingency awareness even with extremely powerful statistical tests. The results also demonstrate for the first time that the impact of number of CS–US pairings on EC is modulated by contingency awareness. This may suggest that increasing the number of pairings has an effect on EC only because it increases the probability that participants become aware of the contingencies. Second, we demonstrate for the first time that EC is related to self-reports regarding the intentional use of contingency knowledge. These results support the conclusion that EC is at least in some cases due to the fact that participants use contingency knowledge to determine their liking of the CSs. Third, contingency memory is not an exclusive measure of contingency awareness. Several aspects of our results show that attitudes towards CSs can bias memory about CS–US contingencies. The first and second of these conclusions are in line with propositional models of EC.

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