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BRIEF REPORT

Evaluative Conditioning of Artificial Grammars: Evidence That Subjectively-Unconscious Structures Bias Affective Evaluations of Novel Stimuli

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Evaluative conditioning (EC) refers to the acquisition of emotional valence by an initially neutral stimulus (conditioned stimulus [CS]) after being paired with an emotional stimulus (unconditioned stimulus [US]). An important issue regards whether, when participants are unaware of the CS–US contingency, the affective valence can generalize to new stimuli that share similarities with the CS. Previous studies have shown that generalization of EC effects appears only when participants are aware of the contingencies, but we suggest that this is because (a) the contingencies typically used in these studies are salient and easy to detect consciously, and (b) the performance-based measures of awareness (so-called "objective measures"), typically used in these studies, tend to overestimate the amount of available conscious knowledge. We report a preregistered study in which participants ($N = 217$) were exposed to letter strings generated from two complex artificial grammars that are difficult to decipher consciously. Stimuli from one grammar were paired with positive USs, whereas those from the other grammar were paired with negative USs. Subsequently, participants evaluated new, previously unseen, stimuli from the positively conditioned grammar more positively than new stimuli from the negatively conditioned grammar. Importantly, this effect appeared even when trial-by-trial subjective measures indicated lack of relevant conscious knowledge. We provide evidence for the generalization of EC effects even without subjective awareness of the structures that enable those generalizations.

Keywords: evaluative conditioning, generalization, artificial grammar learning, implicit learning, emotion

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Evaluative conditioning (EC) is defined as the acquisition of positive or negative affective valence by an initially neutral stimulus (conditioned stimulus [CS]) because of its co-occurrence with a positive or negative stimulus (unconditioned stimulus [US]; e.g., Levey & Martin, 1975). Decades of research have shown that this phenomenon can influence evaluations of initially neutral persons, social categories, brands, and various other types of stimuli (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).

Most EC studies try to change the affective valence only for the specific CSs that are paired with the USs. However, in order for EC to have a significant impact in daily life, the effect must also generalize to previously unseen stimuli that share similarities with the presented CSs (Hütter & Tigges, 2019; Unkelbach, Stahl, & Förderer, 2012). Moreover, a core objective for EC research has been to determine whether the conditioning (e.g., Sweldens, Corneille, & Yzerbyt, 2014) and the generalization (e.g., Glaser & Kuchenbrandt, 2017) effects can appear without the awareness of the contingencies formed between the CSs and the USs, because evaluations that are based on unconscious knowledge might have different properties from consciously based ones. For example, the former could be more difficult to change, to integrate with infor-

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mation from other sources (cf. Aust, Haaf, & Stahl, 2019; Baars, 1997), to communicate to other persons (Mercier & Sperber, 2018), to control, or to prevent from influencing behavior (cf. Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012; Jacoby, 1991).

In order to test whether generalization can occur without awareness, Glaser and Kuchenbrandt (2017) presented participants with two groups of alien creatures. On their heads, members of one group had an antenna, whereas members of the other group had a triangle-shaped object. When members of one group were paired with negative (or positive) images, even previously unseen creatures that had the same object on the head were evaluated more negatively (or positively). Thus, this study found evidence for generalization to new stimuli, but only when participants were aware of the contingencies (i.e., remembered accurately which group of creatures was associated with which valence; for similar results, see Hütter, Kutzner, & Fiedler, 2014, and Hütter & Tigges, 2019). In conclusion, generalization of EC effects to new stimuli seems possible, but the available evidence largely shows that generalization is dependent on awareness (contrast Olson & Fazio, 2006; see Glaser & Kuchenbrandt, 2017, for a discussion).

We argue that even if generalization of EC would be possible without awareness, most studies present participants with simple regularities that are easy to detect consciously: The CSs paired with a positive valence are easily distinguishable from those paired with negative valence (for example, they belong to clearly different and salient categories [e.g., men vs. women in Hütter et al., 2014] and/or are differentiated by obvious cues [e.g., Glaser & Kuchenbrandt, 2017]). Furthermore, these generalization studies typically use so-called "objective" measures of awareness, which assume that if participants accurately identify the valence the CSs have been paired with, they have conscious memory of the CS–US contingencies. However, these methods are biased toward overestimating the role of awareness in conditioning and in generalization effects (e.g., Sweldens et al., 2014; Sweldens, Tuk, & Hütter, 2017), because participants are able to identify accurately the valence from sources other than the conscious memories of the CS–US or CS–valence pairings, that is, from their affective reaction toward the CS (Hütter et al., 2012; Sweldens et al., 2014) and from *implicit* memory-based feelings of familiarity (Sweldens et al., 2017; Timmermans & Cleeremans, 2015). Although alternative, subjective, measures of awareness have already begun to gain dominance in the study of EC (especially the process-dissociation method of Hütter et al., 2012),[1] these measures are more difficult to adapt to generalizations studies, so they have not penetrated the generalization literature. In sum, most previous studies on the generalization of EC (a) employed methods that favor the development of conscious knowledge, by using salient contingencies, and further, (b) used measures that are suspected to overestimate the amount of conscious knowledge available to participants.

In the present study, we propose an approach that employs more complex regularities that are difficult to detect consciously but that are nonetheless learned, producing mostly unconscious knowledge. Also, starting from current theories of consciousness, such as global workspace and higher order thought theories, we use a subjective measure of awareness, which can be more precise in disentangling implicit from explicit influences (e.g., Dienes, 2012; LeDoux & Hofmann, 2018; contrast Shanks, 2005) if specific conditions regarding the sensitivity, relevance, immediacy, and reliability of the measure are met (Berry & Dienes, 1993; Shanks & St John, 1994; Sweldens et al., 2014, 2017).

The regularities that we use are called *artificial grammars* and consist of complex sets of rules that specify permitted, "grammatical" combinations of elements (see Figure 1). In a typical artificial grammar learning (AGL) task (Reber, 1967), participants are presented with meaningless letter strings that, unknown to them, follow an artificial grammar. After exposure, participants are informed that the strings followed some rules, but nothing is disclosed about the rules' configuration. Then, they are presented with *new* strings, some of which follow the same grammar and some of which do not. Participants' task is to respond, for every string, whether it follows the grammar or not. The typical result is that participants are able to accurately classify new strings as "grammatical" or "nongrammatical," even when they rely on subjectively-unconscious knowledge of the grammar (e.g., Dienes & Scott, 2005; Ivanchei & Moroshkina, 2018; Norman & Price, 2012; Scott & Dienes, 2008, 2010; contrast Shanks, 2005; although the task typically also produces some conscious knowledge). Moreover, several studies have shown that participants can learn two grammars and classify new strings according to any of the two grammars (e.g., Dienes, Altmann, Kwan, & Goode, 1995; Norman, Scott, Price, & Dienes, 2016).

The Present Study

We propose a task in which, in an acquisition/conditioning phase, strings generated according to one grammar are paired with negative stimuli, whereas strings generated according to the other grammar are paired with positive stimuli. For brevity, we call the grammar associated with negative stimuli the *negative grammar* and the grammar paired with positive stimuli the *positive grammar*. We assume that participants will acquire structures coding the relations between the elements of the grammars and between the elements of the grammar and the positive/negative affect. Accordingly, in a subsequent test phase, we expect that participants will evaluate *new* strings that follow the positive grammar more positively compared with new strings that follow the negative grammar. In this case, it means that we have obtained a generalizable conditioning effect, because participants evaluate previously unseen strings.

EC research is typically interested whether conditioning effects occur when participants do not remember consciously (a) the *specific US* the evaluated CS has been paired with, and/or (b) *the valence* the evaluated CS has been paired with (e.g., Sweldens et al., 2014). In contrast, in our task, participants do not evaluate CSs that have been directly paired with a US or with a valence; they evaluate stimuli that contain elements from a grammar that has been associated with a valence. Therefore, although in standard EC and EC generalization studies, the CSs are made more or less

[1] Although it has not been explicitly framed as a subjective method, the process-dissociation method developed by Hütter et al. (2012) is a subjective measure of awareness, as it requires participants to respond contingent on their own assessment of their mental states. That is, for each CS, they have to introspectively assess whether they have explicit memory for the CS–valence association. In the exclusion task, if they consciously remember the CS–valence association, they have to respond contrary to their memory of the CS–valence association; if they do not remember the valence, they have to respond according to their attitude toward the CS.

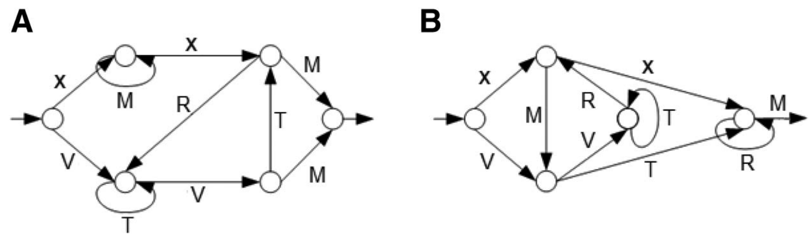

Figure 1. The artificial grammars used in the present study (Dienes et al., 1995; Norman et al., 2016; Reber, 1967). Strings are generated by following the order permitted by the arrows. For example, XMXRTVM is consistent only with Grammar A and XMVTRXM is consistent only with Grammar B.

pleasant by the established CS–US or CS–valence relations, the evaluated strings in our task can be made more or less pleasant by the relations between grammatical elements in their composition and a valence (e.g., between the fragment RTV and a positive valence). Note that even if participants learned some elements of the grammar (e.g., that TV appeared after R), if they did not also learn that those elements were related with a valence, the generalized EC effect could not appear. In conclusion, we are interested, for each string, whether participants are aware of the *relations between elements of the grammar and the valence*, which make the string more or less pleasant. Participants can be unaware of these relations for two reasons: first, because they are unaware of the grammar, and hence have no conscious content to consciously relate with the valence, and second, because even if they are aware of the grammar, they are unaware of whether it was paired with a positive or a negative affect.[2]

If we detect an EC effect in the absence of awareness, this would mean, more specifically, that participants generalize their evaluations toward new stimuli without being aware of the relations between the elements of the grammar and the affective valence, which enable them to make those generalizations.

Our conceptualization and measure of awareness is based on *global availability/global workspace* (Baars, 1997; Dienes, 2012; Shea & Frith, 2019), and, even closer, on *higher order thoughts* theories of consciousness (e.g., Rosenthal, 2004), which assume that in order to be aware of a mental content, one has to have the representation that one has the content (see Dienes, 2007, 2012; Dienes & Scott, 2005). Accordingly, we probe the existence of these metarepresentations that are necessary for consciousness by asking participants to report what they know about their knowledge of the structures coding the relations between elements of the grammar and a valence that make the string likable or dislikeable. If participants exhibit, objectively, knowledge of the structures (inferred from the differential liking of strings that follow the positive vs. the negative grammar) when they claim that they do not have the knowledge, it means that their knowledge of the structures is unconscious (cf., e.g., Dienes, 2012; Dienes & Scott, 2005; Ling et al., 2018; Seth, Dienes, Cleeremans, Overgaard, & Pessoa, 2008). We use a subjective measure of awareness, as we require participants to discriminate between their own mental states. Although subjective measures of awareness have been previously criticized in the context of EC research, it was typically not their subjective character per se that has been criticized. Rather, the target of the criticism has been the relatively low sensitivity of the specific scales used. For instance, they probed the presence of conscious knowledge via open-ended questions, which were presented only at the end of the experiment. Hence, participants might underreport conscious knowledge (e.g., Sweldens et al., 2014). As presented in the Method section (and in Supplementary C of the online supplemental materials), our measure of awareness differs substantially from the subjective measures previously used in EC research, and is specifically tailored to address limitations of past measures, in the context of our task.

We hypothesized that there will be (a) an overall conditioning effect, (b) a conditioning effect based on unconscious knowledge, and also (c) a conditioning effect based on conscious knowledge. Furthermore, we compared the unconscious with the conscious effects, in order to determine whether awareness enhances the generalization of the EC.

Method

The hypotheses, procedure, data collection, and statistical analyses were preregistered on the Open Science Framework (https://osf.io/cbdu6/).

Participants

A total of 240 undergraduate students from a Romanian university underwent the task in exchange for course credit; 23 failed the attention/engagement checks (see Procedure); therefore, the final sample is composed of 217 participants (176 women, M_{age} = 19.94 years, SD = 4.14).

Materials

We employed the two grammars depicted in Figure 1 and took the strings from Norman et al. (2016). In the acquisition/conditioning phase, we presented 32 strings from each grammar. In the test phase, participants had to evaluate 20 strings from each grammar. In the acquisition phase, the strings from one grammar were always presented together with negative images, whereas the strings from the other grammar were always presented with pos-

[2] These two reasons are analogous to the reasons for unawareness from typical EC and EC generalization studies: Participants could be unaware of the CS–valence relations either because (a) they cannot remember consciously whether the CS has been presented in the conditioning phase, and thus have no conscious content to consciously relate with a valence; or (b) they remember having seen the CS but cannot remember whether it was paired with positive or negative affect.

itive images. For counterbalancing, for some randomly determined participants, Grammar A was the positive grammar (and Grammar B, the negative one; conversely for the rest of participants). We used 23 positive and 23 negative images, taken from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1997), the Nencki Affective Picture System (Marchewka, Żurawski, Jednoróg, & Grabowska, 2014), and the Open Affective Standardized Image Set (Kurdi, Lozano, & Banaji, 2017; see Supplementary A of the online supplemental materials for the list of images and strings). It was randomly determined which particular image appeared with which particular string.

Procedure

The study was conducted according to the regulations of Babeş-Bolyai University's Research committee and with the American Psychological Association (2002) ethical guidelines. All participants gave written consent. Data were collected online using gorilla.sc (Anwyl-Irvine, Massonnié, Flitton, Kirkham, & Evershed, 2019). All instructions and response options were presented in Romanian (the original Romanian version and a translated English version are presented in Supplementary A of the online supplemental materials).

Acquisition/conditioning phase. In this phase, participants were expected to learn both grammars and to associate them with emotions. On each trial, the emotional image appeared first. Then, after 1.5 s, the string appeared just below the image. The string remained on the screen, together with the image, for 7.5 s, and then the next trial began automatically. Participants were instructed to memorize which string appeared together with which image. They were not informed that there were regularities in how the strings were constructed or that they would have to do a subsequent affective evaluation task.

The acquisition phase was divided into four blocks: two for Grammar A and two for Grammar B. After each block, participants had a 30-s break. In each block, participants were exposed to all 32 strings from one grammar, each string being paired with an emotional image. Thus, in each block, the participant saw strings that followed only one grammar and images that had only one valence (positive or negative), in order to facilitate learning the grammar, by reducing interference with the other grammar and to benefit from emotional carryover effects. It was randomly determined whether the participant was exposed first to the grammar associated with the negative affect or to that associated with the positive affect.

At 10 random moments in the acquisition, we presented, for attention/engagement check purposes, a string and an image and asked participants whether the string and the image they saw in that moment were identical or not to those from the previous trial. If both were identical, the correct answer was "yes." If either the string or the image was changed, the correct answer was "no." Based on the calibration from a pilot study, we excluded participants that made more than four mistakes.

Test phase (valence rating and awareness measure). Participants were presented with new letter strings without images. They had to evaluate, for every string, how much they liked or disliked it using a Likert scale with values ranging from −5 (*strongly dislike*) to +5 (*strongly like*). The scale did not have a neutral point (i.e., zero was removed), because while piloting the task, participants reported that it felt strange to rate preference for meaningless strings of letters and had the tendency to give neutral ratings. Therefore, by removing the neutral point, we intended to constrain participants to attend even very subtle positive or negative feelings toward the strings (see Eder, Krishna, & Van Dessel, 2019, for a similar solution). After rating the string's valence, participants had to respond to an Awareness scale while the string was still on the screen. More specifically, we informed them that they might not know what makes some strings likable/dislikeable but that it is also possible that, for some strings, they might be aware of some "groups or patterns of letters" that make the strings likable/dislikeable. The scale was adapted from awareness scales that are widely used in AGL (e.g., Dienes & Scott, 2005; Norman et al., 2016; Wierzchoń, Asanowicz, Paulewicz, & Cleeremans, 2012) and in reward-learning/operant-conditioning studies (e.g., Leganes-Fonteneau, Scott, & Duka, 2018):

> To what extent are you aware of what makes the string likable/dislikeable for you?
>
> *1 – I do not have any clue about what makes it likable/dislikeable.*
>
> *2 – I am more or less guessing what makes it likable/dislikeable, but I could not describe what it is that makes it likable/dislikeable.*
>
> *3 – I think I know what makes it likable/dislikeable.*
>
> *4 – I know what makes it likable/dislikeable.*

Because the evaluation of a string could be influenced by *relations between a valence and elements of the grammar that were present in that string*, if participants are aware of these relations, they should be able to identify, in each string, the grammatical elements that carry the affective valence and that make the string pleasant/unpleasant.[3]

Responses 1 and 2 denote that participants are not aware of the structures that make the string likable/dislikeable, whereas Responses 3 and 4 indicate that participants have some conscious knowledge of the structures (cf. Dienes & Scott, 2005; Leganes-Fonteneau et al., 2018; Ramsøy & Overgaard, 2004; Wierzchoń et al., 2012). In order to decrease the probability that participants would report as *unaware* trials in which they actually used conscious knowledge, but held with low confidence, we explicitly instructed them to use Response 3 if they have some conscious knowledge, even if they do not have much confidence in it (see Supplementary C of the online supplemental materials for more details regarding the relevance, sensitivity, and reliability of the scale).

Finally, we collected data regarding age, sex, education, and socioeconomic status. More specific details regarding the stimuli and the procedure are presented in Supplementary A of the online supplemental materials and in the preregistration form (https://osf.io/cbdu6/).

[3] One reviewer suggested that participants might be aware of these relations but that they might not be aware of their influence. This is unlikely, as it would mean that a participant, for example, positively rates the string XMXRTVM, is aware that the fragment RTV has been paired with a positive valence, has been informed that liking/disliking can be generated by groups/patterns of letters, but still responds that they have "no clue" why they positively rated a string containing the fragment RTV.

Results

We report both Bayes factors and significance tests; our conclusions will follow from the Bayes factors, though in all cases both approaches lead to the same conclusions. In the Bayesian analyses, by convention, we interpret Bayes factors (B) between 0.33 and 3 as insensitive, between 3 and 10 as providing moderate evidence, and 10 or greater as providing strong evidence for the alternative hypothesis (H1) over H0. Conversely, we interpret $1/3 \leq B < 1/10$ as moderate evidence, and $B \leq 1/10$ as strong evidence, for H0 over H1.

For testing the first three hypotheses, the model of H1 used in the Bayesian analyses was a half-normal, with a mode of zero and the standard deviation equal to an expected raw effect size of 0.66 (accordingly, the Bayes factor is noted as $B_{\text{H}(0;\ 0.66)}$; e.g., Dienes, 2008, 2014; see Supplementary B of the online supplemental materials for the justification of this model, preregistered before data collection). Typically, we would report robustness regions for Bayes factors, but in what follows, the results are so clear, there was no need.

In order to determine whether there was an overall conditioning effect, we compared the ratings received by all strings that followed the positive grammar with those received by the strings that followed the negative one, irrespective of the conscious/unconscious basis of the evaluation. Table 1 presents mean evaluative ratings received by strings from negative and from positive grammars. A repeated-measures t test revealed, as expected, that strings from the positive grammar were evaluated more positively than those from the negative grammar, $t(216) = 7.69$, $p < .00001$, Cohen's $d_z = 0.52$, $M_{\text{diff}} = 0.538$, 95% CI [0.40, 0.67], $B_{\text{H}(0;\ 0.66)} = 10^{12}$.

As in typical AGL studies (Dienes & Scott, 2005), most participants' responses (66.05%) were based on unconscious knowledge (i.e., Responses 1 and 2 on the Awareness scale). When testing whether there was a conditioning effect based on unconscious knowledge (Figure 2A), we found, again, that the strings from the positive grammar were evaluated more positively than those from the negative grammar, $t(208) = 4.38$, $p = .00001$, $d_z = 0.30$, $M_{\text{diff}} = 0.317$, 95% CI [0.17, 0.46], $B_{\text{H}(0;\ 0.66)} = 3{,}133.45$. We found the same pattern when we analyzed Responses 1 and 2 separately. For Response 1, $t(192) = 2.34$, $p = .004$, $d_z = 0.20$, $M_{\text{diff}} = 0.245$, 95% CI [0.06, 0.43], $B_{\text{H}(0;\ 0.66)} = 9.53$. For Response 2, $t(175) = 2.67$, $p = .01$, $d_z = 0.17$, $M_{\text{diff}} = 0.305$, 95% CI [0.05, 1.39], $B_{\text{H}(0;\ 0.66)} = 5.41$. The effect was also present when participants relied on conscious knowledge (Responses 3 and 4 from the Awareness scale; Figure 2B), $t(181) = 6.35$, $p < .00001$, $d_z = 0.47$, $M_{\text{diff}} = 1.06$, 95% CI [0.73, 1.39], $B_{\text{H}(0;\ 0.66)} = 8 \times 10^7$.

Finally, we found that the conditioning effect based on conscious knowledge was higher than that based on unconscious knowledge, $t(173) = 4.60$, $p < .00001$, $d_z = 0.35$, $M_{\text{diff}} = 0.822$, 95% CI [0.47, 1.18], $B_{\text{U}(0;\ 1.59)} = 11{,}993$. This Bayesian test was conducted with a different prior (see Supplementary B of the online supplemental materials).

In sum, we found strong support for (a) an overall conditioning effect, (b) an effect based on unconscious knowledge, (c) an effect based on conscious knowledge, and (d) that the conscious effect was higher than the unconscious one.

Discussion

The present study is one of the first to show evidence for EC of complex structures. Moreover, it offers evidence that the EC effect generalizes to new stimuli that follow the conditioned structures, even in the absence of subjective awareness of the structures, contradicting previous studies that found affective processing only in the presence of awareness (e.g., Lähteenmäki, Hyönä, Koivisto, & Nummenmaa, 2015). However, consistent with the previous literature, the effect was significantly stronger in the presence of conscious knowledge, supporting the idea that awareness is an important moderator of EC (e.g., Hofmann et al., 2010).

Although we believe that the present study can contribute to discussions regarding the role of awareness in EC and, more broadly, in affective phenomena, it departs substantially from the existing approaches in EC research: First, we did not condition individual stimuli but structures followed by stimuli. Consequently, a second difference was that we did not measure whether participants consciously remembered the valence the evaluated strings were paired with (as they were not paired directly with any US), but we evaluated whether participants were aware of the structures (i.e., of the contingencies between elements of the grammars and valence) that make each string likable/dislikeable. Third, we subscribed to a subjective definition and measurement of awareness, whereas most previous studies on the relationship between EC and awareness have used objective measurements. In sum, we consider that the present study provides evidence for a new phenomenon in the family of EC effects, in which participants like or dislike a previously unseen stimulus because the stimulus follows an emotionally loaded structure that participants are subjectively unaware of.

Limitations

Even though we took several measures for ensuring that our assessment of awareness is reliable and sensitive, it still has several

Table 1
Mean Evaluative Ratings Received by Strings From the Positive and the Negative Grammar, Split on Different Levels of Awareness

Grammar	All responses (N = 217)	1 and 2 (n = 209)	1 (n = 193)	2 (n = 176)	3 and 4 (n = 182)
Positive grammar	0.153 (1.036)	−0.279 (1.166)	−0.543 (1.370)	0.109 (1.575)	1.218 (1.857)
Negative grammar	−0.386 (1.119)	−0.596 (1.120)	−0.788 (1.287)	−0.196 (1.686)	0.155 (2.103)

Note. The values represent means and standard deviations (in parentheses). *N*s refer to the number of participants that used a specific awareness level with strings from both the positive and the negative grammar and that were included in the analyses. *N*s differ because not all participants had responses for all awareness levels. Numbers on the top row refer to awareness levels: 1 = *I don't have any clue*; 2 = *I am more or less guessing*; 3 = *I think I know*; 4 = *I know*.

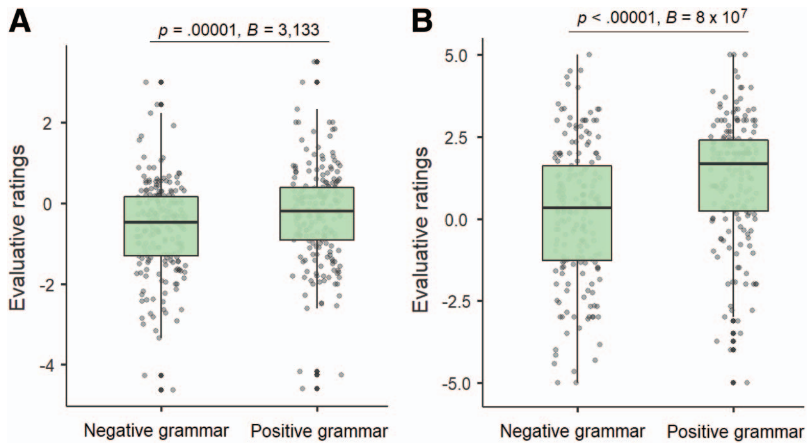

Figure 2. Evaluative ratings received by strings from the positive and the negative grammars when participants used (A) unconscious knowledge, and (B) conscious knowledge. See the online article for the color version of this figure.

limitations. First, we cannot rule out the possibility that participants inferred, post hoc, parts of the regularities that were associated with positive and with negative affect. For instance, in the test phase, they could notice that a specific group of letters always triggers negative affect. Hence, after observing this relationship, they responded that they know what makes the string negative. Therefore, even though conscious knowledge did not play a role in their evaluation (as it emerged postevaluation), this would count, according to our scale, as an evaluation based on conscious knowledge. This limitation could lead to an underestimation of the unconscious EC effect, because some evaluations sustained by unconscious knowledge would be attributed to conscious knowledge (cf., e.g., Sweldens et al., 2014).

Second, it is possible that our awareness measure did not disentangle all types of knowledge that could sustain participants' evaluations. Specifically, unconscious knowledge could produce generalized EC effects based on two routes. Let us assume that a participant has to evaluate the string XMXRTVM, which follows the positive grammar and gives it a positive rating. First, this could be because the participant holds an unconscious association, say, between the trigram RTV and the positive valence. In this case, the participant holds no conscious knowledge of the association between elements of the grammar and the emotion, so they should use Level 1 of the Awareness scale ("I do not have any clue"). In a second case, the participant has learned unconsciously something about the grammar's configuration (e.g., TV appeared after R), and, based on their unconscious knowledge of the grammar's configuration (TV after R), they might be able to judge consciously that the string is somehow similar to the strings paired with positive images (even though they do not know what makes it similar to those strings; e.g., Dienes & Scott, 2005; Norman & Price, 2012). In these situations, participants would be likely to use Level 3 of the Awareness scale ("I think I know"), but because they cannot fully express the reasons for liking (they do not know what makes the string belong to those paired with positive images), they could also use Level 2 ("I am more or less guessing"). Even in this case, the fact that the conscious judgment of similarity was based on unconscious knowledge of the grammars enables us to draw the conclusion that the detected EC effect was influenced by nonconscious structures (see, for more details, the distinction between structural and judgment knowledge from the AGL literature; Dienes & Scott, 2005). Moreover, the effect appeared even when we excluded responses based on Level 2 of the scale and took into consideration only evaluations based on response 1 ("I do not have any clue about what makes it likable/dislikeable"), which was designed to exclude any type of conscious knowledge.[4]

Also, the AGL task has been criticized on the grounds that participants can discriminate strings from the two grammars not necessarily by acquiring complex structures but by identifying bigrams and trigrams (i.e., successions of two or three letters) that differ between the grammars. Furthermore, because these bigrams and trigrams are relatively simple, they are relatively easy to be detected consciously; thus, they are sometimes represented explicitly (cf. Dulany, Carlson, & Dewey, 1984; Perruchet & Pacteau, 1990). However, several studies from the past decades, using various implicit learning tasks, have found that even when the regularities are solely at the level of bigrams and trigrams, most of participants' knowledge is still implicit (e.g., Fu, Dienes, & Fu, 2010; Gomez, 1997; Ling et al., 2018). Thus, it is unwarranted to assume that if participants learn bigrams and trigrams, learning is, ipso facto, conscious. In the same vein, all previous AGL studies that have used the very same grammars and the very same acquisition and test strings that we used consistently found evidence for implicit learning (Dienes et al., 1995; Norman, Price, & Jones, 2011; Norman et al., 2016; Norman, Scott, Price, Jones, & Dienes, 2019; Wan, Dienes, & Fu, 2008). Finally, we conducted additional (nonpreregistered) analyses on our data, which showed that, al-

[4] We consider very unlikely a more extreme scenario, in which participants evaluated the string as pleasant because it was similar to the strings paired with positive images, and were also aware of the elements that make it similar to the positively conditioned strings, but systematically responded that they have no idea what makes the string positive. This scenario would invalidate our conclusion, that nonconscious structures had an influence on the EC effect, but given the measures we took for ensuring the validity of our Awareness scale, we consider it highly implausible.

though liking is indeed predicted by bigrams and trigrams, it is also predicted by more complex and abstract types of knowledge, which are, presumably, more difficult to be consciously detected (see Supplementary B of the online supplemental materials).

Implications and Future Directions

A propositional account would have difficulties in fully explaining a conditioning effect when participants have no conscious knowledge of the structures present in a string, as the formation of propositions is assumed to be applicable only to conscious contents (e.g., De Houwer, 2018). For situations discussed in the Limitations section, in which participants were presumably aware that the string is somehow related to the strings paired with a valence, but were not aware of the grammar elements that gave this similarity, relating the string with a valence could be explained by the formation of conscious propositions (e.g., because the string is more similar to those paired with positive valence, the string is pleasant/likable). However, the acquisition of unconscious structures, which were responsible for ensuring the similarity, cannot be explained by the formation of propositions, but rather by the formation of associations between the elements of the grammar. Cases in which participants lacked any kind of conscious knowledge leave even less room for an influence of propositions, but, again, these situations might be explained by the unconscious formation of associations between elements of the grammar, and between elements of the grammar and a valence (e.g., Greenwald & De Houwer, 2017; see Corneille & Stahl, 2019, for a discussion). More precise data on the conscious/unconscious status of all types of knowledge acquired in this task (knowledge of the grammars, knowledge of the grammar-valence contingencies) would also enable more precise discussions regarding the nature of the representations responsible for the detected generalized EC effect.

Beyond the EC literature, our results are also compatible with those from research on *affect misattribution* (e.g., Schwarz & Clore, 1983, 2003; but see Cummins, Hussey, & Hughes, 2019, and Simonsohn, 2015), which has claimed that participants are not always able to accurately identify what influences their affective responses. For example, they can attribute their negative affect to a low life satisfaction even though the negative affect was actually generated by a rainy weather (Schwarz & Clore, 1983). Thus, in these studies, participants exhibit affective influences from stimuli they are aware of (e.g., they are aware that the weather is rainy) while being unaware of their influence (i.e., think something else exerts the influence). Our study presents a particular case of incapacity to consciously detect the causes for one's affective evaluations in which the causes are newly acquired, conditioned, structures, and in which the influence is generalized to previously unseen stimuli that fit those structures. Moreover, in the present study, the causes themselves (i.e., the associations between elements of the grammar and a valence) were unaware, not just their influence.[5]

Future studies should try to assess awareness for different components that can contribute to the detected EC effect: In addition to awareness of the relations between elements of the grammar and the valence, they should also assess awareness *that a string belongs* to the positively or to the negatively conditioned grammar and awareness of *the grammar elements that makes the string belong* to that grammar. This would help to determine whether, as explained above, the combination of unconscious knowledge of the grammars but with conscious knowledge of the similarity (Dienes & Scott, 2005) is indeed involved in producing the EC effect.

Future studies could also investigate additional characteristics of the revealed EC effect, such as its automaticity or controllability. For instance, in affective-priming tasks, stimuli with emotional valence automatically enhance the detection of stimuli with the same valence (Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Ivanchei & Asvarisch, 2018). Using the present paradigm, participants might undergo an affective-priming task in which primes could be new strings that follow the positive or the negative grammar. Another approach would be to adopt process-dissociation methods, as those often used in AGL (e.g., Norman et al., 2016) and EC research (e.g., Hütter et al., 2014), and to test whether participants can voluntarily control the influence of the acquired structures.

Other essential properties regard the malleability of consciously and unconsciously based EC effects. It would be important to determine whether extinction of the EC effect is achieved in different time frames when the effect is sustained by conscious versus unconscious knowledge, or whether, for example, there are differences in the amount of exposure needed to positively condition a structure that has been initially conditioned negatively, as a function of conscious versus unconscious status of knowledge or of the associative versus propositional representations sustaining the EC effect (cf. Mann, Kurdi, & Banaji, 2019).

In conclusion, the present study proposes a novel experimental paradigm in EC research, in which evaluations are based on structures; provides evidence that EC effects can generalize in the absence of subjective awareness of the conditioned structures; and, more generally, that subjectively nonconscious structures can influence affective responses.

Context of the Research

We are often able to evaluate whether a sentence is grammatically correct or incorrect, even without being able to explain why it is so. Thus, our evaluations can be based on complex nonconscious knowledge about word associations permitted by a certain language. Can knowledge that we are unaware of also influence our affective evaluations? We show in this study that we can learn very complex associations between neutral stimuli and positive or negative emotions, and that these associations can remain outside awareness but still influence our affective judgments.

For research on unconsciously based affective phenomena, this approach based on learning complex associations presents advantages over existing methods: It permits the use of strong, supra-

[5] When the real causes are conscious (e.g., participants are aware that the weather is rainy), the misattribution effect is claimed to appear only when participants' attention is actively directed, via experimental manipulation, toward the mistaken cause (e.g., they are asked explicitly about their life satisfaction but no mention is made about the weather). When the manipulation hints, even subtly, at the real causes (e.g., by asking participants about the weather), the misattribution effect is claimed to disappear (see also Cummins et al., 2019). In contrast, in our task, participants' attention was actively directed toward the real causes for the evaluation (i.e., were told that the affective valence can be carried by groups or patterns of letters), and thus we have little reason to suspect that in trials in which participants claimed to have no conscious knowledge, they were actually aware of the structures and were unaware only of their influence.

liminal stimuli (as opposed to the methods using subliminal exposure), and it also keeps participants unaware of the regularities in most of the trials (as opposed to some of the studies using simple CS–US relations). Accordingly, although not without limitations (e.g., it does not afford a direct manipulation of awareness, as in the case of subliminal exposure), it could complement existing approaches in the study of unconscious emotional learning.

We are interested to test, in future studies, whether unconscious evaluative and fear conditioning based on such complex structures can occur in more ecologically relevant contexts, with regard to more realistic stimuli (e.g., with regard to complex behaviors of a virtual avatar).

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