Indirect Evaluative Conditioning

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Evaluative Conditioning in the Absence of Directly Experienced CS-US Pairings

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Abstract

Evaluative conditioning (EC) is the valence change of a stimulus (CS) that is due to the previous pairing with another stimulus (US). We investigated whether EC can occur also when the CS-US pairings are not experienced directly by the participant but are implied by other events that the participant encounters. In two experiments, positive USs were presented in some trials and negative USs in other trials. Afterwards, participants were given information from which it was possible to conclude that CSs were present during these trials. Finally, the valence of these CSs was registered using both implicit (IAT, affective priming) and explicit measures (valence ratings). In line with the assumption that EC effects can be based on CS-US pairings that are not directly experienced, the valence of the CSs changed in the direction of the US with which they were covertly paired. This effect was observed both on explicit and implicit measures. We argue that several aspects of our results are in line with propositional models of EC and fit less well with association formation models.

Key words: Evaluative Conditioning, Propositional Model, Implicit Measures, Implicit Attitudes, Second Order Conditioning
Evaluative conditioning (EC) is a change in the valence of a stimulus (conditioned stimulus or CS) that is due to the pairings with another stimulus (unconditioned stimulus or US, De Houwer, 2007). This definition of EC as an effect is based on specifying a regularity in the environment (in this case, stimuli being paired) and a result of that regularity (in this case, a change in valence, De Houwer, 2007, 2009). EC is considered to be an important phenomenon because it sheds light on the origins of the preferences that guide many aspects of our thoughts, emotions, and behavior (see De Houwer, Thomas, & Baeyens, 2001; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010, for reviews).

In a typical EC experiment, a simple regularity, that is the pairing of the CS and the US, is directly experienced by the participants. In this paper, we focus on indirect EC. We define indirect EC as a change in liking that is due to events that imply the presence of CS-US pairings. This definition refers to a set of events in the environment (i.e., events that contain within them information about a CS-US relation that is not experienced directly) and is therefore not directly linked to any theory of EC. The inspiration for studying EC under these conditions, however, came from propositional models of EC. These models assume that (evaluative) conditioning effects are due to the acquisition of conscious propositional knowledge about stimulus regularities (e.g. Corneille, Yzerbyt, Pleyers, & Mussweiler, 2009; De Houwer, 2007; De Houwer, 2009; Hofmann et al., 2010, Mitchell, De Houwer, & Lovibond, 2009a). They are able to account for much of the evidence concerning EC, including the fact that EC effects seem to depend on participants’ awareness about the stimulus contingencies (see Hofmann et al., 2010, for an overview). While propositional knowledge about stimulus regularities is crucial for these models, it does not matter how this knowledge is acquired. The propositional belief that a CS and a US are related can be formed on the basis of direct experiences of CS-US pairings but also on
the basis of other experiences that imply the presence of these pairings such as for example verbal instructions about the pairings. Hence, EC should not depend on the direct experience of CS-US pairings.

Learning about contingencies via instructions has already been investigated in the area of fear conditioning. It has, for instance, been demonstrated that informing participants about the pairings of a light and an electric shock can lead to changes in skin conductance in response to a light (e.g. Cook & Harris, 1937; Field & Lawson, 2003; Lovibond, 2003; McNally, 1981). In the area of EC, indirect learning has been studied much less. One study investigated the influence of instructing participants about future pairings (De Houwer, 2006). In two experiments, participants were given the information that certain CSs would later be paired with positive photos, while other CSs would later be paired with negative photos. After these instructions, an implicit measure of CS valence (i.e., the Implicit Association Test or IAT) showed that the valence of the CSs changed in line with the instructions. To the best of our knowledge, this is currently the only published demonstration of instruction based EC.

The studies of De Houwer (2006) are, however, limited in that they show the effect on only one measure (i.e., IAT). The observed valence change might therefore be due to particularities of this measure. A second and more important limitation relates to whether these studies provide evidence for EC in the absence of directly experienced CS-US pairings. By stating that certain CSs would be followed by positive or negative pictures, the instructions included direct pairings of the word “positive” or “negative” with the CSs. If these words are seen as USs, it can be argued that participants directly experienced CS-US pairings, albeit in only one trial per pair (see Field, 2006, for such an account of conditioning via instruction). Thus, although instructing participants about stimulus co-occurrences instead of showing them
the stimulus co-occurrences sharply reduces the number of experienced co-occurrences, it does not completely remove them.

The main goal of this paper is to provide more solid evidence for indirect EC. We therefore developed a two-step procedure in which the US is not mentioned in the instruction about the CS. Participants in Experiment 1 first experienced the presentation of a positive picture US together with a number (e.g., 1) and a negative picture US together with another number (e.g., 2). Afterwards, the participants were instructed that hidden in trials with a certain number a certain neutral picture was present (e.g., one picture was hidden on trials with the number 1 and another picture on trials with the number 2). These neutral pictures functioned as the CSs. The information about the CSs implied that CS-US pairings occurred during the first phase, even though the participants did not experience these pairings directly, nor did they receive instructions in which direct reference was made to both the CSs and USs. Indirect EC would be evidenced by a change in the liking of a CS in the direction of the valence of the US with which it was supposedly paired.

Experiments 2 was based on a different but structurally similar set-up in which participants first ate good tasting cookies from one bowl and bad tasting cookies from another bowl without being able to see the cookies. Afterwards, participants were asked to remove a cover so that they could see what the cookies in the bowls looked like. In line with previous research (Verhulst, Hermans, Baeyens, Spruyt, & Eelen, 2006), the good and bad tastes were conceived of as the positive and negative USs whereas the visual appearance of a cookie functioned as the CS in this experiment. Also this set-up provides the information necessary to learn the relation between the CS (appearance) and the US (taste) without ever having directly experienced them together. In all experiments, we used implicit measures to assess CS valence.
Indirect Evaluative Conditioning

(i.e., affective priming, Fazio, Sanbonmatsu, Powell, & Kardes, 1986, and an IAT, Greenwald, McGhee, & Schwartz, 1998) and evaluative ratings. Implicit measures are assumed to be less susceptible to the impact of demand effects and able to capture more automatic evaluations.

These procedures were designed to contain all the building blocks that participants would need to draw conclusions about the presence of the CS-US relation in the absence of direct CS-US pairings. However, when considering only the mere occurrence of stimuli, it can be seen that the procedures are second order conditioning procedures. In second order conditioning, participants experience two different pairings: First, a US is paired with a neutral stimulus CS1 and then the CS1 is paired with another neutral stimulus CS2. Second order evaluative conditioning consists in a change of valence of the CS2. In our procedures, the numbers (Experiment 1) or the location of the bowls (Experiments 2) can be seen as an equivalent to a CS1. The neutral pictures or the appearance of the cookies would qualify as a CS2. Hence, a valence change of these neutral stimuli would also be an instance of second order conditioning. Second order conditioning has been reported only once in the literature on EC with only visual stimuli and with only an explicit valence measure (Walther, 2002, Experiment 4; see Hammerl & Grabitz, 1996, for a related study). Our studies go beyond these studies by using also gustatory stimuli and implicit valence measures in addition to valence ratings. More importantly, our procedures also differed from earlier second order conditioning procedures in that CS1 and CS2 were paired only once (i.e., when participants received information about the occurrence of the CS in the first phase or when they saw the cookies in the bowls). Moreover, this single event was specifically set up in such a way that it allowed participants to draw conclusions about the presence of CS2 during the first phase and thus about the covert CS2-US relation. Please also note that propositional models predict EC effects only for participants who actually infer the CS-
US relation that is implied by the experienced events. We therefore asked participants to indicate their beliefs about the relation between the CSs and USs.

**Experiment 1**

During a first phase, the positive and the negative US picture were each shown in several trials along with two other stimuli: a grey rectangle and a number serving as cue (either 1 or 2, depending on the US). After this phase, participants were informed that in the trials with the number 1, respectively 2, a specific neutral picture (i.e., a picture of an unknown product) had been hidden behind the grey rectangle. We were interested in whether EC effects can be found for these neutral product pictures (which we will refer to as the CSs). If, for example, a positive US was presented with a grey square in trials with the number 1, and if participants were later informed that in trials with the number 1, the grey square had covered a picture of an unknown brand of toothpaste, we would expect the picture of the toothpaste to become more positive.

**Method**

**Participants.** Forty-nine native Dutch speaking students at Ghent University (36 women, 13 men) participated either for course credits or for a monetary reward of 4 €. All participants reported normal or corrected to normal vision. Their ages ranged from 18 to 38 years ($M = 20.69; SD = 3.92$).

**Materials.** The CSs were pictures of fictitious commercial products taken from Pleyers, Corneille, Luminet, & Yzerbyt, (2007). The selection of the two CS pictures (toothpaste, package of toilet paper) was based on their relatively neutral ratings in a pilot study conducted at our lab ($N = 35$; toothpaste: $M = 1.94, SD = 1.81$; toilet paper: $M = 1.54, SD = 1.31$ on scales ranging from -10 to +10). They were presented on the computer screen in a size of
approximately 3.2 by 4.5 cm. The USs were pictures taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999). They were presented on the computer screen in a size of approximately 8 by 10.5 cm. One positive and one negative IAPS picture was selected individually for each participant from a set of 60 pictures (see Procedure). The numbers were about 2.5 cm high and written in black on a white background surrounded by a black frame of approximately 8 by 10.5 cm.

For the IAT, smaller pictures of the CSs (toothpaste, toilet paper) as well as the words “positive” and “negative” were used as category labels. The words “toothpaste”, “mendo” (name of the toothpaste written on its package), “toilet paper”, and “vlaush” (name of the toilet paper written on its package) were used as target stimuli in the IAT. Four positive and four negative Dutch adjectives selected from Hermans and De Houwer (1994) were used as attribute stimuli in the IAT (sympathetic, nice, pleasant, original, jealous, annoying, impolite, aggressive). Positive and negative attributes were matched in word length, valence extremity, and familiarity.

**Procedure.** After participants had given informed consent, they were seated in front of a computer screen on which all instructions appeared. The experiment consisted of the following phases: rating of the IAPS pictures and computerized selection of the USs based on these ratings, US presentation phase, CS uncovering manipulation, post-conditioning rating of the CSs and the numerical cues, IAT procedure, testing of the CS-US contingency knowledge, and finally some questions regarding participants’ US evaluations, contingency observations and evaluative strategies. The experiment lasted about 25 minutes.

**US pre-rating.** Participants were told that they would be shown pictures and that their task would be to indicate their general impression of the positivity or negativity of these pictures...
on a scale from -10 to +10. They were encouraged to be precise. Sixty IAPS pictures were then presented on the screen one-by-one with a rating scale consisting of 21 green squares indicated with numbers from -10 to +10 on which the participants could click with the computer mouse. Based on these ratings, the computer program individually selected the most positive and the most negative picture as USs.

**US presentation.** At the beginning of this phase, participants were informed that in each of the following trials they would see a number, a picture, and a grey rectangle. They were instructed to look at the stimuli attentively. In each trial the number 1 or 2 was shown on the left side of the screen. In the middle of the screen one of the USs was presented, and on the right side of the screen a grey rectangle of approximately 9 by 11.5 cm. Each of the two USs was always combined with the same number. During each trial, the stimulus combination stayed on the screen for 4000 ms. After an inter trial interval of 2000 ms, the next trial started. The US presentation phase consisted of eight blocks of one positive and one negative US presentation each. Within each block of two trials, the presentation order was randomized.

**CS uncovering.** After the US presentation phase, participants were informed that – depending on the number – the grey squares were covering other pictures and that they would now be shown these pictures. For both numbers, the participants saw a slide stating “In trials with the number 1 (2), the grey square covered this picture” and a picture of one of the CSs. The number was again shown in a black frame. The slide stayed on the screen for at least 7000 ms; then a signal appeared on the screen informing the participants that they could press the space bar to continue. We will refer to pictures that according to this instruction were paired with a positive picture as CS\textsubscript{pos} and pictures that according to this instruction were paired with a negative picture as CS\textsubscript{neg}. 

**CS and number ratings.** With a similar instruction as for the USs in the first phase, participants were then asked to rate the CSs. Both CSs were presented in random order; participants could rate them with the same scale as used before. Following a similar instruction, participants then rated the numerical cues.

**IAT.** Participants were informed that in the following task they would see words appear on the screen one-by-one and that their task would be to categorize them using the keys “D” and “L”. The four categories (“positive” and “negative” as attribute categories and the two CSs as target categories) were described by displaying the items in those categories (see Materials section). Participants were told that the assignment of a category to a key would change between phases, which would be announced at the beginning of each phase and indicated throughout the trials by displaying the category labels assigned to the left key on the upper left side of the screen and the category labels assigned to the right key on the upper right side of the screen.

The category-labels (“positive”, “negative”, a smaller toothpaste picture, a smaller picture of the package of toilet paper) were shown in the upper left and upper right corner of the computer screen throughout the blocks in which they were relevant. All participants pressed the right key (“L”) for “positive” and the left key (“D”) for “negative” in the attribute trials. Depending on congruency and counterbalancing conditions, participants pressed the right key for one product and the left key for the other product (see below).

Each trial started with the presentation of a fixation cross in the centre of the screen for 200 ms, followed by the presentation of an attribute or target word in the centre of the screen. The word remained on the screen until the correct key was pressed. If the wrong key was pressed, a correction signal appeared below the stimulus until the correct key was pressed.
Each participant completed the following blocks: (1) A practice block of 16 trials in which each of the positive and negative attribute stimuli appeared twice. Participants had to press the right key (L) for positive attributes and the left key (D) for negative attributes. (2) A practice block of 16 trials in which each of the target stimuli (“toothpaste”, “mendo”, “toilet paper”, “vlaush”) appeared four times with the category toothpaste assigned to the right key and the category toilet paper assigned to the left key. (3) A practice block of 16 trials in which each of the eight attribute stimuli appeared once and each of the four target stimuli appeared twice with the attribute categories assigned as in Block 1 and the target categories assigned as in Block 2. (4) A main experimental block of 64 trials in which each of the attribute stimuli appeared four times and each of the target stimuli appeared eight times with the categories assigned as in Block 3. (5) A practice block of 16 trials in which each of the target stimuli appeared four times with the category toilet paper assigned to the right key and the category toothpaste assigned to the left key. (6) A practice block of 16 trials in which each of the attribute stimuli appeared once and each of the target stimuli appeared twice with the attribute categories assigned as in Block 1 and the target categories assigned as in Block 5. (7) A main experimental block of 64 trials in which each of the attribute stimuli appeared four times and each of the target stimuli appeared eight times with the categories assigned as in Block 6. Whether participants worked first on Blocks 2 to 4 or first on Blocks 5 to 7 depended on two counterbalancing factors. First, we varied across participants the assignment of toothpaste and toilet paper to the role of $CS_{pos}$ and $CS_{neg}$ (CS assignment). Second, half of the participants started with the congruent IAT blocks in which $CS_{pos}$ and positive attributes were assigned to the same key and $CS_{neg}$ and negative attributes to the other. The other participants started with the incongruent blocks in which the first key was
assigned to $\text{CS}_{\text{neg}}$ and positive attributes and the second key was assigned to $\text{CS}_{\text{pos}}$ and negative attributes (IAT order). Within each block, the order of trials was randomized.

**CS-US contingency awareness.** To test whether a participant correctly inferred with which US a CS was covertly paired, participants saw two slides in random order, each with one of the CSs on the left side and both USs on the right side of the screen. The USs were indicated by the letters A and B. Participants were instructed to type in the letter of the US that according to them had been paired with the CS.

**Strategy Questions.** Finally, participants were given a number of additional questions displayed on the computer screen in a forced-choice format. These questions concerned their US evaluations, contingency observations and their evaluative strategies. Most of these served exploratory purposes and will not be discussed further. For the present purposes, the most relevant of these questions regarded participants’ perceived demand compliance: Participants were asked whether they had used the knowledge about the hidden pairings intentionally because they thought that this was the purpose of the experiment (see Bar-Anan, De Houwer, & Nosek, 2010).

**Design.** The main experimental factor was US valence ($\text{CS}_{\text{pos}}, \text{CS}_{\text{neg}}$: within). It was counterbalanced across participants which product picture was used as CS in the positive and in the negative condition (CS assignment in positive condition: toothpaste or toilet paper), which number was used for the positive and for the negative condition (number in positive condition: 1 or 2), and whether congruent or incongruent response assignments were worked on first in the IAT (IAT order: congruent first or incongruent first).

**Results**
**CS-US contingency awareness.** Twenty-nine participants (59.2 %) selected the correct US picture for both CS pictures, ten participants (20.4 %) selected the correct US picture for only one CS picture, and ten participants (20.4 %) selected the wrong US picture for both CS pictures.

This CS-US-awareness question tested whether the crucial inference that CS and US had been paired was made. Based on propositional models, we only predicted an EC effect for those participants who actually made this inference – and who in particular did not make the opposite inference. Therefore, unless otherwise stated, the main analyses were based on only those participants who indicated the correct US for both CSs.²

**CS ratings.** A 2 (US valence: CSpos, CSneg; within) by 2 (CS assignment in positive condition: toothpaste, toilet paper; between) by 2 (number in positive condition: 1, 2; between) ANOVA was performed.³ Most importantly, it revealed the crucial main effect of US valence (EC effect) indicating that the CSpos (picture hidden in trials with a positive US; \( M = 1.83; SD = 3.14 \)) was rated more positively than the CSneg (picture hidden in trials with a negative US; \( M = -0.34; SD = 3.42 \)), \( F(1,25) = 6.04, MSE = 9.90, p = .02, \eta^2_{\text{partial}} = .19 \). There was also a significant interaction of valence and CS assignment, \( F(1,25) = 7.99, MSE = 9.90, p = .009, \eta^2_{\text{partial}} = .24 \), indicating that the difference between the CSpos and the CSneg was larger when the CSpos was the toothpaste and therefore that the toothpaste was somewhat preferred over the toilet paper. There was no significant interaction between number and US valence, \( F(1,25) = 1.86, MSE = 9.90, p = .18, \eta^2_{\text{partial}} = .07 \), and no significant three-way interaction, \( F < 1 \).

**IAT.** The IAT data were prepared following one of the recommended scoring algorithms (D5; Greenwald, Nosek, & Banaji, 2003). According to this algorithm, trials from Blocks 3 and 6 (practice blocks), and 4 and 7 (main blocks) were included in the analysis. Outliers (below 400 and above 10.000 ms; 1.44 %) were deleted and errors (5.05 % of non-outlier responses) were
replaced by the mean RT plus two standard deviations. The difference between mean response
latencies on incongruent and congruent practice blocks (Blocks 3 and 6) was divided by the
standard deviation from the practice blocks. The difference between congruent and incongruent
main blocks (Blocks 4 and 7) was divided by the standard deviation from the main blocks. The
D5 score is the equal weight average of these ratios (Greenwald et al., 2003). Following our
hypothesis, a block was considered as congruent in which the CS_{pos} was assigned to the same
key as the positive attributes and the CS_{neg} was assigned to the same key as the negative
attributes. Blocks in which this assignment was reversed were considered as incongruent.
Positive D values are thus indicative of an EC effect.

As D is a single score, it is often only tested against zero with a simple t-test. To test the
difference from zero while taking into account the potential impact of the counterbalancing
factors, we instead conducted a regression analysis with D as dependent variable. The
counterbalancing factors and all their interactions were effect coded (+1/-1) and entered as
predictors. Thus, the intercept can be interpreted as the influence of D independent of the
counterbalancing factors. This intercept differed significantly from 0, \( B = 0.19, SE = 0.05, t(21) = 3.59, p = .002 \), indicating an EC effect of the hidden CSs. There was an influence of CS
assignment, \( B = 0.26, SE = 0.05, \beta = .52, t(21) = 4.80, p < .001 \), indicating a more pronounced
EC effect when toothpaste was the CS_{pos} and therefore that the toothpaste was more positive than
the toilet paper. There was also an influence of number, indicating that the effect was somewhat
stronger when positive pictures appeared in trials with the number 1, \( B = - 0.12, SE = 0.05, \beta = -
.23, t(21) = -2.14, p = .04 \). Finally, there was an influence of IAT order, \( B = - 0.29, SE = 0.05, \beta
= - .58, t(21) = -5.34, p < .001 \), indicating that the EC effect was stronger when participants
worked first on the congruent block. Neither of the interactions had a significant influence, all \( p \)
> .10. D did not correlate significantly with an EC effect variable calculated based on the ratings (CS\textsubscript{pos} - CS\textsubscript{neg}), \(r = .13, \text{ns}\).

**Analyses including CS-US unaware participants.** Including also those participants in the analyses who selected the wrong US for one or both CSs, revealed an EC effect on the ratings, \(F(1,45) = 9.68, MSE = 8.61, p = .003, \eta^2_{\text{partial}} = .18\). Also in this analysis, CS\textsubscript{pos} (\(M = 1.84; SD = 2.79\)) were rated more positively than CS\textsubscript{neg} (\(M = 0.22; SD = 3.45\)). On the D measure, however, no significant EC effect was found, \(B = 0.06; SE = 0.06\), \(t(41) = 1.03, p = .31\).

Including CS-US awareness (both correct vs. both wrong) as an additional factor, shows no interaction with the EC effect on the ratings, \(F < 1\). This factor does, however, influence the EC effect on the D measure, \(B = 0.49, SE = 0.11, \beta = .71, t(34) = 4.45, p < .001\). Participants who made the opposite inference for both CS-US pairs showed a descriptively reversed, but non-significant EC effect, \(B = -0.12, SE = 0.13, t(7) = -.95, \text{ns}\).

**Number ratings.** The CS-US aware participants rated the number that was paired with a positive picture (\(M = 3.32; SD = 3.64\)) as more positive than the number that was paired with a negative picture (\(M = -0.43; SD = 4.51\), \(F(1,24) = 10.71, MSE = 19.40, p = .003, \eta^2_{\text{partial}} = .31.6\)). An effect variable of the numbers (number in positive condition - number in negative condition) was correlated with the EC effect variable on the ratings (CS\textsubscript{pos} - CS\textsubscript{neg}), \(r = 0.66, p < .001\). There was no correlation of the number effect variable with the IAT’s D measure, \(r = -.01, \text{ns}\).

**Self report of demand compliance.** Five of the 29 participants who were CS-US contingency aware indicated that they intentionally used their knowledge about the pairings because they thought that this was the goal of the experiment. The EC effect did not interact with this self-report-based estimate for demand compliance on either of the measures (both \(F’s < 1\)). When the five presumably demand complying persons were excluded, the EC effects on the
ratings ($F[1,20] = 5.35, MSE = 10.46, p = .03, \eta^2_{\text{partial}} = .21$; \text{CS}_{\text{pos}}: M = 2.17; SD = 2.99; \text{CS}_{\text{neg}}: M = -0.04; SD = 3.52) and on the IAT, $B = 0.20, SE = 0.06, t(16) = 3.28, p = .005$, remained intact.

**Discussion**

Experiment 1 showed an EC effect that was in line with a covert CS-US relation. For those participants who correctly indicated which CS was covertly paired with which US, we found an EC effect both on ratings and in an IAT. The result on the IAT data crucially depended on whether a participant correctly indicated the hidden pairings. This was not the case for the ratings. Please note, however, that the time span between the ratings and the CS-US awareness check was longer than that between the IAT and the awareness check. In other words, participants performed the IAT between the ratings and the awareness check, which might have influenced their memory for the CS-US contingencies. Therefore, the CS-US awareness check might be a better estimate of the knowledge during the IAT than during the ratings, which could explain why it is related to the EC effect on the IAT but not to the EC effect on the ratings.

The fact that we obtained an indirect EC effect not only in an explicit but also in an implicit measure, makes it less likely that the effect is due to demand compliance. This is corroborated by the fact that the effect was unaffected when the data of five self reportedly demand complying participants were excluded.

In the next experiment, we aimed to generalize the indirect EC effect to different stimulus materials. Additionally, we used a different implicit valence measure – the affective priming procedure. While the use of implicit measures reduces the risk that effects are based on demand compliance, the use of just one implicit measure entails the risk that effects are due to artefacts
based on the particular procedure. The use of different implicit measures helps to validate the results and ensure that what we are measuring is actually a change in valence.

**Experiment 2**

Experiment 2 was modeled after a study of Verhulst et al. (2006) in which the taste of cookies served as USs and the appearance of cookies served as CSs. During the conditioning phase, participants were instructed to eat small cookies from two bowls without being able to see the cookies. The taste of the cookies in one bowl was positive and the taste of the cookies in the other bowl was negative. After this phase, participants were instructed to remove the napkin which covered the cookies and to look at the cookies. We were interested in whether the liking of the visual appearance of the cookies (CSs) changed even though participants could not directly experience the CS-US pairings.

**Method**

**Participants.** Twenty-five native Dutch-speaking students at Ghent University participated either for course credits or for a monetary reward of 5 € (see Footnote 1). They gave their informed consent after being told that they would participate in a study that included tasting of cookies and after seeing a list of all ingredients.

**Materials.** Four types of cookies were used as CS-US compounds: Good and bad tasting pink cookies in the shape of a car and good and bad tasting green cookies in the shape of a cat. The visual appearances of the cookies and their pictures served as CSs and the tastes of the cookies served as USs. The pastry for the cookies was made from 250 g flour, 125 g butter, and one egg. It was then divided into two halves. Fifty g of sugar and a pinch of vanilla were added to the supposedly good tasting half. Four teaspoons of Tween 20 (polysorbate, a bitter soap-like
tasting substance) were added to the supposedly bad tasting half. The pastry was again divided into two halves which were coloured pink or green respectively with food colour. The pastry was thinly rolled, trimmed with cutters in the shape of a cat or a car and baked for 8-10 minutes at approximately 190 degrees Celsius. For the first part of the learning phase (US presentation), the cookies were broken into six pieces of approximately 1.5 cm². The cookies were placed in white plastic bowls with two layers: In the bottom layer we placed an unbroken cookie of the chosen appearance. On top of this, a second transparent bowl was placed which carried six broken pieces of a cookie of the same appearance and some crumbs. This way, participants could eat only small pieces during the first conditioning phase, but saw a whole cookie after uncovering the bowls. The two double-layered bowls were placed and fixated in a cardboard box (approx. 30 cm by 16 cm by 11 cm), which was open at the front side. The bowls were covered by a napkin. A second napkin was fixed to the top side of the box, covering the sight into the box.

For the rating and affective priming phases, we used photographs of the pink car and the green cat cookies (approx. 13 cm by 16 cm) as CSs. Pictures of two additional cookies (a yellow ship and a blue rocking horse) were used for exploratory reasons, as filler stimuli in the rating phases, and as practice stimuli in the affective priming procedure. Eight positive and eight negative Dutch nouns selected from Hermans and De Houwer (1994) were used as target stimuli in the affective priming procedure (friend, vacation, hug, present, spring, party, applause, wish, accident, illness, fear, grief, exams, waste, damage, worries). Positive and negative targets were matched in word length, valence extremity, and familiarity. Eight additional nouns were used as practice targets.

**Procedure.** After participants had given informed consent, they were seated in front of a computer screen on which all instructions were presented. The experiment consisted of the
following phases: CS pre-conditioning ratings, US presentation, CS uncovering, CS post-conditioning ratings, affective priming procedure, testing of CS-US contingency knowledge, and finally some questions regarding participants’ evaluations of the bowls, their US, contingency observations and evaluative strategies. The experiment took about 30 minutes.

**CS pre-conditioning ratings.** Participants were told that they would be shown pictures of cookies and that their task would be to indicate their general impression of the positivity or negativity of these pictures on a scale from -10 to +10. Participants were encouraged to make a precise judgment. Participants then rated the pictures of four cookies, two pictures that later served as CSs (the pink car and the green cat) and two filler pictures. The four pictures appeared in random order.

**US presentation.** Before this phase, the cardboard box containing the two plastic bowls was placed on the table between the monitor and the participant with the open but covered side facing towards the participant. The napkin that was fixed to the top of the box was then on the other side fixed to the face of the participants with medical tape (on both cheeks and between the nose and the upper lip). This way, the participants could see the screen but not the cookies (see Picture 1). Participants were also given a cup of water with a straw. They were told that their task would be to eat cookies one by one from the two bowls covered in the box and to drink water in between. In each conditioning trial, the sentence “Now, please eat a cookie from Bowl 1 (Bowl 2)” appeared on the screen. The word “bowl” was written in letters of approximately 2.5 cm height and presented in a black frame of approximately 12 by 15 cm. To prevent the influence of aftertastes, participants received an instruction to take a sip of water after each cookie. Each instruction to eat a cookie or to drink water stayed on the screen for 20 seconds. The inter trial interval was 0.5 seconds. The US presentation phase consisted of 6 blocks in each of which two
cookies were eaten (one cookie from Bowl 1 and one cookie from Bowl 2 – that is one positive and one negative US presentation). Within each block, the order of trials was randomized.

(Picture 1 about here)

**CS uncovering.** After the US presentation phase, participants were instructed that in order to find out about the appearance of the cookies, they should remove the napkin and look at the cookies. It was emphasized that they were not allowed to taste the cookies anymore. This instruction remained on the screen for 40 seconds. Afterwards the box was taken away by the experimenter.

**CS post-conditioning ratings.** Participants were asked to indicate their impression of the cookie pictures again. To make sure that participants would not misunderstand the task, it was emphasized that they were supposed to rate the pictures and not the tastes. As in the pre-rating phase, the two CSs and the two filler stimuli were presented one by one in random order with a rating scale ranging from -10 to +10.

**Affective priming.** In the affective priming procedure, the CSs served as primes whereas positive and negative words served as targets. Participants were told that they would see pictures rapidly followed by words. They were instructed to decide as quickly as possible whether the word was positive or negative, and press the right key (‘‘L’’) for positive and the left key (‘‘S’’) for negative words. They were informed that they had 750 ms to respond. Each trial started with the presentation of a fixation cross for 500 ms. After an interval of 500 ms, the prime (a CS) appeared on the screen for 200 ms. Immediately after the offset of the prime, the target appeared on the screen (stimulus onset asynchrony 200 ms), where it remained until the participant responded. To emphasize speed, the target disappeared from the screen after 750 ms of presentation. If a participant responded after 750 ms, the message “TOO SLOW!” was displayed
in red letters for 1500 ms. The next trial started after an interval that varied randomly between 500 and 1500 ms.

The affective priming procedure started with a practice block of twelve trials. The two cookie pictures used as fillers in the rating phase were used as primes and were combined with four positive and four negative practice targets. In this practice phase, participants received feedback on erroneous responses. To increase motivation, after the practice block, participants were reminded again to work fast. As another measure to keep participants focused on speed, error feedback was not provided in the main affective priming block. This block started with four randomly ordered warm-up trials in which the two practice primes were combined with two positive and two negative practice targets. In the core part of the affective priming procedure, each of the two CSs was used as a prime once with each of the 16 (eight positive, eight negative) targets, adding up to 32 trials altogether. The 32 trials were divided into eight blocks of four trials, in which each of the four trial types (CS\textsubscript{pos} – positive target, CS\textsubscript{neg} – positive target, CS\textsubscript{pos} – negative target, CS\textsubscript{neg} – negative target) was realized once in new random orders for each block and participant. The same target never appeared twice in a row.

**CS-US contingency awareness.** To find out whether participants correctly inferred the CS-US relationship, that is how a cookie with a certain appearance tasted, participants were given two small plates that were indicated by the letters A and B. Each of these plates contained small square uncoloured cookie samples that either had the positive or the negative taste. Participants were shown both CS pictures on the screen one-by-one and were asked to taste the samples and indicate the letter of the plate that contained samples with the same taste as the cookie on the screen.
**Additional questions.** Finally, participants were asked a number of additional questions regarding their evaluations of the bowls and of the USs, their contingency observations and their evaluative strategies. All of these questions were presented on the screen in a forced-choice format. Most of these served exploratory purposes and will not be discussed further. For the current research question, the most relevant of these questions regarded participants’ bowl ratings and their demand compliance: For the bowl ratings, participants were asked to indicate their liking for the two bowls. “Bowl 1” and “Bowl 2” were presented on the screen surrounded by a black frame one-by one and participants rated these. For the self-report based estimate of demand compliance, participants were asked whether they used the knowledge about which cookie had which taste intentionally because they thought that this was the purpose of the experiment.

**Design.** The experiment consisted of a 2 (US valence: CS\textsubscript{pos}, CS\textsubscript{neg}; within) by 2 (time: pre-conditioning, post-conditioning; within) design. The visual appearance of the good (bad) tasting cookies (CS assignment in positive condition: pink car or green cat) and the bowl in which the good (bad) tasting cookies were placed (bowl in the positive condition: Bowl 1 [left] or Bowl 2 [right]) were counterbalanced across participants.

**Results**

**CS-US awareness.** Twenty-one participants (84.0 %) indicated the correct taste for both CS pictures, one participant (4.0 %) indicated the correct taste for only one CS picture, and three participants indicated the wrong taste for both CS pictures (12.0 %). As in Experiment 1, only participants who correctly indicated the taste of both CS pictures in the CS-US awareness check were included in the main analyses.
Ratings. Based on ratings of both CSs before and after the conditioning phase, a 2 (US valence: CSpos, CSneg; within) by 2 (time: pre-conditioning, post-conditioning; within) by 2 (CS assignment in positive condition, pink car, green cat; between) by 2 (bowl in positive condition, Bowl 1, Bowl 2; between) ANOVA was calculated. We found a main effect of US valence indicating that the CSpos (picture of the good tasting cookie) was rated more positively than the CSneg (picture of the bad tasting cookie), $F(1,17) = 17.07, MSE = 11.90, p < .001, \eta^2_{\text{partial}} = .50$.

Importantly, this main effect was qualified by an interaction with time, which is indicative of an EC effect, $F(1,17) = 28.88, MSE = 10.01, p < .001, \eta^2_{\text{partial}} = .63$. Before conditioning, CSpos ($M = -2.33, SD = 4.32$) did not differ significantly from CSneg ($M = -1.57; SD = 4.13$), $t(20) = -0.73, ns$. After conditioning, CSpos were rated more positively ($M = 2.67, SD = 4.37$) than CSneg ($M = -3.95, SD = 3.63$), $t(20) = 5.39, p < .001, d = 1.18$. Somewhat less important, there was also a marginally significant interaction of US valence and CS assignment, $F(1,17) = 4.14, MSE = 11.90, p = .06, \eta^2_{\text{partial}} = .20$, which indicates that the difference between the CSpos and the CSneg tended to be larger when the CSpos was the pink car and therefore that the pink car was somewhat preferred over the green cat. There was also a marginally significant interaction of US valence and bowl, $F(1,17) = 4.23, MSE = 11.90, p = .06, \eta^2_{\text{partial}} = .20$, indicating that the preference for the CSpos tended to be bigger when the CSpos lay in Bowl 1. Furthermore, there was a marginally significant three-way interaction of US valence, CS assignment and number, $F(1,17) = 4.01, MSE = 11.90, p = .06, \eta^2_{\text{partial}} = .19$, which is difficult to interpret, and a marginally significant main effect of time, $F(1,17) = 3.36, MSE = 13.97, p = .08, \eta^2_{\text{partial}} = .17$, which indicated that in general the appearance of the cookies tended to be rated more positive after conditioning. No other effect reached significance, All $F$’s $< 2.1$. 
Affective priming error data. Participants are expected to respond both slower and with higher error probability in incongruent as compared to congruent prime-target pairs. We first report the error data. We calculated an evaluative score based on the number of correct and erroneous responses for positive and negative CSs separately: For each CS, the number of correct responses from trials in which it appeared with a negative target were subtracted from the number of correct responses from trials with positive target words. Thus, higher values indicate more positive evaluations. Please note that, given possible main effects of prime and target valence, only the difference of these scores between conditions and not their absolute value should be interpreted. Based on the evaluative scores, we calculated a 2 (US valence: CSpos, CSneg; within) by 2 (CS assignment in positive condition, pink car, green cat; between) by 2 (bowl in positive condition: Bowl 1, Bowl 2; between) ANOVA. We found higher evaluative scores for CSpos ($M = 0.76; SD = 1.04$) than for CSneg ($M = 0.14; SD = 1.31$), $F(1,17) = 6.52$, $MSE = 0.73$, $p = .02$, $\eta^2_{\text{partial}} = .28$. This is evidence for an EC effect. The effect tended to be stronger when the good tasting cookies lay in Bowl 1, $F(1,17) = 3.73$, $MSE = 0.73$, $p = 0.07$, $\eta^2_{\text{partial}} = .18$. No further interaction was significant, all $F$'s < 1. An EC effect variable of the errors (CSpos - CSneg) was not correlated with an effect variable of the ratings, $r = -.26$, ns.

Affective priming reaction time data. For the analysis of the reaction time data from the affective priming procedure, response time outliers (RT < 300 ms or RT > 750 ms [the response deadline], 5.36 %) as well as erroneous responses (10.71 % of the non-outlier responses) were discarded. Analogous to the evaluative scores based on the number of correct responses, we calculated evaluative scores for positive and negative CSs based on the RTs (RT negative targets - RT positive targets), for which higher values indicate more positive evaluations. We found a main effect of US valence, indicating that the picture of the CSpos yielded a more positive
Indirect Evaluative Conditioning

Evaluative score ($M = 27; SD = 46$) than the picture of the $CS_{neg}$ ($M = -11; SD = 42$), $F(1,17) = 6.46, MSE = 2587, p = .02, \eta^2_{\text{partial}} = .28$. This main effect was neither qualified by CS assignment, $F < 1$, nor by bowl number, $F(1,17) = 1.97, MSE = 2587, p = .18, \eta^2_{\text{partial}} = .10$. There was no significant three-way interaction, $F < 1$. As the results pointed in the same direction as the error data, an alternative explanation in terms of speed-accuracy trade-offs seems not warranted. The EC effect variable of the response times ($CS_{pos} - CS_{neg}$) was not correlated with the EC effect variable of the ratings, $r = -.16, ns$.

**Analyses including CS-US unaware participants.** Including in the analyses also the data of those participants who did not correctly indicate the taste (US) for a picture (CS), led to a similar pattern of results. In particular, the crucial interaction of time and valence was significant for the ratings, $F(1,21) = 27.58, MSE = 10.70, p < .001, \eta^2_{\text{partial}} = 0.57$ ($CS_{pos}$ preratings: $M = -1.92; SD = 4.25$; $CS_{neg}$ preratings: $M = -1.00; SD = 4.23$; $CS_{pos}$ postratings: $M = 2.84; SD = 4.44$; $CS_{neg}$ postratings: $M = -3.16; SD = 4.55$). For the affective priming data, the crucial difference between $CS_{pos}$ and $CS_{neg}$ was marginally significant for the error data, $F(1,21) = 4.09, MSE = 0.72, p = .06, \eta^2_{\text{partial}} = 0.16$ ($CS_{pos}$: $M = 0.68; SD = 1.07$; $CS_{neg}$: $M = 0.20; SD = 1.39$) and for the reaction time data, $F(1,21) = 3.11, MSE = 2862, p = .09, \eta^2_{\text{partial}} = 0.13$ ($CS_{pos}$: $M = 24; SD = 50$; $CS_{neg}$: $M = -2; SD = 45$). Including CS-US awareness (both correct [$n = 21$] vs. both wrong [$n = 3$]) as additional factor, did not show an interaction with the EC effect on the ratings, $F < 1$. It did interact with the EC effect on the RT data, $F(1,18) = 6.26, MSE = 2457, p = .02, \eta^2_{\text{partial}} = 0.26$, but not with the EC effect on the error data, $F(1,18) = 1.31, MSE = 0.70, p = .27, \eta^2_{\text{partial}} = 0.07$. Please note the limited power of these analyses.

**Bowl ratings.** The 21 CS-US aware participants rated the bowl which contained the good tasting cookies more positive ($M = 5.00; SD = 3.89$) than the bowl which contained the bad
tasting cookies ($M = -5.48; SD = 4.55$), $F(1,17) = 78.36, MSE = 15.79, p < .001, \eta^2_{\text{partial}} = .82$. We calculated an effect variable for the difference of the positive and the negative bowl and correlated it with the effect variables for CS ratings and CS affective priming data. None of these correlations were significant: CS ratings: $r = 0.10$, $ns.$, CS affective priming error data: $r = .12$, $ns.$, CS affective priming response times: $r = -.05$, $ns.$

**Demand compliance.** Two of the 21 participants indicated that they intentionally used their knowledge about the taste because they thought that this was the goal of the experiment. When these two presumably demand complying persons were excluded, the EC effects on the ratings ($F[1,15] = 30.37, p < .001, \eta^2_{\text{partial}} = .67$; CS$_{\text{pos}}$ preratings: $M = -2.53; SD = 4.43$; CS$_{\text{neg}}$ preratings: $M = -1.74; SD = 4.27$; CS$_{\text{pos}}$ postratings: $M = 2.63; SD = 5.00$; CS$_{\text{neg}}$ postratings: $M = -4.42; SD = 3.45$), on the affective priming error data ($F[1,15] = 4.48, p = .05, \eta^2_{\text{partial}} = .23$; CS$_{\text{pos}}$: $M = 0.74; SD = 1.05$; CS$_{\text{neg}}$: $M = 0.21; SD = 1.36$), and on the affective priming RT data ($F[1,15] = 7.27, p = .02, \eta^2_{\text{partial}} = .33$; CS$_{\text{pos}}$: $M = 26.69; SD = 39.32$; CS$_{\text{neg}}$: $M = -10.18; SD = 38.18$), remained intact.

**Discussion**

We found a valence change of the pictures of cookies that had a positive or negative taste, although the cookies could not be seen while they were eaten. Participants first ate good and bad tasting cookies from two bowls that were blocked from view by a cover. Afterwards, the cover was removed so that participants could see what the cookies in these bowls looked. Participants who correctly indicated the taste of a cookie when shown a picture of that cookie, evaluated pictures of the good tasting cookies more positive than pictures of the bad tasting cookies. This effect was found both on ratings and in an affective priming procedure. As in Experiment 1, there was no indication that demand compliance contributed to the EC effect.
As was the case in Experiment 1, the effect on the response time measure crucially depended on whether participants indicated the correct taste for the CS pictures. Again, this was not the case for the ratings. This pattern of results, however, needs to be interpreted with caution. Only very few participants indicated the incorrect taste, which raises doubts about the validity and power of these analyses. Furthermore and similar as in Experiment 1, due to the time span and the presence of the affective priming procedure between the rating and the CS-US awareness test, it is possible that the CS-US awareness check is a better estimate for the knowledge during the affective priming than during the ratings. This could explain that measured CS-US awareness was related only to the results on the affective priming data.

Different from Experiment 1, the CSs and USs in this experiment were aspects of the same object. The use of such a CS-US compound is not unusual in EC research, in particular in studies with gustatory stimuli (Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Kerkhof, Vansteenwegen, Baeyens, & Hermans, 2009; Verhulst et al., 2006; Zellner, Rozin, Aron, & Kulish, 1983). Although the CS (e.g., the appearance of a cookie) and US (e.g., the taste of a cookie) in these designs are not part of separate objects, they are conceptually clearly separable and the EC effect refers only to the valence of the CS.

**General Discussion**

The data of two experiments show that EC effects can be found even if participants do not experience CS-US pairings directly. We defined a change in liking that is due to events that imply the existence of CS-US pairings as indirect EC. A two-step procedure was devised to provide participants with the information about the CS-US pairings in an as indirect manner as possible. Participants experienced first the repeated presentation of USs and only afterwards received information that implied the presence of CS-US pairings. In both experiments, this
information led to conditioning effects on valence ratings of the CSs as well as in implicit measures (IAT, affective priming). Demonstrating the effects not only on ratings but also on implicit measures makes it less likely that they are due to demand compliance. This conclusion is corroborated by what participants told us about their compliance to perceived demand. Excluding participants who indicated demand compliance did not alter the results in any of the experiments. Furthermore, demonstrating the effects on two different implicit measures and on an explicit measure makes it less likely that they are based on particularities of one measure and substantiates the validity and generality of our findings. Together with previous evidence that EC effects can be found due to instructing participants about upcoming pairings (De Houwer, 2006), the current experiments thus show that EC effects can be found when participants learn only indirectly about CS-US pairings. Importantly, whereas EC as the result of instructions can be interpreted as resulting from the direct pairing of words (Field, 2006), in our experiments, the CSs and USs were not even paired directly in the instructions.

We derived our predictions concerning indirect EC from propositional models that claim that EC effects are due to the acquisition of conscious propositional knowledge about stimulus regularities (e.g. Corneille et al., 2009; De Houwer, 2007; De Houwer, 2009; Hofmann et al., 2010, Mitchell et al., 2009a). According to these models knowledge about a stimulus relation should lead to EC effects also if this knowledge is only inferred. The experiments reported here corroborate this prediction and are in line with the idea that EC can originate not only from experiencing CS-US pairings, but also from inferences about CS-US pairings that are made on the basis of other available information. Interestingly at least for the implicit measures, the effects depended on whether participants could verbalize the covert CS-US relations. This is in
line with the proposal that indirect EC effects occur only if participants infer the covert relation from the experienced events.

A competing explanation for EC effects is provided by association formation models. The core assumption of these models is that the (automatic) registration of temporal-spatial co-occurrences of stimuli (CS and US) leads to the formation of associations between the representations of these stimuli in memory. EC is thus based on association formation that directly follows from experiencing the stimuli together rather than from knowledge about the pairings. The presentation of the CS can thus activate the representation of the US, which influences the evaluation of the CS (e.g. Baeyens, Eelen, Crombez, & Van den Bergh, 1992; Baeyens, Eelen, & Crombez, 1995; Gawronski & Bodenhausen, 2006; Petty & Briñol, 2010).

Is it possible to explain the current results in terms of association formation? As explained before, our procedure can be interpreted as second order conditioning. Second order conditioning cannot only be explained with a propositional model in terms of inferences about an underlying CS2-US relation, but it can also be explained by association formation models. An associative account of second order conditioning assumes that both steps in the conditioning procedure (US-CS1 and CS1-CS) lead to the formation of an association, so that the presentation of the CS2 can activate the mental representation of CS1 (e.g., the number or bowl due to the second leaning phase) and the activated representation of CS1 can in turn activate the representation of the US (due to the first learning phase), which then might influence the evaluation of the CS.

In particular one aspect of our procedure argues against this explanation. Consider the second step of the second order conditioning procedure, which usually consists of repeated pairings of the CS1 and the CS2. In our experiments, CS1 and CS2 were paired only once.
According to many dual process models that distinguish propositional and associative processes, associations form gradually as the result of many pairings (e.g. Gawronski & Bodenhausen, 2006; Smith and DeCoster, 2000; Strack & Deutsch, 2004). Therefore, the second phase should not be sufficient to lead to the formation of an association. Nevertheless it is possible to assume that associations can in fact be formed at least partially due to only one pairing trial. In this case, the reported effects could be explained on the basis of association formation. 

A possible way to further evaluate this associative explanation, relates to another unique element of our studies: In both experiments, we provided explicit information about how the two phases of the experiment were related. For instance, when people were shown the CS2 in Experiment 1, it was explicitly mentioned that these had been covered by a grey square in previous trials with a certain number. This information thus determines what the experienced events imply about the relation between the USs and the product pictures (the CS2s) and it is crucial for our prediction from the propositional model. From the perspective of second order conditioning, however, the presented stimulus pairs (i.e., CS1-US and CS1-CS2) are important regardless of whether they imply a covert CS-US relation. In future studies, it would therefore be interesting to manipulate the presence or content of information about the relation between the two phases of the experiment. For instance, in a replication of Experiment 1, only one group of participants could be told that CS2 (product picture) was hidden under the grey square in Phase 1, while all participants would see the single pairing of the CS1 (number) and the CS2. An EC effect that depends on whether participants do receive the information, would be difficult to explain on the basis of association formation models.

Another question that our studies might raise is whether what we test is actually EC. We defined EC as a valence change in a stimulus that is due to pairings with another stimulus (De
Houwer, 2007). Our participants, however, did not directly experience the CS-US pairings. Given that the CS-US pairings were not experienced directly, could they be considered as a cause of the observed changes in liking? That is, could the changes in liking be considered as EC effects? This question can be answered in several ways depending on the perspective that one takes. First, one could argue that EC effects by definition imply directly experienced CS-US pairings. From this perspective, the observed effects do not qualify as EC and even the question of whether EC can occur in the absence of directly experienced CS-US pairings is rendered meaningless. However, such a position would not imply that our studies are without merit. To the degree that our studies support the predictions of propositional models of EC, they lend credence to the claim that propositional processes underlie also standard EC effects. More generally, the results shed new light on the determinants of stimulus preferences. They show that liking can change as the result of the interaction between different types of experiences (i.e., stimulus pairings, verbal instructions) and support the idea that preferences can be based on propositions that are inferred from those experiences.

A second point of view entails that in the definition of EC, the concept “pairings” can be understood as pairings in the environment that the participant can potentially detect or experience (cf. Wills, 2005) rather than as pairings that the participant has actually experienced directly. The participants’ verbal abilities and learning history before they entered the experiment enabled them to learn about pairings and other regularities in the environment without actually experiencing those pairings or regularities (e.g., Hayes, Barnes-Holmes, & Roche, 2001). In fact, evolution would favour organisms that can adapt their behaviour to regularities in the environment even before those regularities have been experienced directly. “Pairings” can therefore be understood broadly as including those environmental events that are – due to earlier
learning experiences – functionally equivalent to directly experienced CS-US pairings. Hence, also CS-US pairings that have not been experienced directly can be considered as causes of changes in liking and thus as a source of EC. From this perspective, our studies provide important new information about the conditions under which such indirect EC effects can occur.

Another possible conceptualization relates to the phenomenon of second order conditioning. Second order EC falls under the definition of EC because the CS is paired with another stimulus (i.e., CS2-CS1 pairings). The events that precede these pairings (i.e., CS1-US pairings) could be seen as a moderator of the effect of the CS2-CS1 pairings on the liking of CS2. Our studies are important also from this perspective. They show that, at least under some conditions, second order conditioning can be shown after only one presentation of the CS2-CS1 pairing. In sum, although there are different ways to relate our studies to the literature on EC and the learning of preferences in general, the reported results are important from all of these perspectives.

The present studies raise a number of issues that can be addressed in future research. We pointed out that we derived our predictions from a propositional model of EC. Many aspects of how propositions lead to EC effects, however, still need to be investigated. One important aspect of propositions is that they contain more information than associations. A proposition can for example state that a stimulus causes, predicts, follows, co-occurs with, be part of, or in the simplest case is another stimulus. It is still relatively unclear which role this additional information plays and whether EC effects are influenced by it (but see Förder & Unkelbach, 2011; Zanon, De Houwer, & Gast, 2011, for demonstrations of moderated EC effects due to negative propositions).
Another important question is how propositional knowledge about the relationship between the stimuli actually translates into a certain outcome. Propositional models of EC have not yet specified this translation process, which is clearly a shortcoming (cf. Dickinson, 2009; Mitchell, De Houwer, & Lovibond, 2009b). This means that although we think that we have collected suggestive evidence that forming propositions about stimulus relations causes valence changes in these stimuli, we do not yet know whether the process that leads from this proposition to the evaluation is also propositional. Also for this question, it could be relevant to investigate the influence of the type of relationship that is described by the proposition. If the formation of propositions about different types of relationships leads to differences in the EC effects, it is plausible that also the translation process is propositional. If on the other hand, the EC effect is independent from which type of relationship is described by the proposition, it seems more plausible that the translation process is based on automatic activation of the elements described by the proposition.
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Due to the use of implicit measures, we excluded data from non-native Dutch speaking students who we let participate for reasons of fairness from all analyses on an a priori basis. In both experiments, two non-native Dutch students had participated. Conclusions did not alter when the data of these participants were treated in the same way as the data of the other participants.

Counterbalancing was based on those participants who were included in the analysis, that is, counterbalancing conditions of participants who made incorrect inferences were repeated until the counterbalancing conditions were realized in approximately equal numbers. See also Footnote 3.

In the main analyses, counterbalancing conditions were included as factors in order to correct for the potential influence of incomplete counterbalancing due to the use of varying samples (e.g. inclusion vs. exclusion of CS-US unaware participants).

We thank Jan Lammertyn and Yves Rosseel from the Department of Data Analysis, Ghent University, for their advice on this issue.

Also the more common t-test shows that D is significantly above 0 \((M = 0.20; SD = 0.51), t(28) = 2.17, p = .04, d = 0.40\).

One participant failed to rate one of the numbers.

To explain the results in Experiment 2 in associative terms, it is also necessary to assume that representation of the “felt” bowl in phase 1 is translated into the representation of the “seen” bowl in phase 2.