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Distinguishing the role of conscious and unconscious knowledge in Evaluative Conditioning

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Abstract

Evaluative conditioning (EC) refers to a change in liking of a conditioned stimulus (CS) subsequent to its repeated pairing with a valent stimulus (US). Two studies that bring new light on the highly debated question of the role of awareness in EC were conducted. We developed an innovative method motivated by higher order and integration theories of consciousness to distinguish between the role of conscious and unconscious knowledge about the pairings. On each trial of the awareness test, participants had to indicate the valence of the US associated with a given CS and to make a '*structural knowledge attribution'* by reporting the basis of their response. Valence identification accuracy was used to evaluate knowledge while the knowledge attribution was used to measure the conscious status of knowledge. Memory attribution indicated conscious knowledge about the pairings while feeling-based and random attributions indicated unconscious knowledge. A meta-analysis of the two studies revealed that valence identification accuracy was above chance level for memory and feeling-based attributions but not for the random attribution. EC was found in the three attributions. While EC effect size was medium for the memory attribution it was small for feeling-based and random attributions. Moreover, Experiment 2 included a delayed test. EC was still present 24 hours after the conditioning took place. The results obtained for memory and feeling-based attributions suggest that both conscious and unconscious knowledge may underlie EC. The results obtained for random attribution suggest that EC may also occur without any knowledge of US valence.

Keywords: evaluative conditioning, contingency awareness, conscious knowledge, unconscious knowledge, attitude learning

Distinguishing the role of conscious and unconscious knowledge in Evaluative Conditioning

One of the most basic mechanisms by which attitudes (i.e., our likes and dislikes) may be formed or changed is evaluative conditioning (EC). EC is based on a very simple procedure in which a conditioned stimulus (CS) is repeatedly presented in close spatio-temporal contiguity with an unconditioned stimulus (US) of either positive or negative valence. An EC effect is demonstrated if the attitude toward the CS changes in the direction of the US valence. This effect has been replicated many times (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). However, the role of awareness in EC remains highly debated. While some studies suggest that EC only occurs when the subject is consciously aware of the CS-US contingencies, others support the opposite conclusion (Sweldens, Corneille & Yzerbyt, 2014).

The theoretical debate has essentially focused on the role of awareness of the CS-US contingencies during the conditioning phase, in other words during the encoding of the information (Corneille & Stahl, 2018). Experiments that have addressed this question in the most direct way manipulated awareness during the conditioning phase. For example, experiments used subliminal presentation of stimuli. Some of these studies support the view that awareness of stimuli is not required for EC to occur (e.g., Dijksterhuis, 2004; Field & Moore, 2005). However, they have been criticized on methodological grounds and their conclusions have been challenged empirically (Stahl, Haaf, & Corneille, 2016; Stahl & Bading, 2019). Other studies manipulated cognitive load during the encoding of information in order to diminish awareness of the CS-US contingencies. The results support the view that taxing participants’ cognitive resources prevents EC (Dedonder, Corneille, Yzerbyt, &

Kuppens, 2010; Mierop, Hütter, & Corneille, 2017; Pleyers, Corneille, Yzerbyt, & Luminet, 2009) to the extent that the same type of material is used in the conditioning and the distracting task (Halbeisen & Walther, 2015). Besides the role of awareness during the encoding of information, another theoretical question is the one of the awareness of the CS-US associations after the conditioning phase, when the subject is subsequently asked to evaluate the CS. Few studies have attempted to answer it directly (Gast, De Houwer, & De Schryver, 2012; Halbeisen, Blask, Weil, & Walther, 2014). The current paper will focus on this last question.

Awareness during encoding and during CS evaluation are two different things. As pointed out by Gawronski and Walther (2012), measurements of awareness made after the conditioning phase remain ambiguous about the role of awareness during encoding. Similarly, awareness during encoding does not necessarily imply awareness during CS evaluation. For example, a person may be perceptually aware of a given CS and a given US or even be aware that they are presented contiguously at the time they are displayed. However, when subsequently evaluating the CS, he or she may be unaware that the CS has been repeatedly paired with the US. For this reason, we relied on a measure taken at the time of testing to study the role of awareness during CS evaluation. A recent account of EC (Gast, 2018) postulates that the vast majority of EC effects depend on the awareness of the relation between CS and US valence during attitude expression. In this view, awareness during the conditioning phase is only a prerequisite. It is thus important to test whether, at the time of CS evaluation, EC is exclusively sustained by conscious knowledge or whether unconscious knowledge about the pairings may also give rise to EC effects.

Several methods have been used to measure awareness after the conditioning phase. It has recently been proposed that awareness should be measured for each pair rather than for each participant as a given participant is unlikely to be aware of either all or none of the CS–US pairings (Pleyers, Corneille, Luminet, & Yzerbyt, 2007). In these studies, a participant was considered as aware of a given association when he was able to identify the US associated with the CS and as unaware when he did not select the correct US. Stahl, Unkelbach and Corneille (2009) refined this method in order to measure the awareness of US valence. Their results suggest that awareness of US valence is crucial while US identity does not further contribute to EC. It is thus important to measure awareness of US valence (Sweldens et al., 2014). These are *objective measures* of awareness, as any correct identification of the US or of its valence is assumed to be based on conscious knowledge, regardless of the subjective experience of the participant. They have been criticized because participants may identify US identity or its valence on the basis of their attitude toward CS which may skew awareness measurement (we will come back to this question in Experiment 2) or because unintended retrieval processes may lead to US identification (Hütter, Sweldens, Stahl, Unkelbach & Klauer, 2012; Halbeisen et al., 2014). The present studies differentiate from these last two approaches because rather than focusing on the role of retrieval processes they seek to assess the conscious status of knowledge itself, namely the awareness of knowing. To do so, we introduced a novel *subjective measure* of awareness (Wierzchoń, Asanowicz, Paulewicz & Cleeremans, 2012; Wierzchoń, Paulewicz, Asanowicz, Timmermans & Cleeremans, 2014).

Any measure of awareness presupposes a theory (Dienes & Seth, 2010, 2018). The use of objective measures relies on the assumption that there is a perfect overlap between performance and awareness (Timmermans & Cleeremans, 2015). However, there is considerable evidence showing that a person can report she is guessing while having a performance well above baseline (e.g., Dienes, 2012). Hence, from the subject point of view there may be a dissociation between awareness and performance. Subjective measures are designed to capture this dissociation. Those measures are motivated by global workspace (and other integration theories) and higher order theories (Rosenthal, 2005; Michel et al., 2018) which are the dominant theories of consciousness amongst psychologists, neuroscientists and other researchers in the field. According to global workspace theory (Baars, 1993; Dehaene, Changeux, & Naccache, 2011) information becomes conscious when it enters a ‘global workspace’ that broadcasts it to many processors in the brain. As a result, information becomes widely available to many cognitive processes and can be used flexibly. For example, one can exert voluntary control over conscious content or report it while it is not the case for unconscious content. Higher order theory of consciousness relies on another characteristic associated with consciousness to differentiate conscious form unconscious contents. By this theory, one has to have a meta-representation of having a mental content (i.e., a higher order state) to be aware of that content. In other words, one has to be aware of knowing. If information is in the global workspace, it is thereby available to mechanisms that produce higher order states. A first order state is just about the world; it allows discriminations about the world. Unconscious knowledge would be an example of such a state. A second order state has content about mental states; the second order states specifically relevant to consciousness assert one is in a lower order state. Thus, on the global workspace and higher order theories, the conscious status of mental states is revealed by the ability of people to tell they are in that state (seeing, knowing, etc.). For example, the ability to indicate the valence of the US paired with a given CS may be based on either conscious or unconscious knowledge. For the knowledge to be considered as conscious subjects must be aware that they know the valence of the US. We developed a subjective measure of the conscious status of knowledge in the EC paradigm motivated by the higher order and global workspace theories of consciousness.

In addition of asking participants to indicate the valence of the US associated with each CS as in previous research (e.g., Pleyers et al., 2007), we asked them if they remembered having seen this CS presented with either a positive or a negative US. This allows us to test for awareness of knowing. Above chance level identification is regarded as based on conscious knowledge if the participant reports remembering having seen the pairs. In contrast, above chance level identification is regarded as based on unconscious knowledge if the participant reports that he doesn’t remember having seen the pairs. This type of subjective measure has been used in various implicit learning paradigms, and these studies are the first to adapt it to a classical EC paradigm.

Subjective measures of awareness in implicit learning

Dienes and Scott (2005) introduce this way of measuring the conscious status of knowledge in artificial grammar learning. In this paradigm, after incidental exposure to apparently random strings of letters, participants classify new strings as obeying or violating a set of rules. For each classification they are asked to indicate the basis of their response (random guessing, intuition, familiarity, conscious rules or memory). Experiments using this method demonstrated that classification of the test strings was above chance level not only when participants made memory and rules attributions (which indicates conscious knowledge of the structure of the material) but also when they made intuition, familiarity or guessing attributions (which indicates unconscious structural knowledge) (e.g., Scott & Dienes, 2008; see Dienes, 2012, for a review).

The same kind of results using the structural knowledge attributions have been obtained not only with artificial grammar learning (e.g. Ivanchei, & Moroshkina, 2018; Jurchiş, & Opre, 2016), but also with other implicit learning paradigms, such as sequence learning (e.g. Fu, Dienes & Fu, 2010), symmetry learning (e.g. Jiang, Zhu, Guo, Ma, Yang & Dienes, 2012; Ling et al, 2018), second language learning (e.g. Paciorek & Williams, 2015; Rebuschat, 2013; Rogers, Revesz, & Rebuschat, 2016), probabilistic category learning (e.g., Kemény & Lukács, 2013), learning conjunctive rule sets (Neil & Higham, 2012), and learning multiple grammars (Wan, Dienes, & Fu, 2008; Norman, Scott, Price, Jones, & Dienes, in press). Hence, participants may acquire knowledge that they are aware of as well as knowledge that they are not aware of in various implicit learning paradigms. We will be the first to adapt structural knowledge attributions to a classical EC paradigm.

Overview of the experiments

EC is one of the simplest incidental learning paradigms. Participants are incidentally exposed to pairs of stimuli and learn the structure of this material (i.e., the CS-US pairings) presumably without full awareness of what has been learned. We thus adapted Dienes and Scott's (2005) attribution method to test for the awareness of what has been learned. To do so, we designed a valence awareness test in which participants were first asked to indicate the valence of the US associated with a given CS. This forced choice served as an objective measure of US valence awareness. In addition, we took a subjective measure of awareness by asking participants to report the basis of their response. They could make a memory attribution by reporting that they responded positive or negative because they remembered having seen the CS presented with a positive or a negative picture. They could make a feeling-based attribution by reporting that they did not remember with which picture the CS had been presented and that their response was based on an intuition or a feeling of familiarity. They could make a random attribution by reporting that they responded completely randomly, and that they don't have any confidence in their response.

We relied on the valence identification task to evaluate whether performance was above chance in each attribution. Provided that this is the case, by making a memory attribution, participants indicate that their knowledge about the structure of the pairings (i.e., their structural knowledge) is conscious as they are aware of the basis of their responses. By contrast, the other types of attributions indicate that the structural knowledge is unconscious as participants are not aware of the basis of their responses. Besides the distinction between conscious and unconscious structural knowledge, the knowledge attributions also allow distinguishing between conscious and unconscious judgement knowledge. In the current task, judgement knowledge refers to the knowledge about the accuracy of the responses on the valence identification test. A memory attribution indicates that both judgment and structural knowledge are conscious (i.e., “I have some confidence in my response, and I know why”). A feeling-based attribution indicates that judgment knowledge is conscious and structural knowledge unconscious (i.e., “I have some confidence in my response, but I don’t know why”). Finally, a random attribution indicates that both structural and judgment knowledge are unconscious (i.e., “I don’t have any confidence in my response, and I don’t know why I responded like this”).

We conducted two studies based on using structural knowledge attributions which allowed us to examine not only whether correct valence identification is necessary for EC to occur, but also whether correct identification is necessarily based on conscious knowledge about the pairings. This new method brings new light on the question of awareness which is central in characterizing the nature of EC.

As conscious and unconscious structural knowledge may be acquired in various implicit or incidental learning paradigms (Dienes, 2012), we expected that US valence identifications (i.e., structural knowledge) would be above chance level in all attributions. First-order knowledge about the world enables appropriate engagement with the world. Awareness of structural knowledge requires a second order state, with content that one has that structural knowledge; but such content gives no additional information for actually acting on the world (Dienes, 2012). On this analysis, EC effects should obtain whether the knowledge about the pairings is conscious or unconscious. Hence, EC should obtain for the memory attribution (i.e., conscious structural knowledge) as well as for the feeling-based (intuition and familiarity) and random attributions (i.e., unconscious structural knowledge). Besides these main analyses, we also examined whether US valence identification moderates EC (as it was done in previous research). Because representations of the link between CS and US valence (i.e. structural knowledge) would allow both valence identification and EC, valence identification should moderate EC. More specifically, on this analysis, an EC effect should obtain only when US valence has been correctly identified.

Experiment 1

Effect size and statistical power

On the basis of the mean EC effect size (Cohen's d = .52) obtained in the most recent meta-analysis (Hofmann et al., 2010), a power analysis indicated that 51 participants would be needed to achieve a 95% power (G*Power; Faul, Erdfelder, Buchner, & Lang, 2009). We systematically collected larger samples to accommodate for potential data loss (e.g., all participants might not use all attributions). The power analysis is used to legitimate frequentist decisions by the reader, bearing in mind the Type II error rate is controlled only with respect to the average previously obtained relevant effect size. In fact, we will be making decisions with reference to Bayes factors.

Participants and design

Eighty-seven Clermont Auvergne University students (M_{age} =19.60; SD_{age} = 1.47; 69 females) took part in the experiment. All participants were native French speakers and gave their written informed consent to participate. They received course credits in return for their participation. The ethic committee of Clermont Auvergne University approved the ethic applications for Experiments 1 and 2 (approval number: 2016-CE04). The design of the study included US valence (positive vs. negative) and time of measurement (preratings vs. postratings) as within-subjects factors.

Materials

A set of 60 black-and-white pictures of human faces (30 females, 30 males) was used as the CS repertory (Hütter & Sweldens, 2013; Lundqvist, Flykt & Öhman, 1998). For each participant, CS were selected from that pool based on an initial evaluative rating. Twenty pleasant and 20 unpleasant pictures from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008) served as US. CS and IAPS numbers of US are available on the Open Science Framework (https://osf.io/unbem/?view_only=3d240471cec448d1984f96ad145a3fbc).

Procedure

Participants were first asked to rate the extent to which they liked 60 faces on a continuous scale with the endpoints “not at all” and “enormously”, converted into a 400-point scale. They were asked to rate each face within 10 seconds. If they exceeded this time-limit they were simply asked to hurry up. For each participant, 40 faces with a medium rating were selected as CS. Before the conditioning phase, participants were instructed to look at the pictures that would be presented and to press the space bar when a fixation cross was presented. In the subsequent conditioning phase, each US was randomly paired with one of the selected CS. The conditioning phase consisted of 6 presentation blocks. In each presentation block, the 40 CS-US pairs were presented simultaneously for 1500 ms in a random order with an interstimulus interval of 100 ms. For half of the presentation blocks, CS were displayed to the right of the US and for the other half they were displayed to the left. In addition to the CS-US pairs, 4 fixation crosses were displayed in random order within each block. After the conditioning phase, participants were given explanations concerning the next phase of the experiment. The following instructions were displayed:

You will answer to 40 series of three questions. 1) You will first rate to what extent you like a face. 2) During the previous phase of the experiment each face has been presented several times together with a positive or negative picture. A face will be presented anew. You will have to try to remember the picture that has been paired with this face to answer the following question: Was the picture paired with this face positive or negative? 3) You will then answer the following question: “What is the basis of your answer to the previous question?” – My memory: I have chosen positive/negative because I remember that this face has been presented at the same time as a positive/negative picture. – An intuition: I don’t remember with which picture this face has been presented. However, I have some confidence in my response, but I could not explain why. – A feeling of familiarity: I don’t remember with which picture this face has been presented. However, I have the feeling that this face was associated with something positive/negative, but I don’t know where it comes from. – I responded totally randomly: I don’t have any confidence in my answer.

After confirming that they had understood the instructions, participants started the test phase. The test phase comprised 40 series of three questions: an evaluation question, a valence identification and an attribution question. Participants were given 10 seconds to rate each face. The US identification and attribution questions were displayed on the same screen. Participants were given 20 s to answer both questions. If they exceeded this time-limit, they were simply asked to hurry up. Hence, the measurement of US valence awareness was made immediately after evaluative ratings to avoid any forgetting (Berry & Dienes, 1993; Shanks &

St. John, 1994). At the end of the experiment, they provided demographic information, were thanked and debriefed.

Data analysis

The data of the two experiments are available on the Open Science Framework at https://osf.io/unbem/?view_only=3d240471cec448d1984f96ad145a3fbc.

Bayes factors (*B*) were used to assess strength of evidence (Wagenmakers et al., 2017). Unlike null-hypothesis significance testing, Bayes factors have the advantage of distinguishing sensitive evidence for H_0 from insensitive evidence (which is little or no evidence for or against a hypothesis). A *B* of above 3 indicates substantial evidence for the alternative over the null hypothesis and below 1/3 substantial evidence for the null over the alternative hypothesis. *B*s between 3 and 1/3 indicate data insensitivity in distinguishing null and alternative hypotheses (Dienes, 2014; Jeffreys, 1939; Lee & Wagenmakers, 2013).

Here, $B_{\mathrm{H}(0,\, x)}$ refers to a Bayes factor in which the predictions of H1 were modelled as half-normal distribution with an SD of x (Dienes 2014). The half-normal distribution can be used when a theory makes a directional prediction where x scales the size of effect that could be expected (so x can be chosen from relevant past studies; or it can be set to half of a plausible maximum effect).

We now describe how we modelled H1 for our tests. The expected scale of effect, x, cannot be set by the actual difference being tested but must be derived otherwise. Other aspects of the same data may constrain plausible values of the effect (e.g. the size of an effect overall may constrain how much that effect could be expected to be modified) (Dienes, 2019).

For the effect of evaluative conditioning on liking, the average effect from three previous papers using a similar paradigm to us was 23.5 liking units (when expressed on our 400 point scale) (Hütter & Sweldens, 2013; Hütter et al. 2012, study 2a, 2b and 3; and Mierop et al. 2017, study 1, 2, 3 control condition). Note we only need a rough indication of the expected effect size, as the model of H1 indicates any value between 0 and twice the expected value as plausible. Thus, H1 for liking change was modelled as a half-normal with SD = 23.5 liking units. When analysing data regardless of US valence identification accuracy and when only considering CS for which the correct US valence was identified, we only tested H1. As incorrect knowledge might lead to reverse EC effects we also modelled a H2. While H1 refers to Bayes factors testing the hypothesis that positively paired CS will be evaluated more positively than negatively paired CS, H2 refers to Bayes factors testing the opposite hypothesis according to which positively paired CS will be evaluated more negatively than negatively paired CS. When participants indicated the wrong US valence, we tested H1 as well as H2. H2 for liking change was modelled as a half-normal with SD = 23.5 in the opposite direction.

For valence identification, Stahl et al. (2009 exp 1) using a somewhat similar EC paradigm found percent correct classification as about 15% above baseline. Thus, for identification accuracy we used SD = 15%.

To indicate the robustness of Bayesian conclusions, for each *B*, a robustness region is reported, giving the range of scales that qualitatively support a given conclusion (i.e. evidence as insensitive, or as supporting H0, or as supporting H1), notated as: Rob. Reg. [x1, x2] where x1 is the smallest SD that supports the conclusion and x2 is the largest.

Results

Number of attributions of each type

Table 1 shows the mean number of trials attributed to memory, feelings or random guessing. Participants reported conscious structural knowledge (i.e., knowledge about the structure of the pairings) and conscious judgment knowledge (e.g., having some confidence in the response) by responding memory. Intuition and familiarity attributions were pooled into a ‘feeling-based’ attribution because in each of these attributions, participants reported unconscious structural knowledge and conscious judgment knowledge (Mealor & Dienes, 2012). Provided above chance performance at the valence identification test, random selection responses would reflect instances where both structural and judgment knowledge are unconscious.

Table 1

Number of trials (out of forty) attributed to each response type. Standard deviations appear in parentheses.

	Exp. 1	Exp. 2	Exp. 2 Follow-up
Memory	13.89 (6.61)	11.93 (6.08)	9.55 (6.22)
Feeling-based	17.05 (5.91)	12.88 (6.99)	13.09 (6.11)
Evaluation	n.a.	8.25 (5.30)	9.41 (6.79)
Random	9.06 (5.55)	6.95 (4.76)	7.94 (6.93)

US valence identification

As can be seen in Table 2, there was decisive evidence that the proportion of correct responses at the US valence identification test was higher than chance overall, $t(86) = 11.18$, $p < .001$, $B_{\mathrm{H}(0,\ 15\%\ \mathrm{above\ H0})} = 1.48 \times 10^{26}$, Rob. Reg. [0.10, >100%], Cohen’s $d = 1.20$, and for memory attributions, $t(86) = 15.25$, $p < .001$, $B_{\mathrm{H}(0,\ 15\%)} = 1.25 \times 10^{49}$, Rob. Reg. [0.13, >100%], Cohen’s $d = 1.63$. Similarly, the evidence for above chance performance was strong for feeling-based attributions, $t(86) = 3.45$, $p < .001$, $B_{\mathrm{H}(0,\ 15\%)} = 73.85$, Rob. Reg. [0.52, >100%], Cohen’s $d = .37$. By contrast, there was substantial evidence for chance performance for random attributions, $t(86) = -.147$, $p = .88$, $B_{\mathrm{H}(0,\ 15\%)} = 0.14$, Rob. Reg. [5.84, ∞], Cohen’s $d = -.016$. Hence participants acquired both conscious and unconscious structural knowledge as they performed above chance for memory and feeling-based attributions. However, they did not acquire any structural knowledge in trials attributed to random.

Table 2
Proportion of correct responses at the US valence identification test for each response type.

	Exp 1.			Exp 2.			Exp 2. Follow-up		
	M	SD	n	M	SD	n	M	SD	n
Overall	.62	.10	87	.58	.08	57	.58	.08	56
Memory	.79	.18	87	.78	.16	55	.82	.17	53
Feeling-based	.55	.14	87	.53	.15	56	.53	.15	54
Evaluation	n.a.	n.a.	n.a.	.51	.22	56	.51	.17	53
Random	.50	.22	87	.50	.21	51	.50	.23	49

Note. Chance level = .50.

EC effects

We first computed the difference between preratings and postratings for positively and negatively paired CS. This served as an index of attitude change. We then conducted repeated measures ANOVAs comparing attitude change in positively paired and in negatively paired CS to examine EC effects. We first report the results overall and for each knowledge attribution. Next, we tested whether US valence identification moderates EC and reported results for CS for which US valence was correctly identified and for CS for which US valence was not correctly identified.

The comparison between attitude change in positively paired and negatively paired CS provided decisive evidence for a general EC effect, $F(1,86) = 34.88$, $p < .001$, $B_{\text{H1(0, 23.5 liking units)}} = 6.41 \times 10^6$, Rob. Reg. [0.5, >400], partial $\eta^2 = .289$. The mean difference between attitude change for positively and negatively paired CS can be seen in Figure 1. Next, we examined EC effects separately for each knowledge attribution. We found decisive evidence for an EC effect for memory attributions, $F(1,84) = 39.70$, $p < .001$, $B_{\text{H1(0, 23.5)}} = 7.35 \times 10^7$, Rob. Reg. [0.84, >400], partial $\eta^2 = .321$, substantial evidence for feeling-based attributions, $F(1,85) = 5.20$, $p = .025$, $B_{\text{H1(0, 23.5)}} = 3.25$, Rob. Reg. [1.81, 25.6], partial $\eta^2 = .058$, but no evidence one way or the other for random attributions, $F(1,83) = 1.60$, $p = .21$, $B_{\text{H1(0, 23.5)}} = 0.65$, Rob. Reg. [0, 46.9] partial $\eta^2 = .019$. Finally, to test whether EC may occur in the absence of conscious structural knowledge, we also grouped feeling-based and random attributions into a ‘no conscious structural knowledge’ category. This analysis yielded substantial evidence for an EC effect, $F(1,84) = 8.09$, $p < .01$, $B_{H1}(0, 23.5) = 9.31$, Rob. Reg. [0.86, 75.3], partial $\eta^2 = .087$.

In order to replicate previous findings (e.g., Halbeisen et al., 2014; Pleyers et al., 2007; 2009), we tested whether US valence identification moderated EC. We ran a two (US valence) by two (accuracy of US valence identification) ANOVA. This analysis provided decisive evidence that US valence identification moderated EC, $F(1,86) = 77.79$, $p < .001$, $B_{H1(0, 23.5)} = 3.09 \times 10^{15}$, Rob. Reg. [0.76, >800], partial $\eta^2 = .475$. There was decisive evidence for an EC effect for CS for which US valence was correctly identified ($M_{diff} = 34.9$, 95%CI = [26.7; 48.1]), $F(1,86) = 71.34$, $p < .001$, $B_{H1(0, 23.5)} = 3.80 \times 10^4$, Rob. Reg. [0.53, >400], partial $\eta^2 = .453$. By contrast, there was decisive evidence for a reversed EC effect when US valence was not identified, $F(1,86) = 44.87$, $p < .001$, $B_{H1(0, 23.5)} = 0.017$, Rob. Reg. [0.89, ∞], $B_{H2(0, 23.5)} = 1.06 \times 10^9$, Rob. Reg. [0.49, >400], partial $\eta^2 = .343$. In this case, the mean difference between attitude change for positively and negatively paired CS was negative ($M_{diff} = -20.2$, 95%CI = [-26.2; -14.2]) which indicates a reversed EC effect.

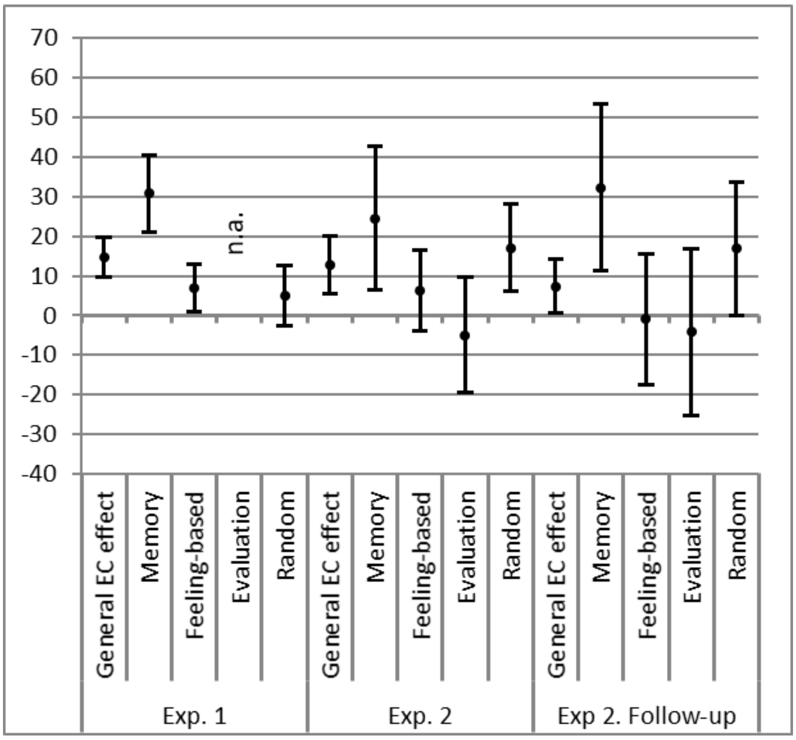

Figure 1. Mean difference between attitude change for positively and negatively paired CS in as a function of attribution type. Error bars represent 95% confidence intervals.

Discussion

The conditioning procedure yielded a large general EC effect. A large EC effect and a high proportion of correct US valence identifications was obtained for the memory attribution; and there was also an EC effect and above chance proportion of correct US valence identifications for the feeling-based attribution. As far as the random attribution is concerned US valence identification accuracy was at chance and there was no evidence one way or the other for the EC effect. Grouping feeling-based and random attributions into a ‘no conscious structural knowledge’ category yielded substantial evidence for EC. Moreover, additional analyses revealed that US valence identification moderated the general EC effect. More specifically, while large EC effects was obtained among CS for which US valence had been correctly identified, a large reversed EC effects was found for incorrect valence identifications.

Our hypothesis that US valence identification would be above chance level and EC would occur in each attribution was supported for memory and feeling-attributions but not for the random attribution. Hence, for the two former attributions, participants acquired some knowledge about the structure of the associations. By making memory attributions they reported that this structural knowledge was conscious while they reported that it was unconscious by making feeling-based attributions. Hence, the results suggest that both conscious and unconscious structural knowledge may underlie EC. At the subjective threshold, awareness does not seem necessary for EC to occur as participants acquired both knowledge that they were aware of and knowledge that they were not aware of.

Additional analyses also replicated previous findings (Halbeisen et al., 2014; Pleyers et al., 2007; 2009) that US valence identification moderates EC and that EC effects are only obtained among CS for which US valence can be identified. In other words, awareness, measured at the objective threshold, seems necessary for EC to occur. Reversed EC effects were found when US valence had not been correctly identified. These effects might seem surprising at first sight. However, several recent studies that distinguished between CS for which US valence had been correctly or incorrectly identified found similar effects (Förderer & Unkelbach, 2013; Stahl & Unkelbach, 2009; Halbeisen et al., 2014). As suggested by Halbeisen and colleagues (2014), false memory of the US could be responsible for these effects. Participants could, in some cases, experience phantom recollection of a wrong US when they made an incorrect response or when they evaluate CS (Brainerd, Payne, Wright & Reyna, 2003).

Participants could also have based their responses at the valence identification test on their attitudes toward CS (Hütter et al., 2012, but see Mierop et al., 2017). This might have contributed to the finding that EC effects were found for correct US identifications while reversed EC effects were found for incorrect valence identifications. In this first experiment, US valence identification immediately followed CS evaluation. This procedure minimizes any forgetting that might have led to underestimate awareness (Shanks & St. John, 1994). However, this procedure might have strengthened the tendency to respond to memory questions on the basis of attitudes. Hütter et al. (2012) suggested that conditioned attitudes, acquired in the absence of memory of US valence, could lead to indicate the correct US valence which would in turn lead to overestimate contingency awareness and underestimate unaware EC (at the objective threshold). Furthermore, when pre-existing attitudes toward CS happen to be congruent with US valence in the absence of genuine conditioning (e.g., because all CS are not perfectly neutral for each participant), US valence could be correctly identified if participants rely on affect-as-information (Schwarz & Clore, 1983) which would lead to overestimate EC among correct identifications. Conversely, if pre-existing attitudes toward CS are incongruent with US valence, participants could often indicate the wrong valence which could lead to reversed EC effects (Bar-Anan, De Houwer & Nosek, 2010). However, because we measured attitude change rather than only measuring attitudes after conditioning, this last phenomenon should be reduced in the present study. Moreover, we conducted an additional analysis and found a very weak correlation between pre-existing attitudes and valence identification. The evidence against the existence of a correlation was insensitive (r(86) = 0.055, BF = 0.34, Rob. Reg. [0, 0.34])[1].

Experiment 2

The goal of experiment 2 was to replicate the finding of Experiment 1. A few changes were made to the procedure in order to deal with the limitations of Study 1. In Study 2, participants evaluated all CS before performing the US valence identification task. Moreover, we added an evaluation attribution. Hence participants could report that they relied on their attitude toward CS to answer the valence identification questions (Hütter et al., 2012). These modifications allow us to reduce and evaluate the impact of attitudes on US valence identification. Additionally, a follow-up test was administered approximately 24 hours after the first phase of the experiment. On the basis of previous research, we expected EC to be robust over this time delay (Grossman & Till, 1998; Hütter, et al., 2012). We expected valence identification accuracy to decline over time (Wixted & Ebbesen, 1991). We also expected that the number of memory attributions would diminish while the number of other types of attributions would increase.

Participants and design

Fifty-nine first year Clermont Auvergne University students took part in the experiment. All of them were native French speakers and gave their written informed consent to participate. They received course credits in return for their participation. Two participants were excluded from analyses because they failed to comply with instructions. The final sample consisted of 57 participants (M_{age} =19.12; SD_{age} = 2.70; 50 females) among which one did not take part to the follow-up session. The design of the study included US valence (positive vs. negative) and time of measurement (preratings vs. postratings vs. follow-up) as within-subject factors.

Materials

The material was the same as in Experiment 1.

Procedure

The procedure was very similar to that of Experiment 1 except for a few changes. Participants rated the same set of sixty faces as in the first part of Experiment 1. However, the

CS repertory was composed of a fixed subset of 40 faces. The assignment of the CS to the US was counterbalanced across participants (4 versions) rather than randomized anew for each participant. The conditioning phase was similar to that of Experiment 1. The test phase was divided in an evaluation and a US valence identification phase. Participants first rated the 40 CS. They then took part to the valence identification test in which they had to identify the valence of the US associated with each CS and to make an attribution for each of their responses. As compared to Experiment 1, we added an “evaluation attribution”. The item was phrased: “*My evaluation of the face: I don’t remember with which picture this face was presented. I responded on the basis of my positive or negative feelings toward the face”*. The experiment also included a follow-up session administered online 24 hours later. During this session, participants rated the 40 CS again and then took part to a second valence identification test.

Results

We first report analyses concerning the first session of the experiment before reporting analyses concerning the follow-up session.

First session

Number of attributions of each type

Table 1 shows the mean number of trials attributed to memory, feelings, evaluation or random guessing. About eight responses out of forty were attributed to the feelings evoked by the CS, the evaluation attribution. Consequently, the sample number of attributions of the other types was smaller than in Experiment 1. This was more pronounced for the feeling-based attribution.

US valence identification

As can be seen in Table 2, there was decisive evidence that the proportion of correct responses at the US valence identification test was higher than chance overall, $t(56) = 7.67$, $p < .001$, $B_{\text{H(0, 15\% above H0)}} = 7.45 \times 10^{11}$, Rob. Reg. [0.15, >100], Cohen's $d = 1.02$, and for the memory attribution, $t(54) = 12.65$, $p < .001$, $B_{\text{H(0, 15\%)}} = 3.22 \times 10^{33}$, Rob. Reg. [0.18, >100], Cohen's $d = 1.71$. By contrast there was no evidence one way or the other for the feeling-based attribution, $t(55) = 1.48$, $p = .14$, $B_{\text{H(0, 15\%)}} = .74$, Rob. Reg. [0, 34.2], Cohen's $d = .20$, and substantial evidence for chance performance for the evaluation, $t(55) = .24$, $p = .81$, $B_{\text{H(0, 15\%)}} = .23$, Rob. Reg. [10.2, ∞], Cohen's $d = .032$, and the random attributions, $t(50) = -.09$, $p = .93$, $B_{\text{H(0, 15\%)}} = .19$, Rob. Reg. [7.86, ∞], Cohen's $d = -.012$. Hence, the results were similar to those of Experiment 1, except that data were insensitive for the feeling-based attribution.

EC effects

We followed the same analytical strategy as in Experiment 1: we compared attitude change between positively and negatively paired CS. As in Experiment 2, CS-US pairings were counterbalanced (rather than randomized), the two variables used to counterbalance the assignments were entered in the analyses.

There was decisive evidence for a general EC effect, $F(1,53) = 12.18$, $p = .001$, $B_{\text{H1(0, 23.5)}} = 124$, Rob. Reg. [1.20, >400], partial $\eta^2 = .187$. The mean difference between attitude change for positively and negatively paired CS can be seen in Figure 1. Next, we examined EC effects separately for each knowledge attribution. We found strong evidence for an EC effect for memory attributions, $F(1,47) = 7.39$, $p = .009$, $B_{\text{H1(0, 23.5)}} = 17.7$, Rob. Reg. [4.13, 237], partial $\eta^2 = .136$, insensitive evidence for feeling-based attributions, $F(1,51) =$

1.55, $p = .22$, $B_{H1(0, 23.5)} = .78$, Rob. Reg. [0, 58.0], partial $\eta^2 = .029$, substantial evidence for the null in the evaluation attributions, $F(1,42) = .47$, $p = .50$, $B_{H1(0, 23.5)} = 0.19$, Rob. Reg. [12.38, ∞], partial $\eta^2 = .011$, and strong evidence for an EC effect for random attributions, $F(1,44) = 9.66$, $p = .003$, $B_{H1(0, 23.5)} = 43.0$, Rob. Reg. [2.13, >400], partial $\eta^2 = .180$. As in Experiment 1, we also analysed feeling-based and random attributions together. Again, this analysis yielded strong evidence for an EC effect, $F(1,53) = 7.00$, $p < .05$, $B_{H1}(0, 23.5) = 10.35$, Rob. Reg. [1.98, 90.0], partial $\eta^2 = .117$.

Next, we examined whether US valence identification was required for EC. We ran a two (US valence) by two (accuracy of US valence identification) ANOVA. This analysis provided substantial evidence that US valence identification moderated EC, $F(1,52) = 5.92$, $p = .018$, $B_{H(0, 23.5)} = 8.77$, Rob. Reg. [4.00, 92.6], partial $\eta^2 = .102$. There was decisive evidence for an EC effect among CS for which US valence was correctly identified ($M_{diff} = 19.7$, 95%CI = [8.28; 31.1]), $F(1,52) = 12.02$, $p = .001$, $B_{H1(0, 23.5)} = 135$, Rob. Reg. [1.91, >400], partial $\eta^2 = .188$. By contrast, there was substantial evidence for an absence of regular EC effect ($M_{diff} = 1.72$, 95%CI = [-6.33; -9.77]), $F(1,52) = .18$, $p = .67$, $B_{H1(0, 23.5)} = 0.25$, Rob. Reg. [16.9, ∞], partial $\eta^2 = .004$, and an absence of reversed EC effect, $B_{H2(0, 23.5)} = 0.13$, Rob. Reg. [8.1, ∞], when US valence was not correctly identified.

Second session

Number of attributions of each type

Table 1 shows the mean number of trials attributed to memory, feelings, evaluation or random.

US valence identification

As can be seen in Table 2, there was decisive evidence that the proportion of correct responses at US valence identification test was higher than chance overall, $t(55) = 7.28$, $p < .001$, $B_{H(0,\ 15\%\ \text{above}\ H0)} = 3.94 \times 10^{10}$, Rob. Reg. [0.16, >100], Cohen's $d = .97$ for the memory attribution, $t(52) = 13.40$, $p < .001$, $B_{H(0,\ 15\%\ \text{above}\ H0)} = 3.58 \times 10^{37}$, Rob. Reg. [0.19, >100], Cohen's $d = 1.84$. There was no evidence one way or the other in the feeling-based attribution, $t(53) = 1.40$, $p = .17$, $B_{H(0,\ 15\%\ \text{above}\ H0)} = .64$, Rob. Reg. [0, 29.1], Cohen's $d = .19$, substantial evidence for chance performance for the evaluation attribution, $t(52) = .34$, $p = .74$, $B_{H(0,\ 15\%\ \text{above}\ H0)} = .21$, Rob. Reg. [9.0, ∞], Cohen's $d = .046$, and for the random attribution, $t(48) = -.12$, $p = .90$, $B_{H(0,\ 15\%\ \text{above}\ H0)} = .19$, Rob. Reg. [8.3, ∞], Cohen's $d = -.018$.

EC effects

To analyse the data from the follow-up session, we computed attitude change indexes by subtracting preratings from ratings made during the follow-up session (i.e., approximately 24 hours later).

To examine the general EC effect, we compared attitude change indexes on the whole data set. The mean difference between attitude change for positively and negatively paired CS can be seen in Figure 1. There was evidence for an EC effect, $F(1,52) = 4.84$, $p = .032$, $B_{H1(0,\ 23.5)} = 2.98^2$, Rob. Reg. for evidence for H1 [2.3, 23.3], Rob. Reg. for insensitivity [0, 2.2] & [23.4, 221], partial $\eta^2 = .085$. Hence, the general EC effect remained present after a 24 hours delay. Next, we examined EC effects in each knowledge attribution. For the memory attribution, we found decisive evidence for an EC effect, $F(1,41) = 9.63$, $p = .003$, $B_{H1(0,\ 23.5)} = 45.5$, Rob. Reg. [3.98, >400], partial $\eta^2 = .190$. For the feeling-based, $F(1, 50) = .01$, $p = .91$, $B_{H1(0,\ 23.5)} = .31$, Rob. Reg. [21.2, ∞], partial $\eta^2 = .000$, and the evaluation attributions, $F(1, 39) = .16$, $p = .69$, $B_{H1(0,\ 23.5)} = .31$, Rob. Reg. [21.5, ∞], partial $\eta^2 = .004$, there was substantial evidence for the null. By contrast, there was substantial evidence for an

EC effect in the random attribution, $F(1, 35) = 4.14$, $p = .049$, $B_{\mathrm{H1}(0,\ 23.5)} = 4.09$, Rob. Reg. [6.23, 38.2], partial $\eta^2 = .106$. We also analysed feeling-based and random attributions together. This analysis yielded no evidence one way or the other, $F(1,52) = 0.30$, $p = .58$, $\mathrm{B}_{\mathrm{H1}}(0, 23.5) = 0.39$, Rob. Reg. [0, 27.6], partial $\eta^2 = .006$.

Next, we analysed whether US valence identification moderated EC. There was substantial evidence for an interaction between US valence and the accuracy of US valence identification, $F(1, 50) = 14.28$, $p < .001$, $B_{\mathrm{H}(0,\ 23.5)} = 358$, Rob. Reg. [2.75, >800], partial $\eta^2 = .222$. Decisive evidence for an EC effect was found when US valence was correctly identified ($M_{diff} = 20.1$, 95%CI = [9.30; 30.9]), $F(1, 51) = 13.99$, $p < .001$, $B_{\mathrm{H1}(0,\ 23.5)} = 338$, Rob. Reg. [1.65, >400], partial $\eta^2 = .215$. By contrast, there was strong evidence for a reversed EC effect when US valence was not correctly identified, $F(1, 50) = 6.73$, $p = .012$, $B_{\mathrm{H1}(0,\ 23.5)} = 0.067$, Rob. Reg. [4.05, ∞], $B_{\mathrm{H2}(0,\ 23.5)} = 11.0$, Rob. Reg. [2.76, 105], partial $\eta^2 = .119$. Indeed, the mean difference between attitude change for positively and negatively paired CS was negative ($M_{diff} = -14.6$, 95%CI = [-25.9; -3.27]) when participants failed to identify US valence, which indicates a reversed EC effect.

Comparison between session 1 and follow-up 2

As can be seen in Table 1, there was decisive evidence for a decrease in the number of memory attributions in the follow up session[3], $t(55) = 4.24$, $p < .001$, $B_{\mathrm{H1}(0,\ 5)} = 1455$, Rob. Reg. [.14, >40], Cohen's $d = .57$. There was evidence for the null compared to the hypothesis of an increase in the number of feeling-based attribution, $t(55) = .00$, $p = 1$, $B_{\mathrm{H2}(0,\ 5)} = .15$, Rob. Reg. [2.20, ∞], Cohen's $d = 0$. There was insensitive evidence for an increase in the number of evaluation, $t(55) = -1.83$, $p = .073$, $B_{\mathrm{H2}(0,\ 5)} = 1.17$, Rob. Reg. [0, 18.0], Cohen's $d = -.25$, and random attributions, $t(55) = -1.66$, $p = .10$, $B_{\mathrm{H2}(0,\ 5)} = 0.96$, Rob. Reg. [0, 14.9], Cohen's $d = -.22$.

As can be seen in Table 2, valence identification accuracy did not decrease between the first and the follow-up session of the experiment. There was decisive evidence for an absence of difference overall, $t(55) = .66$, $p = .51$, $B_{H1(0, 15)} = 0.13$, Rob. Reg. [5.46, ∞], Cohen's $d = .09$, for the memory attribution, $t(52) = -1.38$, $p = .17$, $B_{H1(0, 15)} = 0.066$, Rob. Reg. [2.58, ∞], Cohen's $d = -.19$, for the feeling-based attribution, $t(53) = -.30$, $p = .77$, $B_{H1(0, 15)} = 0.13$ Rob. Reg. [5.56, ∞], Cohen's $d = -.04$, for the evaluation attribution, $t(51) = -.22$, $p = .83$, $B_{H1(0, -15)} = 0.22$, Rob. Reg. [9.64, ∞], Cohen's $d = -.03$ and for the random attribution, $t(47) = .20$, $p = .84$, $B_{H1(0, 15)} = 0.25$, Rob. Reg. [11.1, ∞], Cohen's $d = .03$.

In order to compare EC effects across the two sessions we computed EC scores for the two sessions by subtracting attitude change for negatively paired CS from attitude change for positively paired CS. We report *B* that test the hypothesis that EC was weaker in the second session than in the first.

There was insensitive evidence that the general EC effect was weaker during the second session, $F(1,52) = 3.39$, $p = .071$, $B_{H1(0, 23.5)} = 1.26$, Rob. Reg. [0, 91.4], partial $\eta^2 = .061$.When considering attributions separately, there was substantial evidence for the null in the memory, $F(1,41) = 0.10$, $p = .75$, $B_{H1(0, 23.5)} = 0.25$, Rob. Reg. [17.0, ∞], partial $\eta^2 = .003$, and for the evaluation attributions, $F(1,39) = 0.087$, $p = .77$, $B_{H1(0, 23.5)} = 0.28$, Rob. Reg. [20.0, ∞], partial $\eta^2 = .002$. There was no evidence one way or the other for other attributions.

Discussion

The results of Experiment 2 were generally congruent with those of Experiment 1. Overall and in the memory attribution the proportion of correct valence identifications was substantial and medium to large EC effects were found. In the feeling-based and the random attributions, EC effects were also in the same direction as in Experiment 1. However, the evidence for an EC effect was insensitive in the feeling-based attribution while it was large in the random attribution. As in the first experiment, grouping feeling-based and random attributions yielded strong evidence for EC. As far as valence identification is concerned, the pattern of results was also congruent with the previous experiment. There was evidence for chance performance in the random attribution. However, there was only insensitive evidence for above chance performance in the feeling-based attribution. As EC effects go in the same direction in both experiments while strength of evidence sometimes differ, we decided to perform a meta-analysis of the two studies to have a better estimation of the effect size and the evidence for EC in these three attributions (see below). Unexpectedly, there was no evidence for an EC effect in the evaluation attribution and valence identification accuracy was at chance.

As in Experiment 1, the EC effects found overall and in the memory attribution were accompanied by above chance US valence identification and additional analyses revealed that the general EC effect was moderated by US valence identification. These results are consistent with the view that knowledge about US valence may underlie EC. However, we also found substantial evidence for an EC effect in the random attribution while US valence identification was at chance. This suggests that EC might also occur in the absence of any structural knowledge. This could reflect the fact that attitude learning may occur in the absence of learning of the pairings structure. A mechanism that could explain this kind of attitude learning is the implicit misattribution of affect (Jones, Fazio & Olson, 2009). According to this view affective reactions evoked by US could be misattributed to CS during the conditioning procedure. In this case, it would be unnecessary to acquire any knowledge about the pairings to be influenced by an EC procedure.

As we did not obtain any EC effect and the valence identification accuracy was at chance in the evaluation attribution, it seems that attitudes did not contribute to valence identification. Hütter and Sweldens (2013) provided evidence that attitudes toward CS may help to identify US valence even in the absence of genuine memory. It seems that, as in Mierop et al. (2017), this was not the case here. One difference between the two studies was that contrary to Hütter and Sweldens (2013), we did not explicitly instruct participants to respond to the US valence identification questions on the basis of their attitudes.

Contrary to Experiment 1, there was not evidence for a reversed EC effect when participants indicated the opposite US valence in the first session of Experiment 2. In this last experiment, attitudes and the ability to identify US valence were measured in two different blocks. It seems that, as expected, this modification of the procedure reduced the tendency to rely on attitudes to respond to valence identification questions and thereby prevented this reversed EC effect from occurring. This interpretation is congruent with the fact that EC was obtained in the random attribution while valence identification accuracy was at chance. Indeed, relying on their attitudes would have allowed participants to identify US valence above chance level.

Finally, the results of the second phase of the experiment support the hypothesis that EC is quite robust over time. Indeed, the EC effects found in the first phase were still present 24 hours later. A delay of 24 hours may not have been long enough. However, as expected, the number of memory attributions decreased which suggests that while EC was still present after a 24 hours delay it was less sustained by conscious knowledge.

Meta-analysis of Experiments 1 and 2

We conducted further analyses across Experiment 1 and the first session of Experiment 2 by computing meta-analytical *B* (Dienes, 2014). In addition, for each EC effect we report, in Table 3, the mean difference between attitude change for positively and negatively paired CS (Dienes, 2014) and a Cohen's *d* (Cumming, 2012) with 95% confidence intervals (CIs) around each of them (Algina & Keselman, 2003). The former is a raw effect size while the latter is a standardized effect size. The fact that the 95% CI excludes zero indicates that the effect is significant in the frequentist approach.

US valence identification

There was decisive evidence that the overall proportion of correct US valence identification was above chance across experiments, $B_{\text{H(0, 15\% above H0)}} = 6.04 \times 10^{37}$, Rob. Reg. [0.062, >100%]. There was also decisive evidence for above chance performance in the memory attribution, $B_{\text{H(0, 15\% above H0)}} = 9.55 \times 10^{83}$, Rob. Reg. [0.076, >100%], and strong evidence in the feeling-based attribution, $B_{\text{H(0, 15\% above H0)}} = 96.3$, Rob. Reg. [0.40, >100%]. By contrast, there was substantial evidence for chance performance in the random attribution, $B_{\text{H(0, 15\% above H0)}} = .108$, Rob. Reg. [4.47, ∞].

EC effects

Across experiments, there was decisive evidence for an overall EC effect which was of medium size, $\text{B}_{\text{H1(0, 23.5)}} = 1.31 \times 10^{9}$, Rob. Reg. [0.33, >400] (see Table 3). This is congruent with previous studies as a meta-analysis indicated that the average effect size of EC is *d* = .52 (Hofmann et al., 2010). In the memory attribution, there was also decisive evidence for an EC effect which was of medium size as well, $\text{B}_{\text{H1(0, 23.5)}} = 9.80 \times 10^{7}$, Rob. Reg. [0.79, >400]. In the feeling-based attribution, the evidence for an EC effect was substantial but it was of small size, $B_{H1(0, 23.5)} = 3.27$, Rob. Reg. [1.6, 25]. Similarly, in the random attribution there was strong evidence for an EC effect which was small, $B_{H1(0, 23.5)} = 20.52$, Rob. Reg. [1.3, 175].

Next, we analysed EC effects for correct and incorrect US valence identifications. Among correct identifications, there was decisive evidence for an EC effect which was of medium size, $B_{H1(0, 23.5)} = 1.47 \times 10^{15}$, Rob. Reg. [0.43, >400]. Among incorrect identifications, there was strong evidence against a regular EC effect, $B_{H1(0, 23.5)} = 0.021$, Rob. Reg. [1.3, ∞], and decisive evidence for a reversed effect which was of small size, $B_{H2(0, 23.5)} = 3934$, Rob. Reg. [0.65, >400].

Table 3. Mean difference between attitude change for positively and negatively paired CS and Cohen's *d* as a function of attribution type and of accuracy of US valence identification across Experiment 1 and 2.

		95 % CI for Mean difference			95 % CI for Cohen's *d*	
	Mean difference	*LL*	*UL*	Cohen's *d*	*LL*	*UL*
General EC effect	13.92	9.86	17.98	0.56	0.39	0.74
Memory	28.97	19.93	38.00	0.54	0.36	0.72
Feeling-based	6.22	0.95	11.50	0.20	0.03	0.36
Random	9.47	3.17	15.77	0.26	0.09	0.43
Correct US valence identification	28.93	22.27	35.58	0.72	0.53	0.90
Incorrect US valence identification	-11.44	-16.52	-6.37	-0.37	-0.54	-0.20

Note. Error bars represent 95% confidence intervals. *LL* and *UL* represent the lower and the upper limit of the confidence interval respectively. An EC effect is significant in the frequentist approach when the 95% CI excludes zero.

General Discussion

We conducted two studies that distinguished between the ability to identify US valence and higher order awareness (i.e., the awareness of knowing) of associations between CS and US valence. One important contribution of these studies was thus to clarify the role of awareness at the objective and subjective threshold. The results were generally in line with the prediction that ability to identify US valence (i.e., awareness at the objective threshold) is required for EC to occur, except for the random attribution. However, a key finding of the meta-analysis of the studies was that US identification may be based on either conscious or unconscious structural knowledge as evidenced by EC effect found not only for the memory attribution but also for the feeling-based attribution. Another important finding of the meta-analysis was that EC was found when participants made a random attribution. In this case, contrary to memory and feeling-based attributions, they performed at chance at the valence identification test. Hence EC can also occur in the absence of any kind of knowledge about US valence, at least at the time of testing. In making this claim, we take knowledge to be that which allows discriminative responding. In any case, those results suggest that, at the subjective threshold, awareness is not required for EC to occur. The meta-analysis also suggests that while conscious knowledge leads to medium EC effects, unconscious knowledge gives rise to small EC effects. Similarly, EC effects occurring in the absence of any knowledge were also of small magnitude. This is congruent with previous finding that awareness is an important moderator of EC (Hofmann et al., 2010). We will first discuss the implications of our findings regarding the conscious status of structural knowledge and for the main models of attitude acquisition through EC. We will then discuss the advantages and limitations of subjective measures of awareness and the potential of knowledge attributions for future research in EC.

Conscious and unconscious knowledge in EC

In a typical EC experiment, participants are incidentally exposed to pairs of stimuli composed of an initially neutral CS and a valent US. As a result, they acquire some knowledge about the structure of the material (i.e., the CS-US pairings) and their attitudes towards CS change in the direction of US valence. Beyond the debate about the learning mechanisms that lead to the acquisition of conditioned attitudes, the main contributions of our studies are to bring to light the distinction between conscious and unconscious knowledge in EC and to propose a new method based on subjective measures of awareness.

Our results replicate previous findings (Pleyers et al., 2007; 2009) showing that correct valence identification is necessary for EC to occur. However, contrary to previous studies, we do not assume that there is a perfect overlap between performance and awareness. Hence, we do not interpret this finding as evidence that participants who correctly identified US valence were necessarily aware of the knowledge. By higher order theories of consciousness (Rosenthal, 2005; Michel et al., 2018), discrimination is based on first-order knowledge whereas awareness of structural knowledge requires a second order state, with content that one has that structural knowledge. Hence, we interpret above chance US valence identification in a forced choice task (i.e., objective measure) as evidence that participants have some knowledge. In order to measure awareness of knowing we relied on a subjective measure, the structural knowledge attributions. Across studies, an EC effect and above chance US valence identification were found in the memory and feeling-based attributions. While participants reported being aware of their structural knowledge in the former attribution they reported being unaware in the latter. This finding provides evidence that both conscious and unconscious knowledge may underlie EC.

The same type of results has recently been obtained in a related paradigm (Jurchiș, Costea, Dienes, Miclea, & Opre, 2020). In this study, strings from a first artificial grammar were positively conditioned and strings from a second grammar were negatively conditioned. Consequently, new strings from the first grammar were preferred over new strings from the second grammar. This result was obtained for the strings for which participants reported that they knew why they liked them but also when they reported that they didn’t know why. Congruently, our results in the memory and feeling-based attributions showed that participants may acquire knowledge that they are aware of as well as knowledge that they are not aware of in a classical EC paradigm.

However, contrary to our initial hypotheses, the meta-analysis revealed that in the random attribution participants did not acquire any knowledge about the pairings but were nevertheless conditioned. This finding provides first evidence that EC may occur even when US valence identification is perfectly at chance. Interestingly, this phenomenon appears to be limited to trials in which the participants believe they had no idea of the valence of the US. As discussed above implicit misattribution of affects could explain this EC effect obtained in the absence of any knowledge.

Implications for models of attitude learning through EC

The main goal of our experiments was to measure the awareness of knowing at the time of testing. Hence, we did not implement any manipulation of awareness during the conditioning phase which would have been the most direct way to study the learning mechanisms that lead to the acquisition of conditioned attitudes (Gawronski & Walther, 2012). However, some previous studies suggest that conscious and unconscious knowledge measured via structural knowledge attributions could be acquired through qualitatively different learning mechanisms (Dienes, 2012, for a review). We thus discuss whether the learning mechanisms proposed by the main models of attitude learning through EC could lead to the acquisition of conscious and unconscious knowledge.

As recent studies using item-level analyses found EC effects only in CS for which the paired US or its valence was correctly identified (e.g., Pleyers et al., 2007), the propositional account of EC has become more prominent (Mitchell, De Houwer, & Lovibond, 2009; but see McLaren, Forrest, McLaren, Jones, Aitken, & Mackintosh, 2014). According to this view, controlled reasoning processes are necessary for learning to take place and EC requires forming conscious propositions about the relation between CS and US. Our data support the existence of a propositional learning mechanism. In our view, this mechanism best explains the EC effect found in the memory attribution as participants indeed reported conscious propositions about the pairings by responding to the attribution question. Moreover, the fact that the EC effect was larger in the memory attribution, in which the proportion of correct valence identification was the highest, than in other attributions is congruent with the propositional account. The propositional account could arguably explain the EC effect obtained in the feeling-based attribution because the percentage of correct valence identification was above chance level for those trials and feelings or intuitions reported by participants might be construed as propositions. By contrast, the EC effect obtained in the random attribution, while US valence identification accuracy was at chance, challenge the propositional account. According to this view, EC should not occur in the absence of awareness. One might still argue that participants were aware of the pairings during the conditioning phase and that we did not detect awareness because it was measured at the time of testing. Hence, participants could have forgotten the associations. However, in Experiment 2, the percentage of correct US valence identifications did not decrease 24 hours after the conditioning phase and there was only a few minutes between conditioning and testing phases. In addition, liking ratings were obtained at the time of testing.

A mechanism that is susceptible to produce EC in the absence of awareness is implicit misattribution of affects. According to the implicit misattribution account, affective reactions evoked by US could be implicitly misattributed to CS during the conditioning procedure and thereby modify the representation of the CS in memory. As a result, EC could occur without acquiring any knowledge about the CS-US pairings. The implicit misattribution mechanism might also explain the EC effect as well as the slightly above chance performance obtained at the valence identification test in the feeling-based attribution (at least in Experiment 1) because conditioned attitude might influence responses during this test (Hütter & Sweldens, 2013).

Finally, conditioned attitude could also be formed through automatically operating association formation processes leading to unconscious associations between CS and US representations (e.g., Baeyens, Eelen, Crombez, & Van den Bergh, 1992). By higher order theories, this type of mechanism explains the result obtained in the feeling–based attribution well as unconscious knowledge should allow US valence identification and leads to EC.

To sum up, the EC effect obtained in the memory attribution is best explained by the propositional account. The EC effect obtained in the feeling-based attribution is arguably compatible with the different theoretical accounts mentioned above while the effect obtained in the random attribution is best explained by implicit misattribution of affects. Our results are thus congruent with the view that several mechanisms may underlie EC in the very same task (De Houwer, 2007, see also, Jacoby, 1991).

Advantages and limitations of subjective measures of awareness

There is currently no better way to find out the content of a person’s awareness than to ask her to produce a report about it (e.g. Rosenthal, 2019). In this view, subjective measures are the most direct method to measure awareness of knowing (Timmermans & Cleeremans, 2015). However, designing reliable and sensitive subjective measures may be challenging.

In the field of EC, the vast majority of studies that used subjective measures to assess knowledge about CS-US pairings relied on general open-ended questions. They have been criticized for their lack of sensitivity as participants may underreport awareness (Sweldens et al., 2014). A few recent studies relied on confidence ratings (Bar-Anan et al., 2010; Bar-Anan, & Amzaleg-David, 2014). The use of these scales is an improvement as it has been showed, in other incidental learning paradigms, that they are more sensitive measures of awareness than free reports (Ziori & Dienes, 2006; see also Wierzchoń et al., 2014). The current experiments go beyond this prior work because the use of structural knowledge attributions allowed us to measure the conscious status of structural knowledge while confidence ratings only measure the conscious status of judgement knowledge (Dienes & Scott, 2005). For example, one may be unaware of the basis of a response (i.e., structural knowledge) and have a sense of the accuracy of that response (i.e., some confidence).

Another contribution of Bar-Anan and colleagues' studies has been to show that valence identification measures could be influenced by pre-existing attitudes. We conducted additional analyses to check if it was the case here and found a very weak correlation and no evidence one way or the other for pre-existing attitudes being related to valence identification across experiments[1] (r(143) = .14, BF= 0.91, Rob. Reg. [0, 0.99]). Additionally, in Bar-Anan and colleagues' studies, valence identification responses to CS with more extreme attitudes were made with more confidence. Across the current experiments, we again found a very weak correlation and no evidence either way for pre-existing attitudes being linked to knowledge attributions[4] (r(143) = .148, BF = 1.32, Rob. Reg. [0, 1]). It is also possible that conditioned attitudes influence valence identification which could lead to overestimate genuine knowledge. The inclusion of an evaluation attribution in Experiment 2 allowed us to examine whether participants used their attitudes deliberately as a cue to respond to valence identification questions. Among those trials, participants performed at chance at the valence identification task. It is still possible that participants have relied on their conditioned attitudes (without noticing it) in other attributions which might have contributed to valence identification. In this case, unaware EC (at the objective threshold) might be underestimated.

More generally, as stated above, designing reliable and sensitive subjective measures may be challenging. Hence, our knowledge attribution question was designed to increase reliability and sensitivity. Assessing awareness retrospectively (e.g., with an open-ended question at the end of the experiment) could constitute a first potential problem. To avoid any forgetting, we measured awareness of knowing on a trial-by-trial basis. Moreover, each attribution immediately followed the valence identification question that itself immediately followed attitude measurement in Experiment 1. Critics of subjective measures may still argue that participants' reports reflect their biases to respond conservatively (i.e., they may fail to disclose their knowledge unless they feel confident enough). For example, if a free recall is requested, participants could choose not to report some knowledge in which they have a low confidence. This problem is ameliorated when using knowledge attributions because participants are not asked to state the content of their conscious knowledge but only whether they have some conscious knowledge (Dienes, 2012). Additionally, attributions were related to valence identification. In particular, participants who reported responding randomly were actually at chance at the valence identification. This ensures that they did not use the random attribution while having some conscious knowledge. Metacognitive judgements about participants' awareness of knowing also seems pretty accurate in the memory attribution, where the percentage of correct valence identifications was systematically about 80%, and in the feeling–based attribution in which it was slightly above chance. See Dienes and Seth

(2010b), Dienes (2004, 2012), Dienes and Perner (2004) and Timmermans and Cleeremans (2014) for further discussion on establishing the validity of subjective measures.

Avenues for future research

At least two avenues for future research could be built upon the distinction between conscious and unconscious knowledge in EC. The first would be to explore the relation between learning mechanisms occurring during the exposition to CS-US pairings and the conscious status of the acquired structural knowledge. This could be done by implementing manipulations of awareness during the encoding of the pairings. In the field of implicit learning, some studies show that performing a concurrent task during the learning phase impairs the acquisition of conscious but not of unconscious structural knowledge (Dienes, 2007; Dienes & Scott, 2005). It would be interesting to test whether the same pattern of results would be obtained in the EC paradigm.

The second research avenue would be to examine the links between the controllability of EC and the conscious status of structural knowledge. The controllability question has recently been investigated in a couple of studies showing that while the acquisition of conditioned attitudes is partially uncontrollable (Hütter & Sweldens, 2018), the explicit expression of these attitudes is controllable (Balas & Gawronski, 2012; Gawronski, Balas, & Creighton, 2014). In light of these studies, it would be interesting to examine the interplay between an instruction to control the impact of the pairings (Balas & Gawronski, 2012; Gawronski et al., 2014; Hu, Gawronski & Balas, 2017a) or information about the relationship between CS and US (Hu, Gawronski & Balas, 2017b) and conscious and unconscious structural knowledge.

Conclusion

We developed an innovative method based on subjective measures of awareness motivated by higher order and integration theories of consciousness. This new method allowed us to test not only whether correct US valence identification is necessary for EC to occur but also for awareness of knowing. Making these distinctions helped us to bring new light on the highly debated question of the role of awareness in EC. Our results provide evidence for three types of EC within the same task, each with a distinct phenomenology. The first is underpinned by conscious knowledge, the second by unconscious knowledge and the third occur in the absence of any knowledge about US valence.

Declarations of Interest

The authors declare that there are no conflicts of interest.

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References

Algina, J., & Keselman, H. J. (2003). Approximate confidence intervals for effect sizes. *Educational and Psychological Measurement, 63*, 537-553.

Baeyens, F., Eelen, P., Crombez, G., & Van den Bergh, O. (1992). Human evaluative conditioning: Acquisition trials, presentation schedule, evaluative style and contingency awareness. *Behaviour Research and Therapy, 30*, 133–142.

Balas, R., & Gawronski, B. (2012). On the intentional control of conditioned evaluative responses. *Learning and Motivation*, *43*, 89-98.

Baars, B. J. (1993). *A cognitive theory of consciousness*. Cambridge University Press.

Bar-Anan, Y., De Houwer, J., & Nosek, B. A. (2010). Evaluative conditioning and conscious knowledge of contingencies: A correlational investigation with large samples. *Quarterly Journal of Experimental Psychology, 63*, 2313-2335.

Bar-Anan, Y., & Amzaleg-David, E. (2014). The effect of evaluation on co-occurrence memory judgement. *Cognition and Emotion*, *28*, 1030-1046.

Berry, D. C., & Dienes, Z. (1993). *Implicit learning: Theoretical and empirical issues.* Hove: Lawrence Erlbaum.

Brainerd, C. J., Payne, D. G., Wright, R., & Reyna, V. F. (2003). Phantom recall. *Journal of Memory and Language, 48*, 445-467.

Corneille, O., & Stahl, C. (2018). Associative Attitude Learning: A Closer Look at Evidence and How It Relates to Attitude Models. *Personality and Social Psychology Review*, *23*, 161-189.

Cumming, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis.* New York, NY: Routledge.

Dehaene, S., Changeux, J. P., & Naccache, L. (2011). The global neuronal workspace model of conscious access: from neuronal architectures to clinical applications. In *Characterizing consciousness: From cognition to the clinic?* (pp. 55-84). Springer, Berlin, Heidelberg.

De Houwer, J. (2007). A conceptual and theoretical analysis of evaluative conditioning. *The Spanish Journal of Psychology, 10*, 230–241.

Dedonder, J., Corneille, O., Yzerbyt, V. Y., & 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.

Dienes, Z. (2004). Assumptions of subjective measures of unconscious mental states: Higher order thoughts and bias. *Journal of Consciousness Studies, 11* (9), 25-45.

Dienes, Z. (2012). Conscious versus unconscious learning of structure. *Statistical learning and language acquisition, 1*, 337-364.

Dienes, Z. (2019). How do I know what my theory predicts? *Advances in Methods and Practices in Psychological Science.*

Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. *Frontiers in Psychololology,* 5, 781. doi: 10.3389/fpsyg.2014.00781

Dienes, Z., & Perner, J. (2004). Assumptions of a subjective measure of consciousness: Three mappings. In R. Gennaro (Ed.), *Higher order theories of consciousness*. John Benjamins Publishers: Amsterdam (pp 173-199).

Dienes, Z., & Scott, R. (2005). Measuring unconscious knowledge: Distinguishing structural knowledge and judgment knowledge, *Psychological research*, *69*, 338-351..

Dienes, Z., & Seth, A. (2010a). The conscious and the unconscious. *Encyclopedia of behavioral neuroscience, 1*, 322-327.

Dienes, Z., & Seth, A. (2010b). Gambling on the unconscious: A comparison of wagering and confidence ratings as measures of awareness in an artificial grammar task. *Consciousness & Cognition, 19*, 674-681.

Dienes, Z., & Seth, A. K. (2018). Conscious versus unconscious processes. In G. C. L. Davey (Ed.), *Psychology (BPS Textbooks in Psychology)* pp 262-323 . Wiley: Chichester

Dijksterhuis, A. (2004). I Like Myself but I Don' t Know Why : Enhancing Implicit Self-Esteem by Subliminal Evaluative Conditioning. *Journal of Personality and Social Psychology, 86,* 345–355.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160.

Field, A. P., & Moore, A. C. (2005). Dissociating the effects of attention and contingency awareness on evaluative conditioning effects in the visual paradigm. *Cognition & Emotion, 19*, 217–243.

Förderer, S., & Unkelbach, C. (2013). On the stability of evaluative conditioning effects : The role of identity memory, valence memory, and evaluative consolidation. *Social Psychology, 44*, 380–389.

Fu, Q., Dienes, Z., & Fu, X. (2010). Can unconscious knowledge allow control in sequence learning? *Consciousness and Cognition, 19,* 462–474.

Gawronski, B., Balas, R., & Creighton, L. A. (2014). Can the formation of conditioned attitudes be intentionally controlled? *Personality and Social Psychology Bulletin, 40*, 419-432.

Gast, A., De Houwer, J., & De Scheryver, M. (2012). Evaluative Conditioning Can be Modulated by Memory of the CS-US Pairings at the Time of Testing. *Learning and Motivation, 43*, 116–126.

Grossman, R. P., & Till, B. D. (1998). The persistence of classically conditioned brand attitudes. *Journal of Advertising, 27*, 23-31.

Halbeisen, G., & Walther, E. (2015). Dual-task interference in evaluative conditioning: Similarity matters! *Quarterly Journal of Experimental Psychology, 68,* 2008–2021.

Halbeisen, G., Blask, K., Weil, R., & Walther, E. (2014). The role of recollection in evaluative conditioning. *Journal of Experimental Social Psychology, 55*, 162–168.

Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: a meta-analysis. *Psychological Bulletin, 136*, 390–421.

Hu, X., Gawronski, B., & Balas, R. (2017). Propositional versus dual-process accounts of evaluative conditioning: I. The effects of co-occurrence and relational information on implicit and explicit evaluations. *Personality and Social Psychology Bulletin*, *43*, 17-32.

Hu, X., Gawronski, B., & Balas, R. (2017). Propositional versus dual-process accounts of evaluative conditioning: II. The effectiveness of counter-conditioning and counter-instructions in changing implicit and explicit evaluations. *Social Psychological and Personality Science*, *8*, 858-866.

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.

Hütter, M., & Sweldens, S. (2018). Dissociating controllable and uncontrollable effects of affective stimuli on attitudes and consumption. *Journal of Consumer Research*, *45*, 320-349.

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,* 539–557.

Ivanchei, I. I., & Moroshkina, N. V. (2018). The effect of subjective awareness measures on performance in artificial grammar learning task. *Consciousness and Cognition*, *57*, 116-133.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541.

Jeffreys, H. (1939). *A theory of probability.* Oxford: Oxford University Press.

Jiang, S., Zhu, L., Guo, X., Ma, W., Yang, Z., & Dienes, Z. (2012). Unconscious structural knowledge of tonal symmetry: Tang poetry redefines limits of implicit learning. *Consciousness and Cognition, 21*, 476–486.

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

Jurchiş, R., & Opre, A. (2016). Unconscious learning of cognitive structures with emotional components: Implications for cognitive behavior psychotherapies. *Cognitive Therapy and Research, 40*, 230-244.

Jurchiş, R., Costea, A., Dienes, Z., Miclea, M., & Opre, A. (2018, December 27). Evaluative conditioning of artificial grammars: Evidence that non-conscious structures bias affective evaluations of novel stimuli. https://doi.org/10.31234/osf.io/jkfu5

Kemény F, & Lukács Á. (2013). Self-Insight in Probabilistic Category Learning. *Journal of General Psychology, 140*, 57-81.

Lang, P. J. ,Bradley, M. M., & Cuthbert, B. N.(2008). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual*. Technical Report A-8. University of Florida; Gainesville, FL.

Lee, M. D., & Wagenmakers, E.-J. (2013). *Bayesian cognitive modeling: A practical course.* Cambridge university press.

Ling, X., Zheng, L., Guo, X., Li, S., Song, S., Sun, L., & Dienes, Z. (2018). Cross cultural differences in implicit learning of chunks versus symmetries. *Royal Society Open Science, 5*, https://doi.org/10.1098/rsos.180469

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska directed emotional faces (KDEF). *CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet*, *91*, 630.

McLaren, I. P., Forrest, C. L. D., McLaren, R. P., Jones, F. W., Aitken, M. R. F., & Mackintosh, N. J. (2014). Associations and propositions: The case for a dual-process account of learning in humans. *Neurobiology of learning and memory, 108*, 185-195.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska directed emotional faces (KDEF). *CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet*, *91*, 630.

Mealor, A. D., & Dienes, Z. (2012). Conscious and unconscious thought in artificial grammar learning. *Consciousness and Cognition, 21*, 865–874.

Michel M., Fleming S.M., Lau H., Lee A.L.F., Martinez-Conde S., Passingham R.E., Peters M.A.K., Rahnev D., Sergent C., & Liu K. (2018) An Informal Internet Survey on the Current State of Consciousness Science. *Frontiers in Psychology, 9*, 2134

Mierop, A., Hütter, M., & Corneille, O. (2017). Resource availability and explicit memory largely determine evaluative conditioning effects in a paradigm claimed to be conducive to implicit attitude acquisition. *Social Psychological and Personality Science, 8*, 758-767.

Mitchell, C. J., De Houwer, J., & Lovibond, P. F. (2009). The propositional nature of human associative learning. *Behavioral and Brain Sciences, 32*, 183–246.

Neil, G. J. & Higham, P. A. (2012) Implicit learning of conjunctive rule sets: An alternative to artificial grammars. *Consciousness and Cognition, 21*, 1393-1400.

Norman, E., Scott, R. B., Price, M. C., Jones, E., & Dienes, Z. (2019). Can unconscious structural knowledge be strategically controlled? In Cleeremans, A., Allakhverdov, V., & Kuvaldina, M. (Eds), *Implicit learning: 50 years on*. Routledge (pp 159-173).

Paciorek, A., & Williams, J. N. (2015). Semantic Generalization in Implicit Language Learning. *Journal of Experimental Psychology: Learning Memory and Cognition, 41*, 989-1002

Pleyers, G., Corneille, O., Luminet, O., & Yzerbyt, V. Y. (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,* 130–144.

Pleyers, G., Corneille, O., Yzerbyt, V. Y., & Luminet, O. (2009). Evaluative conditioning may incur attentional costs. *Journal of Experimental Psychology. Animal Behavior Processes, 35*, 279–285.

Rebuschat, P. (2013). Measuring implicit and explicit knowledge in second language research. *Language Learning. 63*, 595–626.

Rogers, J., Revesz, A., Rebuschat, P. (2016). Implicit and explicit knowledge of inflectional morphology. *Applied Psycholinguistics, 37*, 781-812.

Rosenthal, D. M. (2005). *Consciousness and mind.* Oxford: Oxford University Press.

Rosenthal, D. M. (2019). Consciousness and Confidence. *Neuropsychologia, 128*, 255-265

Scott, R. B., & Dienes, Z. (2008). The conscious, the unconscious, and familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 1264–1288.

Shanks, D. R., & St John, M. F. (1994). Characteristics of dissociable human learning systems. *Behavioral and Brain Sciences, 17*, 367–395.

Stahl, C., & Bading, K. C. (2019). Evaluative conditioning of pattern-masked nonwords requires perceptual awareness. *Journal of experimental psychology. Learning, memory, and cognition*. doi: 10.1037/xlm0000757

Stahl, C., & Unkelbach, C. (2009). Evaluative learning with single versus multiple unconditioned stimuli: the role of contingency awareness. *Journal of Experimental Psychology. Animal Behavior Processes, 35*, 286–291.

Stahl, C., Haaf, J., & Corneille, O. (2016). Subliminal evaluative conditioning? Above-chance CS identification may be necessary and insufficient for attitude learning. *Journal of Experimental Psychology: General, 145,* 1107-1131.

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.

Schwarz, N., & Clore, G. L. (1983). Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality and Social Psychology, 45*, 513-523.

Sweldens, S., Corneille, O., & Yzerbyt, V. Y. (2014). The role of awareness in attitude formation through evaluative conditioning. *Personality and Social Psychology Review, 18*, 187–209.

Timmermans, B & Cleeremans, A 2015, How can we measure awareness? An overview of current methods. in M Overgaard (ed.), *Behavioral Methods in Consciousness Research.* Oxford University Press, Oxford, pp. 21-46.

Wagenmakers, E.-J., Verhagen, A. J., Ly, A., Matzke, D., Steingroever, H., Rouder, J. N., & Morey, R. D. (2017). The need for Bayesian hypothesis testing in psychological science. In S. Lilienfeld & I. Waldman, (Eds.), *Psychological science under scrutiny: Recent challenges and proposed solutions* (pp. 123-138). New York: John Wiley and Sons.

Wan, L. L., Dienes, Z., & Fu, X. L. (2008) Intentional control based on familiarity in artificial grammar learning. *Consciousness and Cognition, 17*, 1209-1218.

Wierzchoń, M., Asanowicz, D., Paulewicz, B., & Cleeremans, A. (2012). Subjective measures of consciousness in artificial grammar learning task. *Consciousness and cognition, 21*, 1141-1153.

Wierzchoń, M., Paulewicz, B., Asanowicz, D., Timmermans, B., & Cleeremans, A. (2014). Different subjective awareness measures demonstrate the influence of visual identification on perceptual awareness ratings. *Consciousness and cognition, 27*, 109-120.

Wixted, J. T., & Ebbesen, E. B. (1991). On the form of forgetting. *Psychological Science, 2*, 409-415.

Ziori, E., & Dienes, Z. (2006). Subjective measures of unconscious knowledge of concepts. *Mind & Society 5*, 105-122.

Footnotes

1. Previous studies found an average correlation of r =.33 between preexisting attitudes and valence identification (Bar-Anan et al., 2010). We used a normal distribution with an SD of z = 0.343 as a prior.
2. As Bayes factors provide continuous degree of support and given the high prior probability that there is an effect we interpreted the *B* of 2.98 as substantial evidence for EC.
3. As there are four options, the average frequency for each attribution is 25% or 10 responses out of 40. Thus, the most this average number can decrease is by 10; hence we used an SD of max/2 = 5 responses. For simplicity we used the same amount for predicting increases in the implicit attributions.
4. Similarly to Bar-Anan and colleagues, we tested whether attitude extremity (i.e., the distance between the evaluation and the midpoint of the evaluation scale) was related to an index of attribution type (1 = memory, 2 = feeling-based or evaluation, 3 = random). Previous studies found an average correlation of r =.24 between attitude extremity and confidence (Bar-Anan et al., 2010). We used a normal distribution with an SD of z = 0.245 as a prior.