


Moderating effect of stimulus presentation type, contingency awareness and anxiety on evaluative conditioning: an attentional perspective

Anca Lazar, Marine Rougier, Marco Perugini & Florin A. Sava

To cite this article: Anca Lazar, Marine Rougier, Marco Perugini & Florin A. Sava (11 Jul 2025): Moderating effect of stimulus presentation type, contingency awareness and anxiety on evaluative conditioning: an attentional perspective, *Cognition and Emotion*, DOI: [10.1080/02699931.2025.2528924](https://doi.org/10.1080/02699931.2025.2528924)



To link to this article: <https://doi.org/10.1080/02699931.2025.2528924>

 [View supplementary material](#) 

 Published online: 11 Jul 2025.

 [Submit your article to this journal](#) 

 Article views: 2

 [View related articles](#) 

 [View Crossmark data](#) 



Moderating effect of stimulus presentation type, contingency awareness and anxiety on evaluative conditioning: an attentional perspective

Anca Lazar ^a, Marine Rougier ^b, Marco Perugini ^c and Florin A. Sava ^a

^aDepartment of Psychology, West University of Timișoara, Timișoara, Romania; ^bDepartment of Experimental Clinical and Health Psychology, Ghent University, Ghent, Belgium; ^cDepartment of Psychology, University of Milano-Bicocca, Milano, Italy

ABSTRACT

The present study explored how evaluative conditioning (EC) is impacted by the type of stimulus presentation (sequential versus simultaneous), considering also other possible attention- and memory-related moderators at both procedural (contingency awareness, ambivalence) and individual levels (anxiety). A sample of 537 adult participants completed either a simultaneous or sequential conditioning procedure using positive, negative, neutral, and ambivalent unconditioned stimuli (US) paired with neutral conditioned stimuli (CS). Participants evaluated the CS both before and after conditioning and completed a memory task assessing their contingency awareness (memory of the US valence paired with each CS). Results indicated that the EC effect was significantly larger in simultaneous conditioning and in the presence of contingency awareness. Participant's anxiety level did not moderate the effect in either monovalent EC (positive versus negative) or ambivalent EC (ambivalent versus neutral). Findings are discussed in terms of theoretical and practical implications.

ARTICLE HISTORY

Received 30 April 2024
Revised 29 April 2025
Accepted 29 June 2025

KEYWORDS

Evaluative conditioning; simultaneous vs sequential; attention; ambivalence; anxiety

The way people form preferences and the factors that influence this process are at the core of learning research. Preference acquisition can be shaped by both environmental and individual factors related to cognitive functions like attention or memory. This study focused on attention- and memory-related moderators of evaluative learning. Specifically, we aimed at clarifying how procedural changes in terms of stimulus presentation (simultaneous versus sequential) can impact evaluative learning, and we also explored the moderating role of contingency awareness and personality traits of neuroticism and anxiety.

The evaluative conditioning (EC) effect is the change in liking of a neutral, conditioned stimulus (CS) due to its pairing with another unconditioned stimulus (US) that is usually of positive or negative valence. It is a well-established and robust

phenomenon with meta-analysis results indicating a moderate effect of Cohen's $d = 0.52$ (Hofmann et al., 2010). Various theoretical frameworks have long relied on associative processes to explain EC, suggesting that this effect derive from the automatic formation of associative links between mental representations of the CS and US due to their co-occurrence. For example, one relevant framework is the implicit misattribution account (see page 392 in Hofmann et al., 2010 for details) which implies EC is the result of automatic misattribution of the valence from one stimulus (US) to another (CS) due to space–time proximity between the stimuli. Alternative theories suggest that EC could rather emerge from propositional processes, that is, from evaluative judgements based on “prior knowledge, instructions, intervention, and deductive reasoning” (De Houwer, 2009). According to propositional models, EC

emerges after a conscious proposition is formed regarding the relationship between the two stimuli (e.g. “the CS and US go together”), hence depending on attention and memory parameters, such as contingency awareness. This refers to the extent to which individuals remember which US (or US valence) was presented with each CS.

Consistent with propositional processes, EC is generally larger when participants remember correctly the US valence paired with each CS – the memory of the specific US identity not contributing further to the effect (Stahl et al., 2009). Nevertheless, associative theories explain this effect by predicting that EC is not so much a function of contingency awareness, but rather of CS-US contiguity (Kattner, 2014), as the mere co-occurrence of stimuli in space and time facilitates association formation and transfer of valence. While spatial–temporal contiguity is best achieved when stimuli are shown together, presenting the CS and the US separately weakens contiguity and thus certain procedures may have a pairing encoding disadvantage (Halbeisen & Walther, 2016).

Although there are conflicting views on the impact of contiguity and contingency awareness in EC (Stahl et al., 2009), attention is essential for both associative and propositional processing. Research shows that contingency awareness and EC effects decrease when attention is diverted away from the stimuli pairings during encoding, supporting that both attention and awareness are fundamental to EC (Kattner, 2012). The underlying role of attention is key in understanding the effect of procedural, but also interpersonal moderators. As explained hereafter, conditioning parameters, such as stimuli type and temporal presentation, may influence people’s directed attention and change their attentional goals.

Procedural variations: presentation type

Previous empirical work used different CS-US presentation formats: simultaneous (stimuli presented together), delayed (CS appears alone first, then joined by the US) and trace or sequential (one stimulus after another). Manipulating the presentation format in an EC procedure may provide additional insights on the role of both contingency awareness and space–time contiguity, by facilitating information encoding in different ways: (a) directing attention to each stimulus individually to avoid parallel processing (sequential format), and (b) directing attention to the

pairing relation through spatial–temporal contiguity between stimuli (simultaneous format).

In this study we chose to focus on two presentation formats, comparing simultaneous to sequential conditioning. Simultaneous presentation maximises spatial–temporal contiguity, therefore it should facilitate effects through associative processing. At the same time, simultaneous formats should also aid visual memory of pairings, thus facilitating contingency awareness essential for propositional processing. Interestingly, contrary to the idea that simultaneous presentation increases contingency awareness, Sweller’s cognitive load theory (1988; as cited in Blask et al., 2012) posits that working memory capacity diminishes when processing multiple stimuli from the same sensory modality. Simultaneous formats would heighten competition for attentional resources, reducing the attention allocated to each stimulus and impairing efficient processing. Conversely, sequential formats would reduce the cognitive burden with visual-only stimuli through enhanced attention allocated to each stimulus separately, thus increasing their salience. This may help create a predictive relationship between the two stimuli (e.g. a specific affective US always follows after a certain CS), facilitating awareness and propositional processing. Therefore, considering sequential conditioning depends on contingency awareness to leave a trace in memory systems through a deliberate inference on the pairing relation, thus reflecting a propositional processing manner, associative processing seems more restricted to simultaneous formats due to their heavy reliance on space–time proximity.

Several studies examined how stimulus presentation type and contingency awareness impacted EC. A study using audio-visual stimuli showed no significant differences in effects between trace and delay formats, confirming EC does not occur without contingency awareness in either, thus supporting propositional models (Kattner et al., 2012). Others found simultaneous formats superior with different modality stimuli but not with visual-only stimuli, nevertheless, there were no reliable insights regarding the role of awareness in EC as this was not specifically measured (Gast et al., 2016).

Looking at studies using a picture-picture paradigm, Lascelles and Davey (2006) found no significant difference in EC effects obtained in simultaneous versus trace conditioning in a sample with contingency awareness present. Comparing simultaneous and sequential formats, Hütter and Sweldens (2013)

used a multinomial processing-tree to dissociate the effects of pairing memory from unaware conditioned attitudes. Results indicated that EC without awareness occurred only in simultaneous formats, providing support for both associative and propositional theories of EC, however their study lacked variability in contingency awareness in the sequential group, with all participants being aware of the CS-US relationship. Their findings also indicated increased memory parameters in the simultaneous condition, in line with the claim that learning is easier when stimuli are jointly presented. Research on brand conditioning using neutral and positive USs suggested that different presentation formats lead to varied attitudes in strength, results indicating significant effects in both formats, but that simultaneous conditioning was less dependent on contingency awareness than sequential (Sweldens et al., 2010). Other research analysed contingency awareness in simultaneous versus trace conditioning and under intentional (free-viewing task) versus incidental (distracting task) learning conditions (Stahl & Heycke, 2016). Initially, they found a medium-sized effect in the simultaneous condition and a non-significant, small effect in the sequential condition. After controlling for contingency awareness, trace conditioning proved marginally significant only in the intentional-learning group, as participants were able to form contingency awareness and not when they were distracted, whereas simultaneous conditioning was significant in both intentional and incidental groups, again supporting both associative and propositional EC theories. However, the results of a study testing conditioned attitudes towards alcohol contrast previous findings, showing a significant interaction between presentation type and US condition, with more negative ratings of CSs paired with negative USs in the sequential rather than simultaneous format (Zerhouni et al., 2018).

To summarise, previous research using different modality stimuli supports single-propositional processes as they found that EC does not occur in the absence of contingency awareness in neither trace nor delay formats (Kattner et al., 2012). However, studies using a picture-picture designs present unclear and conflicting results. Some suggest sequential conditioning may depend more on contingency awareness than simultaneous conditioning (Hütter & Sweldens, 2013; Sweldens et al., 2010), some found that simultaneous EC can also occur in its absence (Stahl & Heycke, 2016), and others even found

stronger effects in sequential formats (Zerhouni et al., 2018). Nevertheless, some of these studies used smaller samples and are lacking variability in the awareness measure (Gast et al., 2016; Hütter & Sweldens, 2013; Lascelles & Davey, 2006). Therefore, it seems unclear whether (a) there are significant differences between simultaneous and sequential conditioning and (b) whether contingency awareness is required in any or both formats or if space-time contiguity alone is sufficient to produce effects. In the present study, we aimed at bridging the gap on the role of contingency awareness and space-time proximity in various conditioning formats. Specifically, we designed a conditioning experiment with a relatively large sample size to determine more robust results on which format best facilitates EC and whether contiguity and contingency are distinctly relevant to the process.

Individual differences: trait anxiety

Aside from procedural parameters, attention-related interpersonal factors may also influence the underlying mechanisms of EC. Building on the premise that attention is essential in EC (Kattner, 2012), any bias affecting this cognitive process should therefore affect the outcome. Individual differences, as neuroticism and trait anxiety, can affect the way people process stimuli by shaping participants' attentional strategies. Literature on attentional biases provides evidence of an increased initial focus on negative stimuli in individuals with higher trait anxiety, however in longer trials (>1000 ms), strategies like maintenance or avoidance could intervene (Bar-Haim et al., 2007).

Recent EC research explored how personality traits, specifically the Big-Five, influence conditioning outcomes (Vogel et al., 2019), showing that individuals scoring high in neuroticism exhibited more extreme evaluations of conditioned stimuli (CS), amplifying both positive and negative responses. This effect appears to be particularly pronounced for individuals high in trait anxiety, a facet of neuroticism, for which heightened sensitivity to valence likely increases the effect of US valence on CS evaluation.

Importantly, our everyday life is not dichotomous and often involves situations of mixed valence. Such situations of ambiguity or uncertainty may render more evident the role of interindividual differences in applying different attentional strategies that can interplay with the processing of stimuli (e.g. the

effect of anxiety). Bunghez and colleagues (2024) studied the effect of neuroticism and its facets, such as anxiety, in conditioning using ambivalent US stimuli (i.e. stimuli consisting of elements of both positive and negative valence). Results indicated that as anxiety levels increased, individuals evaluated the CSs paired with ambivalent USs more negatively compared to neutral. Their work researching the role of anxiety in ambivalent conditioning is worth exploring further with other types of ambivalent stimuli. As materials, they used pictures of people and animals and blended a positive image with a negative to form a compound ambivalent stimulus. We identified an alternative often used in research on attention bias, the face-crowd paradigm, involving multiple people expressing happy and angry emotions (Lange et al., 2011). This paradigm mirrors ecological contexts in which individuals are often surrounded by different emotional ambiguity and simulates real-world encounters with facial expressions in crowds. Therefore, it appears as a promising and ecologically valid implementation of stimuli ambivalence in the context of EC.

Given the limited evidence on the interaction between anxiety and evaluative learning, this study seeks to further explore the moderating role of anxiety in (a) monovalent EC, as shown by Vogel and collaborators (2019) and (b) ambivalent EC, as shown by Bunghez and collaborators (2024). We refer to monovalent EC as the effect resulting from pairing CSs with positive versus negative stimuli, while ambivalent EC represents the effect that results from pairing CSs with ambivalent versus neutral stimuli.

Objectives and hypotheses

The main objective of this study was to clarify the role of procedural changes regarding stimulus presentation format in EC. Taking into account the theoretical arguments and unclear empirical evidence supporting both formats, we hypothesised significant differences in the magnitude of monovalent EC effects (positive versus negative) between simultaneous and sequential formats, considering for contingency awareness (H1). We did not formulate expectations on differences between presentation formats for ambivalent EC (neutral versus ambivalent).

As a secondary objective, we aimed to contribute to the recent evidence linking personality and conditioning, looking at the moderating role of trait

anxiety on EC using both monovalent and ambivalent US conditions. First, we expected people with a higher level of trait anxiety to have stronger monovalent EC effects (H2a). Second, we anticipated participants with increased trait anxiety to evaluate more negatively the CSs in the ambivalent condition compared to those in the neutral condition, testing the ambivalent EC effect (H2b).

Method

Design

We registered a priori hypotheses, methods, and planned analyses; the pre-registration form together with a document detailing the deviations are available at: https://osf.io/mkds6/?view_only=818e56a274de43acaed1df1eddecf261. The model involved a $2 \times 4 \times 2$ mixed-design with time (before versus after conditioning) and US valence (positive versus negative versus ambivalent versus neutral) as within factors and a between-participants presentation condition (simultaneous versus sequential). The CSs were evaluated both before and after the conditioning procedure during which they were paired with positive, negative, neutral, or ambivalent USs. Also, participants were split randomly into one of the two presentation types for the EC procedure, either a simultaneous or a sequential format. The study was approved by our local ethical committee (No. 33944/26.05.2023).

Participants

To determine the sample size, we used GPower to perform a power analysis for the secondary hypothesis since the interaction effect of anxiety with ambivalent EC requires a larger sample than the main hypothesis. Based on previous correlation data on the interaction effect between ambivalent EC and neuroticism, encompassing anxiety as a facet (Bunghez et al., 2024), we tested a z-difference between correlation coefficients: CSs paired with ambivalent and neutral conditions ($r = .23$), neuroticism and ambivalent paired CSs ($r = -.17$) but also neuroticism and neutral paired CSs ($r = .01$), resulting in a sample of 292 participants to reach a statistical power of .80. Given the two presentation formats in our experiment, we targeted a sample of 292 for each condition leading to a highly powered study able to detect small effects. We also verified this

through a post-hoc sensitivity analysis based on the final sample and given our interest in one regression coefficient for the interaction term in a regression with three predictors, results indicated that the study is sufficiently powered to identify very small interaction effects ($f^2 = 0.01$).

Therefore, we recruited 585 English-speaking adult participants via Prolific Academic online platform (<https://prolific.com>) in exchange for a monetary reward. We eliminated 48 participants based on pre-registered exclusion criteria on low variability of CS ratings in pre and/or post conditioning evaluations. For the pre-conditioning scores we excluded participants with extreme CS evaluations: participants selecting “1” (minimum) or “9” (maximum) for over 50% of CSs (> 4/8), indicating a strong bias towards the materials used. For the post-conditioning scores, our dependent variable, we excluded those with low variability in responses, selecting the same answer more than 75% of CS (> 6/8), postulating that selecting the same rating for almost all stimuli represents a lack of involvement from the participants. Our remaining final sample of 537 participants (51% male, $M_{age} = 29.94$, $SD_{age} = 8.73$) was fairly divided with 52% in the simultaneous group and 48% in the sequential group. Our online experiment was open to the global population, therefore the geographical split consisted of 50% participants from various countries in Europe (such as Italy, Netherlands, Portugal and UK), 45% from South Africa and 5% from other countries (Israel, North America, and Australia).

Materials

Questionnaires

To evaluate individual differences on neuroticism and anxiety, we used three questionnaires, presented in the stated order to participants. First, the 10-item subscale from IPIP-NEO measuring anxiety (Johnson, 2014, available at: <https://ipip.ori.org/newNEOKey.htm#Anxiety>). Next, the broader dimension of neuroticism and its 3 facets (4 items each) from the BFI-2 (Soto & John, 2017): anxiety, depression, and emotional volatility. Finally, the 7-item subscale from BIS/BAS (Carver & White, 1994) assessing the behavioural inhibition system which regulates the avoidance mechanisms of negative stimuli, a concept closely related to anxiety proneness. The full list of items and instruments used is available in the Supplemental Material.

Stimuli

In the EC procedure, CSs were greyscale fractals (as in Bungeh et al., 2024). Regarding USs, to allow a better balancing of elements in the ambivalent condition, we adapted a face-crowd design (Lange et al., 2011) using a reduced matrix of faces expressing happy, angry, mixed, or neutral emotions. The stimuli were presented on a 2×2 grid-design of two men, with two portraits each, retrieved from the Nim Stim database (Tottenham et al., 2009). In the positive, negative, and neutral conditions, the two individuals were shown expressing the same emotion, while for the ambivalent condition, the two individuals were presented showing both happy and angry expressions (see Figure S1 in Supplemental Materials).

Procedure

Participants first provided their informed consent, demographic information, and completed the personality questionnaires. They continued with a pre-acquisition rating phase where they were asked to evaluate each of the 8 CSs presented in random order on a scale from 1 (*most unpleasant*) to 9 (*most pleasant*), after which they were instructed to pay attention throughout the following conditioning procedure.

Participants were randomly assigned to one of the two presentation groups: simultaneous or sequential. Sequential conditioning presented the CS first for 1500 ms, followed by a 50 ms fixation cross as inter-stimulus interval and then the US for another 1500 ms. Simultaneous conditioning presented the CS and US jointly for 3000 ms, during which participants directed their attention freely to the presented stimuli. The presentation duration for simultaneous conditioning was longer to allow the same viewing and encoding time per pairing as in the sequential procedure. In both conditions we used an inter-trial interval of 1500 ms during which a fixation cross was displayed to recenter the gaze between stimuli. We counterbalanced the allocation of CS-US pairings across 8 subgroups, each with 8 pairings that were randomly repeated 8 times, resulting in a total of 64 trials. Additionally, we counterbalanced the position of the 4 faces within each US grid, both in terms of the position of the photographed individual (switch left /right) and the position of their two portraits (switch up/down), resulting in 4 combinations per pairing, each presented twice.

After the conditioning phase, the experiment continued with a post-acquisition phase where

participants re-evaluated the CS as before. Next, to measure contingency awareness, we used a memory task where participants were asked to recall the valence of the US paired with each of the presented CS by choosing one of the options: *positive, negative, neutral, or opposite expressions*. We also included a 5th answer choice, if they *don't remember*, not to encourage guessing. We randomised the order of the CS presentation in the pre/post evaluations and the awareness task. The experiment concluded with a short debriefing.

Results

Preliminary analyses

Analyses were performed using R software (version 4.4.2), starting with calculating the mean, standard deviation, distribution parameters for the relevant variables (Table S1 in Supplemental Materials). We then tested the reliability of the personality scales and obtained acceptable coefficients for all scales: IPIP anxiety ($\alpha = .89$), BIS ($\alpha = .79$), BFI-2 ($\alpha = .91$), and its subscales (anxiety $\alpha = .82$, depression: $\alpha = 0.83$; emotional vulnerability: $\alpha = .86$).

Results of our preliminary regression models testing monovalent EC (Table S2 in Supplemental Materials), calculated as the mean difference between post-ratings of CS paired with positive and negative US, showed a strong and significant effect of both pre-evaluations and the intercept (difference between US conditions), indicating our conditioning experiment was successful. Similarly, for ambivalent EC (Table S3 in Supplemental Materials), calculated as the mean difference between post-ratings of CS paired with ambivalent versus neutral US, results showed a non-significant difference. Nevertheless, we were not expecting a significant main ambivalent effect as we were interested in the moderation of ambivalent EC by trait anxiety.

Main model – moderating role of presentation type and contingency awareness on EC

Mixed linear regression

To better understand the interaction between EC and potential moderators such as contingency awareness or presentation format, we performed a mixed linear regression using *lme4* R package (Version 1.1-13). The model defined post-evaluations as dependent variable and used pre-ratings as a covariate at both

fixed and random level to control for the net change in CS liking at individual level (i.e. the observed effects reflected the change in CS evaluation due to the manipulation, beyond pre-ratings). We set participants and stimuli (CS) as random factors, and coded the fixed factors as follows: US valence (positive as +0.5, negative as -0.5), presentation format (sequential as +0.5, simultaneous as -0.5), and contingency awareness (presence as +0.5, absence as -0.5). We tested our main model where US valence was crossed with both participants and stimuli, while participants were nested in presentation conditions, and stimuli were nested in contingency awareness conditions. As the model was over-specified, we applied the method from Bates and collaborators (2015) reducing redundant components (random factors with 0 variance), which we repeated until a model converged to fit the data properly.

Results (Table S4 in Supplemental Materials) indicate a main effect of CS pre-evaluations on CS post-evaluations, $\beta = 0.5$, 95% CI [0.47;0.54], $SE = 0.02$, $t = 28.24$, $p < .001$, and a significant effect of US valence (monovalent EC), $\beta = 0.87$, 95% CI [0.63;1.12], $SE = 0.12$, $t = 7.03$, $p < .001$. Additionally, the analysis showed no significant main effect of contingency awareness, but a significant interaction effect with US valence, as effects were significantly greater when participants were aware of the paired US valence ($\beta = 1.50$, 95% CI [1.18;1.82], $SE = 0.16$, $t = 9.23$, $p < .001$). The US valence also interacted with presentation type, as EC was smaller when stimuli were presented sequentially as compared to simultaneous format, $\beta = -0.52$, 95% CI [-0.84;-0.20], $SE = 0.16$, $t = -3.19$, $p < .01$, confirming our first hypothesis (see Figure 1). Moreover, EC effects without contingency awareness were not significant in either simultaneous or sequential formats, as indicated by the left-sided overlapping confidence intervals in Figure 1 below. A three-way interaction indicated that the interaction between US valence and contingency awareness did not significantly differ by type of presentation, $\beta = -0.26$, 95% CI [-0.88;0.37], $SE = 0.32$, $t = -0.80$, $p = .42$ (see Table S4 in Supplemental Materials).

Pairwise comparisons

In line with the previously observed effect, results of our pre-registered analysis, a $2 \times 2 \times 4$ mixed ANOVA (Table S5 in Supplemental Materials), show a significant three-way interaction between time,

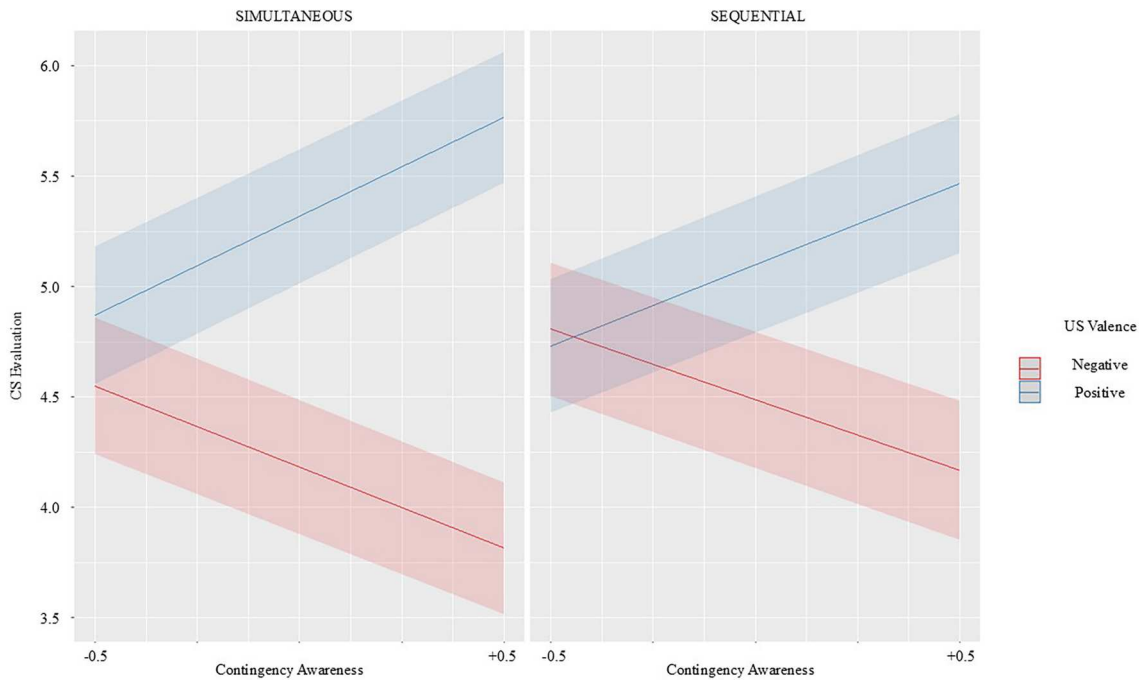


Figure 1. Effect of Contingency Awareness on CS ratings by presentation type and monovalent US conditions. Note. Shaded areas represent the confidence intervals.

presentation type and US valence. There were no significant differences in CS pre-evaluations between conditions. In Figure 2 one can notice that the positive condition had the largest change in time (from pre to post) in both simultaneous and sequential presentation formats. Pairwise comparisons by presentation format, time and US condition, presented in Tables S6 and S7 in Supplemental Materials indicate that the negative condition had a significant change in time only in simultaneous, but not sequential conditioning, while ambivalent and neutral conditions had significant changes in time only in sequential, but not simultaneous format.

Secondary model – moderating role of trait anxiety on EC

Monovalent EC

As a secondary objective, we aimed to explore the moderating role of anxiety on EC. Results of our mixed model analysis (Table S8 in Supplemental Materials) did not support hypothesis 2a, that is, the effect of personality variables on monovalent EC. Variables of anxiety (IPIP-NEO) and neuroticism (BFI) showed no effect on conditioning, only a non-

significant trend towards more positive CS evaluations was observed in participants with higher behaviour inhibition (BIS), $\beta = 0.02$, 95% CI [-0.00–0.04], $SE = 0.01$, $t = 1.82$, $p = .08$, also visible in Figure S2 in Supplemental Materials.

Ambivalent EC

Regarding hypothesis 2b we defined a second contrast scheme for ambivalent EC comparing ambivalent (coded as +0.5) to neutral (coded as -0.5) US conditions. Our results indicated no significant effect of the US condition, nor any significant interaction effect with anxiety: $\beta = -0.02$, 95% CI [-0.06–0.01], $SE = 0.02$, $t = -1.16$, $p = .25$, therefore hypothesis 2b was not supported.

Analyses based on the initial pre-registered exclusion criteria

We also performed the same analyses on a smaller sample with all our pre-registered exclusion criteria applied, eliminating participants without a minimum level of awareness (details in the pre-registration and deviation document). Results for our main model (Table S9 in Supplemental Materials) indicate

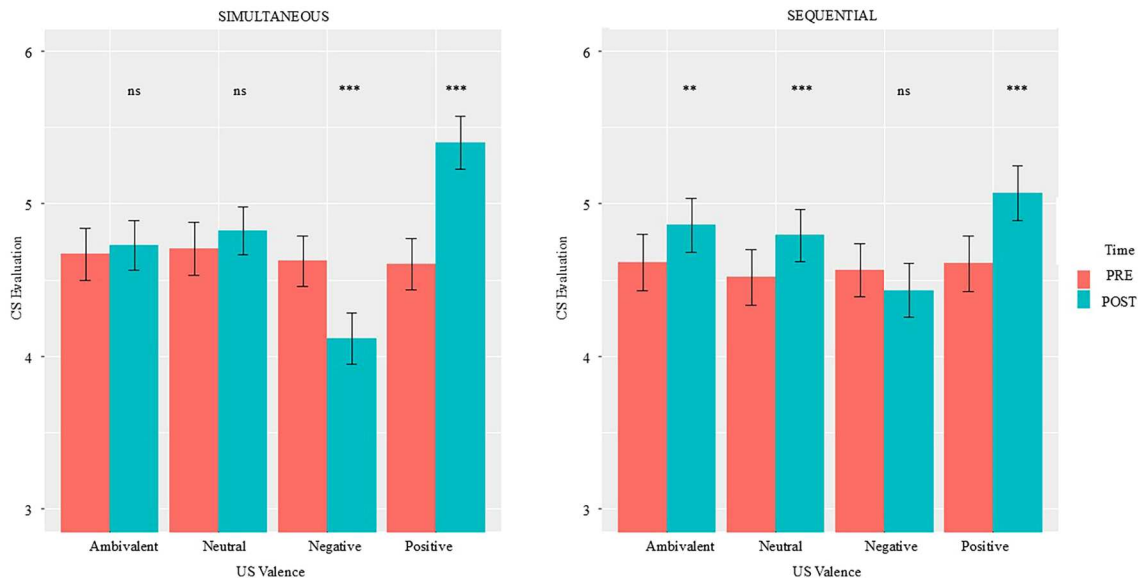


Figure 2. Average PRE and POST CS Evaluations by US Valence and Presentation Conditions. Note. Error bars represent the standard errors and significance levels are presented on top of each condition. * $p < .05$, ** $p < .01$, *** $p < .001$.

the same trends and levels of significance, but slightly stronger interaction effects. Likewise, results from the secondary model (Table S10) showed a significant interaction of behaviour inhibition and monovalent EC, as participants with higher behaviour inhibition evaluated more positively the CSs paired with negative USs.

Discussion

The present study looked at various attention-related moderators at both procedural and individual-level that may influence evaluative learning. Our main objective was to examine how EC varies as a function of contingency awareness and procedural changes in stimulus presentation type. As a secondary objective, we explored the role of personality differences in moderating EC by including measures of neuroticism and trait anxiety, while testing potential interaction effects not just with monovalent conditioning (positive versus negative), but also with ambivalent conditioning (ambivalent versus neutral).

We introduced a well-powered study able to detect small effects and observed an anticipated main effect of the US positive versus negative valence on the CS post-evaluations, indicating that the conditioning procedure for monovalent EC was

successful. Results also confirmed our first hypothesis showing significant differences in EC favouring simultaneous over sequential conditioning. Additionally, the moderating effect of contingency awareness was observed as EC effects increase in its presence, however when absent, effects were not significant in either simultaneous or sequential conditioning. Another noteworthy finding was that CSs paired with neutral and ambivalent USs showed significant evaluative changes over time only in sequential conditioning. It is possible that more complex or ambiguous stimuli benefit from the increased attentional focus and deeper processing enabled by sequential presentation, where CSs appear in isolation. This format may enhance the perceptual salience of individual CSs, leading to greater perceived familiarity and, in turn, more positive evaluations – consistent with the mere exposure effect (Bornstein & Craver-Lemley, 2017). The lack of decreased liking for CSs paired with negative USs may similarly reflect a shift toward familiarity-based impressions in the absence of salient pairings. Referring to interpersonal differences, and contrary to previous findings that suggest monovalent and ambivalent EC is moderated by trait anxiety (Bunghuez et al., 2024; Vogel et al., 2019), results from our sample showed no interaction effect between EC and trait anxiety, neuroticism, nor behaviour inhibition.

Empirical and theoretical contributions

The finding that effects do not emerge in the absence of contingency awareness is in line with previous work with stimuli of different modalities (Kattner et al., 2012) while it contradicts other results supporting EC also in the absence of awareness with same modality stimuli (Stahl & Heycke, 2016). Moreover, our results contradict previous findings that suggest EC effects do not differ between simultaneous and sequential presentation formats (Gast et al., 2016; Hütter & Sweldens, 2013; Lascelles & Davey, 2006; Sweldens et al., 2010) while they are in line with findings from Hütter and Sweldens (2013) suggesting that simultaneous conditioning produces larger effects due to increased memory facilitated by the presentation of stimuli in space and time proximity. The superiority of simultaneous over sequential formats can have important practical implications in deciding procedural parameters to maximise EC effects within experiments, marketing and public campaigns making them more robust and impactful.

As explained in the introduction, testing the effect of procedural changes on EC allows us test predictions from distinct theoretical views. Whereas associative processing should heavily rely on space–time contiguity between stimuli, propositional processing should depend more on contingency awareness. Importantly, both contiguity and contingency should be enhanced in simultaneous presentation. Although previous research suggests learning is easier when stimuli are presented together, Sweller’s cognitive load theory suggests the opposite, as parallel processing of same modality stimuli hinders attention, thus making sequential formats more viable in facilitating contingency awareness and therefore larger EC effects. However, this last reasoning proved to be not supported by our findings indicating that both EC effects and contingency awareness were larger in the simultaneous format compared to the sequential. Importantly, results indicate EC does not occur in the absence of contingency awareness in either presentation format, thus supporting propositional accounts that rely fundamentally on contingency awareness.

Limitations and future work

In terms of limitations, one unanticipated issue was the geographical distribution, given that 45% of the

participants were from South Africa, roughly half of our sample was of a different racial group than the stimuli used (Caucasian male faces). On one hand this may impact results due to cultural variations in sensitivity and accuracy of emotion perception given an in-group processing advantage. On the other hand, this increased the sample’s diversity, providing evidence that the EC effect with current stimuli also occurs when involving non-WEIRD (Western-Educated-Industrialised-Rich-Democratic) populations in the sample (Henrich et al., 2010). Nevertheless, the sample’s composition differed from recent contributions on EC and anxiety, and therefore further research is needed to understand if some variation derives from cultural differences.

Online studies also involve the risk of low adherence to experiment instructions and lack of attendance during the conditioning phase. We had less control over the experiment conditions, whether participants were indeed looking at the monitor during conditioning (approximately 5 min) and were not distracted during this time by their environment. At the same time, note that by considering contingency awareness as a moderator we considered statistically at least part of the inattention and low adherence to the experiment instructions, as they should be reflected in a lower contingency awareness score. Future research could try to replicate these results in lab conditions and to measure proxies of attention, for instance using eye-tracking technology. Such an approach could provide valuable insights into the mediating role of attention in EC and whether anxiety can influence EC by altering attentional strategies of maintenance or avoidance.

Finally, although the face-crowd paradigm is conceptually sound, it is worth noting that ambivalent stimuli showed all 4 portraits with open-mouths, while the monovalent stimuli showed half with open and half with closed mouths. Importantly, this confounding variable could not explain the lack of effects for ambivalent EC, as showing teeth only increases saliency of both emotions.

Conclusion

Our findings indicate that simultaneous, rather than sequential formats better facilitates the emergence of EC effects. This study also highlights the importance of contingency awareness in producing EC, thereby supporting propositional processing theories.

Acknowledgements

We thank Jan De Houwer and the entire LEARNVUL team for their valuable contributions and shared knowledge during the Twinning project.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work received funding from the European Union's Horizon - H2020-WIDESPREAD-2020-5 research and innovation programme under grant agreement no. 952464 and from Exploratory Research Projects—2020 Call under the registration code PN-III-P4-ID-PCE-2020-1964.

ORCID

Anca Lazar  <http://orcid.org/0000-0003-0614-5764>
 Marine Rougier  <http://orcid.org/0000-0002-9467-2726>
 Marco Perugini  <http://orcid.org/0000-0002-4864-6623>
 Florin A. Sava  <http://orcid.org/0000-0001-8898-1306>

References

- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, 133(1), 1–24. <https://doi.org/10.1037/0033-2909.133.1.1>
- Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. arXiv 2015 Vol.1506. <https://doi.org/10.48550/arXiv.1506.04967>
- Blask, K., Walther, E., Halbeisen, G., & Weil, R. (2012). At the crossroads: Attention, contingency awareness, and evaluative conditioning. *Learning and Motivation*, 43(3), 99–106. <https://doi.org/10.1016/j.lmot.2012.03.004>
- Bornstein, R. F., & Craver-Lemley, C. (2017). Mere exposure effect. In R. F. Pohl (Ed.), *Cognitive illusions: Intriguing phenomena in thinking, judgment and memory* (2nd ed., pp. 256–275). Routledge.
- Bunghez, C., Rusu, A., De Houwer, J., Perugini, M., Boddez, Y., & Sava, F. A. (2024). The moderating role of neuroticism on evaluative conditioning: Evidence from ambiguous learning situations. *Social Psychological and Personality Science*, 15(6), 718–727. <https://doi.org/10.1177/19485506231191861>
- Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, 67(2), 319–333. <https://doi.org/10.1037/0022-3514.67.2.319>
- De Houwer, J. (2009). The propositional approach to associative learning as an alternative for association formation models. *Learning & Behavior*, 37(1), 1–20. <https://doi.org/10.3758/LB.37.1.1>
- Gast, A., Langer, S., & Sengewald, M. A. (2016). Evaluative conditioning increases with temporal contiguity. The influence of stimulus order and stimulus interval on evaluative conditioning. *Acta Psychologica*, 170, 177–185. <https://doi.org/10.1016/j.actpsy.2016.07.002>
- Halbeisen, G., & Walther, E. (2016). Evaluative conditioning is sensitive to the encoding of CS-US contingencies. *Social Cognition*, 34(5), 462–479. <https://doi.org/10.1521/soco.2016.34.5.462>
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, 33(2-3), 61–83. <https://doi.org/10.1017/S0140525X0999152X>
- Hofmann, W., Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin*, 136(3), 390–421. <https://doi.org/10.1037/a0018916>
- Hütter, M., & Sweldens, S. (2013). Implicit misattribution of evaluative responses: Contingency-unaware evaluative conditioning requires simultaneous stimulus presentations. *Journal of Experimental Psychology: General*, 142(3), 638–643. <https://doi.org/10.1037/a0029989>
- Johnson, J. A. (2014). Measuring thirty facets of the Five Factor Model with a 120-item public domain inventory: Development of the IPIP-NEO-120. *Journal of Research in Personality*, 51, 78–89. <https://doi.org/10.1016/j.jrp.2014.05.003>
- Kattner, F. (2012). Revisiting the relation between contingency awareness and attention: Evaluative conditioning relies on a contingency focus. *Cognition & Emotion*, 26(1), 166–175. <https://doi.org/10.1080/02699931.2011.565036>
- Kattner, F. (2014). Reconsidering the (in)sensitivity of evaluative conditioning to reinforcement density and CS-US contingency. *Learning and Motivation*, 45, 15–29. <https://doi.org/10.1016/j.lmot.2013.09.002>
- Kattner, F., Ellermeier, W., & Tavakoli, P. (2012). Both trace and delay conditioning of evaluative responses depend on contingency awareness. *Learning and Motivation*, 43(1-2), 35–47. <https://doi.org/10.1016/j.lmot.2012.01.004>
- Lange, W. G., Heuer, K., Langner, O., Keijsers, G. P. J., Becker, E. S., & Rinck, M. (2011). Face value: Eye movements and the evaluation of facial crowds in social anxiety. *Journal of Behavior Therapy and Experimental Psychiatry*, 42(3), 355–363. <https://doi.org/10.1016/j.jbtep.2011.02.007>
- Lascelles, K. R. R., & Davey, G. C. L. (2006). Successful differential evaluative conditioning using simultaneous and trace conditioning procedures in the picture-picture paradigm. *Quarterly Journal of Experimental Psychology*, 59(3), 482–492. <https://doi.org/10.1080/02724990444000140>
- Soto, C. J., & John, O. P. (2017). The next Big Five Inventory (BFI-2): Developing and assessing a hierarchical model with 15 facets to enhance bandwidth, fidelity, and predictive power. *Journal of Personality and Social Psychology*, 113(1), 117–143. <https://doi.org/10.1037/pspp0000096>
- Stahl, C., & Heycke, T. (2016). Evaluative conditioning with simultaneous and sequential pairings under incidental and intentional learning conditions. *Social Cognition*, 34(5), 382–412. <https://doi.org/10.1521/soco.2016.34.5.382>
- Stahl, C., Unkelbach, C., & Corneille, O. (2009). On the respective contributions of awareness of unconditioned stimulus valence and unconditioned stimulus identity in attitude formation through evaluative conditioning. *Journal of Personality and Social Psychology*, 97(3), 404–420. <https://doi.org/10.1037/a0016196>

- Sweldens, S., Van Osselaer, S. M., & Janiszewski, C. (2010). Evaluative conditioning procedures and the resilience of conditioned brand attitudes. *Journal of Consumer Research*, *37*(3), 473–489. <https://doi.org/10.1086/653656>
- Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249. <https://doi.org/10.1016/j.psychres.2008.05.006>
- Vogel, T., Hütter, M., & Gebauer, J. E. (2019). Is evaluative conditioning moderated by Big Five personality traits? *Social Psychological and Personality Science*, *10*(1), 94–102. <https://doi.org/10.1177/1948550617740193>
- Zerhouni, O., Bègue, L., Comiran, F., & Wiers, R. W. (2018). Controlled and implicit processes in evaluative conditioning on implicit and explicit attitudes toward alcohol and intentions to drink. *Addictive Behaviors*, *76*, 335–342. <https://doi.org/10.1016/j.addbeh.2017.08.026>