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When congruence breeds preference: the influence of selective attention processes on evaluative conditioning

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ABSTRACT
We investigated in two experiments whether selective attention processes modulate evaluative conditioning (EC). Based on the fact that the typical stimuli in an EC paradigm involve an affect-laden unconditioned stimulus (US) and a neutral conditioned stimulus (CS), we started from the assumption that learning might depend in part upon selective attention to the US. Attention to the US was manipulated by including a variant of the Eriksen flanker task in the EC paradigm. Similarly to the original Flanker paradigm, we implemented a target-distracter logic by introducing the CS as the task-relevant stimulus (i.e. the target) to which the participants had to respond and the US as a task-irrelevant distracter. Experiment 1 showed that CS–US congruence modulated EC if the CS had to be selected against the US. Specifically, EC was more pronounced for congruent CS–US pairs as compared to incongruent CS–US pairs. Experiment 2 disentangled CS–US congruence and CS–US compatibility and suggested that it is indeed CS–US stimulus congruence rather than CS–US response compatibility that modulates EC.

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Theorists of human and animal learning have long emphasised that attention plays a central role in learning (Kruschke, 2001; Lawrence, 1949; Mackintosh, 1975; Rescorla & Wagner, 1972). As an example, the Rescorla and Wagner (1972) model of associative learning assumes that stimuli possess different attention-grabbing characteristics, resulting in different rates of learning. Moreover, the Rescorla–Wagner model (1972) states that the rate of learning is driven by the surprisingness of the US thereby assuming that conditioning is mediated by changes in the processing of the US. In contrast to this notion, Mackintosh (1975) assumes changes in the processing of the CS. Specifically his theory suggests that the salience of the CS increases with its predictive validity for the US. This means that the organism pays little attention to and will hence learn very little from stimuli that are poor predictors. Although this general notion was later questioned by Hall and Pearce (1979), there is considerable empirical evidence that both changes in the processing of the US and changes in the amount of attention paid towards the CS contribute to conditioning. Thus it can be assumed that encoding of CS and US and their integration in a common representation constitutes a necessary pre-requisite for conditioning effects. This encoding in turn is a function of the attention directed towards CS and US during conditioning.

Despite the undisputed importance of attention to CSs and USs for the encoding processes underlying conditioning, the role of attention has only scarcely been addressed in preference learning (Le Pelley, Calvini, & Spears, 2013). How preferences are learned is typically examined in an evaluative conditioning (EC) paradigm (for reviews, see De Houwer, Thomas, & Baeyens, 2001; Jones, Olson, & Fazio, 2010; Walther, Weil, & Düsing, 2011) in which a neutral conditioned stimulus (CS) is repeatedly paired with an affect-laden unconditioned stimulus (US). The common result is a valence shift in the CS such that

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the CS acquires the valence of the affect-laden US (for a meta-analysis, see Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).

Although there are some researchers who have been interested in the relation between attention processes and EC (Brunstrom & Higgs, 2002; Corneille, Mauduit, Strick, & Holland, 2009; Dijksterhuis & Aarts, 2010; Field & Moore, 2005; Jones, Fazio, & Olson, 2009; Kattner, 2012; Le Pelley et al., 2013), many of these studies focused on the interplay between attention and awareness. For the most part, attention in these studies was varied by the implementation of dual-task paradigms (Field & Moore, 2005; Pleyers, Corneille, Yzerbyt, & Luminet, 2009). Insofar as dual-task paradigms create interference rather at the level of retrieval from CS–US pairs, they do not allow for investigating the role of attention at the level of encoding.

The present experiments aimed at closing this gap in current EC research by adopting a paradigm very well established in selective attention research in order to address the attentional modulation of encoding processes of the CS and the US. From this more fine-grained analysis of the attention processes involved in early encoding stages of evaluative learning, we expect deeper insights into how integration processes of the CS and the US work. In fact, given that USs may automatically attract attention due to their affective nature (e.g. Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Pratto & John, 1991; Roskos-Ewoldsen & Fazio, 1992; Wentura, Rothermund, & Bak, 2000), EC is generally assumed to depend on the degree of attention devoted to the CS. This assumption is supported by a study by Jones et al. (2009, Experiment 4). In manipulating the relative salience of CS and US, the authors found that EC increases if the CS within a given CS–US pair is perceptually more salient (has larger size) than the US. Hence, these results indicate that allocating selectively more attention to the CS results in stronger EC (see also Blask, Walther, Halbeisen, & Weil, 2012, for similar findings).

We assume, however, that the picture may be even more complex. Given the attention-grabbing affective nature of the US (e.g. Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Devue, Laloyaux, Feyers, Theeuwes, & Brédart, 2009; Öhman, Flykt, & Esteves, 2001; Vuilleumier, Armony, Driver, & Dolan, 2001), factors that guide attention to both stimuli, the CS and the US, may modulate evaluative learning. Specifically, it might be argued that in selection situations (in which the CS has to be selected against the US for responding) congruence at the level of stimulus features and/or response compatibility at the level of response selection between the CS and US increase the integration of the CS and the US, which may result in enhanced EC. This hypothesis is based on research on the instance theory (Logan, 1988, 1990) indicating that selective attention does play a role at encoding stimuli (and their relations). For instance, Logan and Etherton (1994) showed that participants encoded (and later on retrieved) relations between words if they attended to both stimuli while they did not encode the relation between the words if they selectively ignored one of the words (see also Boronat & Logan, 1997). In essence the instance theory is based on three main assumptions. First, it is presumed that encoding into memory and, second, retrieval from memory are necessary consequences of attention. Third, each encounter with a stimulus is represented in a single instance or episode that – if accumulated over time – results in improved learning.

Against this background, we incorporated a selection task from the field of selective attention into an EC paradigm. In particular, we used an EC paradigm including a variant of the Eriksen flanker task. In a typical Eriksen flanker task (Eriksen & Eriksen, 1974; see Eriksen, 1995, for a review), participants perform a choice response to the central item in a string of letters (e.g. BAB). The adjacent letters, which are irrelevant for the participants' task, are called "flankers" or "distracters". In compatible conditions, the flankers and the target are mapped onto the same response; in incompatible conditions the flankers and the target are mapped onto different responses. Thus, the difference between compatible and incompatible conditions reflects the flanker effect at the level of response selection. In addition, this paradigm makes it possible to independently measure the influence of stimulus congruence on selection. For instance, the difference between perceptually congruent (AAA) and incongruent (CAC) letter strings taps interference at the level of stimulus congruence, if A and C are both mapped to the same response rather than on different responses (see e.g. Frings & Spence, 2010; Wesslein, Spence, & Frings, 2014).

To investigate the moderating influence of selective attention processes on EC, two experiments were designed in which we presented CS–US pairs within an adapted Flanker paradigm. Similar to the original Flanker paradigm (Eriksen & Eriksen, 1974), we implemented a target-distracter logic by introducing the CS as the task-relevant stimulus (i.e. the target) and the US as a task-irrelevant distracter. If we consider EC through the lens of selective attention processes, the integration of CS and US should critically depend upon whether the US would be processed in relation to the CS. It is this essential premise that justifies the implemented target-distracter logic insofar as it allows for investigating the influence of variations in processing the US in relation to the CS on the integration of CS and US and thus EC. In particular, in Experiment 1, CSs and USs were framed with a coloured line and participants had to classify the colour of the CS's frame, or were required to process both stimuli in order to classify colour differences/similarity of the CS/US in the control condition. The coloured frames of CS and US could be similar (congruent) or dissimilar (incongruent). Concerning the idea of selection as outlined above, we hypothesised that in congruent trials, attending to the US would enhance the internal representation of the US, thereby strengthening the impact of the US on the CS. In contrast, in incongruent trials, the US does have to be selectively ignored. Insofar as processing of the US does then interfere with the target-response, diminished EC effects were expected under this condition. In the control condition, in which participants were not required to select the CS against the US, the frames' congruency should have no modulating influence on EC.

In Experiment 1 we expected stronger EC effects in the congruent condition as the US will further responding to the CS while it will hamper responding to the CS in incongruent trials. In Experiment 1 the possible impact of selection on EC was maximised by means of the full overlap of compatibility and congruency. That is, each congruent trial was also compatible while each incongruent trial was also incompatible. Because results indicated that selection modulated the EC effect, we pinpointed the level at which selection processes modulate EC effects in Experiment 2 by disentangling congruence and compatibility.

Experiment 1

Method

Participants and design

A total of 96 students (70 women) from various disciplines at the University of Trier participated in a study on the relationship between "colours and perception".[1] Participants were randomly assigned to a 2 (US valence: positive vs. negative) × 2 (congruence of the CS and US frame: congruent vs. incongruent) × 2 (selection of the CS: selection vs. no selection) mixed-factorial design with the last factor being manipulated between participants. Participants received either course credit or a monetary compensation of three Euros for their participation. Data from one participant who did not follow the instructions were excluded from the analysis. Another student participated twice in this experiment and therefore data from the second participation were excluded. Excluding these two participants, a total of 46 participants remained in the selection and 48 participants in the no selection condition.

Procedure

Upon entering the laboratory, participants were welcomed by the experimenter and seated in front of a 19-inch LCD screen at a distance of 60 cm. Before beginning the experiment participants were administered a consent form to sign. The experiment was conducted using MediaLab (v.2008) and directRT (v.2008) and consisted of two consecutive phases: a conditioning phase and a test phase. Screen resolution during the whole procedure was fixed to 1024 × 768 pixels.

Conditioning phase. In the conditioning phase, participants were presented with 16 CS–US pairs comprising 16 fictitious water brands (e.g. Abrizzo, Helvipo, Insente, Ustia, Lurent) as CSs (Blask et al., 2012) and 8 positive and 8 negative pictures from the EmoPics database (Wessa et al., 2010) as USs. Positive USs were characterised by mean valence ratings of 7.41 and mean arousal ratings of 4.71. Negative USs had mean valence ratings of 2.74 and mean arousal ratings of 5.65. CS and US pictures subtended visual angles of 12.0 degrees horizontally by 9.6 degrees vertically. Because previous research has shown that backward conditioning (i.e. the US spatially precedes the CS) results in reduced EC (Hofmann et al., 2010), CS–US pairs were presented in the centre of the screen with CSs being always presented on the left side and USs on the right side. The stimuli's centre-to-centre difference was 16.06 degrees. One-half of the USs of each valence was characterised by a frame colour being congruent with that of the paired CS whereas the other half was incongruent with the frame colour of the paired CS. The assignment of the 16 CSs to congruence and US valence conditions was fixed for a given participant. In order to avoid confounding among CS–US assignment and conditions, the assignment of the 16 CSs to the 16

USs was counterbalanced across the US valence and congruence condition resulting in a total of eight conditions being presented in both the selection and no selection condition. In the selection condition, participants were asked to classify the CS with respect to its frame colour. Specifically, participants were either asked to press the left white marked key in response to water brands with a green frame and the right white marked key for water brands with a yellow frame or vice versa (see Figure 1(a)). Participants in the no selection condition were asked to classify the CS with respect to its similarity to the US. That is, if CS and US had the same frame colour, participants had to press the "similar" key, and if they had different frame colours, they were asked to press the "dissimilar" key. Insofar as selection of the CS was varied between subjects, response keys in the selection and no selection condition were the same. CS–US pairs were presented simultaneously for 1000 ms then being followed by a blank screen for 500 ms. These 1500 ms constituted the response time window during which responses in the selection condition were recorded. In order to keep the timing constant across both selection conditions this time window was also applied to the no selection condition. The response time window was then followed by the response feedback screen for 1000 ms. Response feedback was meant to increase participants' commitment to the task by providing a "correct" feedback for a correct response and an "incorrect" feedback for an incorrect response. The presentation of the feedback display was then followed by an inter-trial-interval (ITI) of 500 ms. Within this 500 ms ITI participants were presented with a grey dot appearing at the centre of the later CS position. By cueing the location of the CS in both conditions, an initial attention focus on the CS was kept constant across conditions. Each of the 16 CS–US pairs was repeated 12 times resulting in a total of 192 trials.

Test phase. The conditioning phase was followed by a test phase. Participants were asked to rate how much they liked the presented stimuli in two separate blocks on a graphic rating scale (labelled "dislike" on the left and "like" on the right). Participants assigned their ratings to each stimulus by positioning the cursor on any point of the scale and then pressing the left mouse key. The first block consisted of the 16 CSs, the second block of the USs. To avoid response tendencies, the graphic scale consisted of no additional numbers or other numerical labels. The computer programme recorded negative judgments on the left side from −100 to −1, and positive judgments on the right side from +1 to +100. The neutral midpoint of the scale (0) served as the starting position for each judgement.

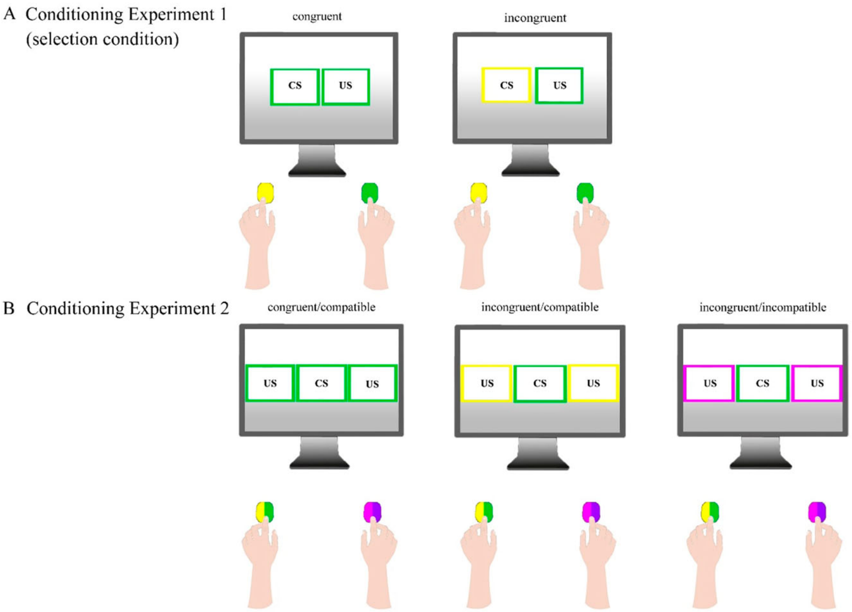

Figure 1. A simplified description of the conditioning procedure realised in Experiment 1 (a) and Experiment 2 (b).

Results and discussion

Manipulation checks – response interference

In order to test whether there was a Flanker effect in the selection condition, but not in the no selection condition, we submitted participants' reaction times (RTs) to a 2 (congruence of the CS and US frame: congruent vs. incongruent) × 2 (selection of the CS: selection vs. no selection) mixed-factorial ANOVA with repeated measurement on the first factor.[2] Only RTs that were correct and longer than 300 ms were considered. The results showed no significant main effect of congruence, $F(1, 92) = 3.05$, $MSE = 585.99$, $p = .084$, as well as no main effect of selection, $F(1, 92) = 1.10$, $MSE = 11531.73$, $p = .298$. However, the expected interaction between selection of the CS and congruence of the CS and US frame reached statistical significance, $F(1, 92) = 4.72$, $MSE = 585.99$, $p = .032$, $\eta_p^2 = .05$. Testing for the contrast between congruent and incongruent CS–US pairs within the selection condition revealed the expected Flanker effect, $F(1, 45) = 7.10$, $MSE = 620.92$, $p = .011$, $\eta_p^2 = .14$. That is participants' reactions on congruent CS–US pairs were significantly faster than on incongruent CS–US pairs. Conducting the same test for the no selection condition revealed no significant difference in RTs for congruent and incongruent CS–US pairs $F(1, 47) = 0.09$, $MSE = 552.57$ (for mean response times and standard deviations in all conditions see Table 1).

Conducting the same analysis on response accuracy revealed no main effect of congruence of the CS and US frame, $F(1, 92) = 2.63$, $MSE = 0.002$, $p = .108$, no main effect of selection of the CS, $F(1, 92) = 1.27$, $MSE = 0.02$, $p = .263$ as well as no significant interaction effect, $F(1, 92) = 1.73$, $MSE = 0.002$, $p = .191$. To compare the errors with the RT, we separately tested for response interference effects within the selection and the no selection condition. The data revealed a significant response interference effect within the selection condition, $F(1, 45) = 4.12$, $MSE = 0.002$, $p = .048$, $\eta_p^2 = .08$. Thus, participants in the selection condition were less accurate in selecting the correct CS response for incongruent CS–US pairs ($M_{accuracy} = 0.91$, $SD = 0.11$) compared to congruent CS–US pairs ($M_{accuracy} = 0.93$, $SD = 0.10$). As for the RT data, there was no moderating influence of congruence on response accuracy in the no selection condition, $F(1, 47) = 0.05$, $MSE = 0.002$ (for means and standard deviations in all conditions see Table 1).

Conditioning effects

In order to test whether CSs paired with positive USs were evaluated more favourably than CSs paired with negative USs, CS ratings were submitted to a paired *t*-test. The analysis revealed a significant conditioning effect, $t(1, 93) = 4.29$, $p < .001$, $d = 0.75$, indicating that CSs paired with positive USs were evaluated more positively ($M_{pos} = 9.49$, $SD = 22.79$) than CSs paired with negative USs ($M_{neg} = -7.57$, $SD = 23.02$; for means and standard deviations in all conditions see Table 1).

Effects of selective attention on EC

EC effects (i.e. the difference between CSs paired with positive USs and CSs paired with negative USs) were computed and then submitted to a 2 (congruence of the CS and US frame: congruent vs. incongruent) × 2 (selection of the CS: selection vs. no selection) mixed-factorial ANOVA with repeated measurement on the first factor.[3] This analysis revealed the expected two-way interaction between congruence of the CS and US frame and selection of the CS, $F(1, 92) = 4.42$, $MSE = 978.66$, $p = .039$, $\eta_p^2 = .05$, indicating that EC differs as a function of congruence and selection group. There was neither a main effect of congruence of the CS and US frame, $F(1, 92) = 0.38$, $MSE = 978.66$ nor a main effect of selection of the CS, $F(1, 92) = 0.24$, $MSE = 2990.08$. In order to test whether the two-way interaction reflects the hypothesised semi-disordinal pattern, congruence effects within the different selection conditions were computed. As expected congruence only modulated EC if the CS had to be selected against the US, $F(1, 45) = 4.62$,

Table 1. Overview of the means and standard deviations of CS evaluations, response times and accuracy rates (Experiment 1).

	Selection				No selection			
	Congruent		Incongruent		Congruent		Incongruent	
US valence	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Positive	12.03	27.28	7.10	29.17	8.71	30.23	10.11	26.64
Negative	−13.20	30.87	−5.74	27.61	−3.05	26.42	−8.45	30.28
Accuracy rates (proportion correct)	0.93	0.10	0.91	0.11	0.94	0.07	0.94	0.11
Response times (ms)	533.31	76.45	547.15	84.67	524.58	77.22	523.08	72.78

$MSE = 765.10$, $p = .038$, $\eta_p^2 = .09$ (see Figure 2). Specifically, EC was more pronounced in the congruent condition ($M = 25.23$, $SD = 48.01$) than in the incongruent condition ($M = 12.84$, $SD = 49.21$). In contrast, there was no significant impact of congruence on EC within the no selection condition, $F(1, 47) = 0.94$, $MSE = 1183.13$, $p = .338$ ($M_{congruent} = 11.76$, $SD = 48.01$; $M_{incongruent} = 18.56$, $SD = 41.55$), indicating that congruence only moderates EC if the CS has to be selected against the US.

Finally, EC in the congruent selection condition, in which the US does not have to be selectively ignored, was significantly different from zero ($t(45) = 3.56$, $p < .001$, $d = 0.53$). However, EC in the incongruent selection condition was weaker and only marginally significant ($t(45) = 1.77$, $p = .084$, one-tailed, $d = 0.26$). Within the no selection condition both EC in the congruent and incongruent condition was significantly different from zero ($t(47) = 2.09$, $p = .042$, $d = 0.31$ and $t(47) = 3.10$, $p = .003$, $d = 0.45$, respectively).

In order to test whether the modulating influence of CS–US stimulus congruence on EC within the selection condition is due to differential selective processing, a simple linear regression was calculated to predict the respective contrast in EC (EC congruent minus EC incongruent) based on the Flanker effect. This analysis revealed no significant result ($F < 1$).

Experiment 1 provided first evidence for the influence of the selective processing of the US on EC. As expected there was more pronounced EC in the congruent condition as compared to the incongruent condition, when participants had to select the CS against the US. As outlined above, we argue that in congruent trials CS response selection is positively related to attending to the US and therefore no negative impact on EC should be observed. In incongruent trials, however, the US has to be selectively ignored because processing of the US interferes with CS response selection. The interference of the US reduces the probability for the integration of the CS with the evaluative response resulting in less pronounced EC. Note that in conditions where the CS had not to be selected against the US stimulus congruence had no modulating influence on EC. Thus the congruence effect in the selection condition of the current experiment can be clearly traced back to the selective processing of the US. However, because there was no significant relationship between the Flanker effect and the respective contrast in EC it is still unclear at which level selective processing of the US modulates EC. Thus, before discussing the implications of this finding in the General discussion section, we are going to disentangle the selection processes that might have produced the congruence effect in Experiment 2.

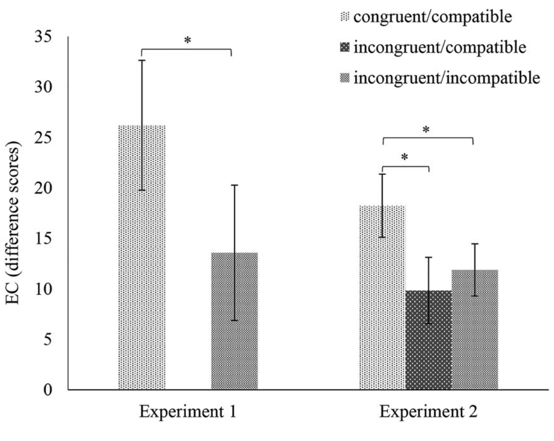

Figure 2. The left panel presents EC effects as a function of congruence in the selection condition of Experiment 1. The right panel depicts EC effects as a function of stimulus congruence and response compatibility in Experiment 2. Error bars indicate the standard errors of the means. *Note*. *$p < .05$.

Experiment 2

One shortcoming of Experiment 1 was that it did not allow for conclusions on the level at which selection impacted upon EC. In particular, given that stimulus congruence and response compatibility completely overlapped in Experiment 1, it is not clear whether the modulation of EC was due to the operation of perceptual or response-based selection processes. In fact, in the incongruent condition, the US frame and the CS frame were perceptually incongruent but also incompatible at the level of responses while in the congruent condition both frames were perceptually congruent and response compatible. The flanker design easily allows disentangling interference of flankers at the level of stimulus congruence and response compatibility by introducing a perceptually incongruent but response compatible condition (Eriksen & Eriksen, 1974). Consequently in Experiment 2, stimulus congruence and response compatibility were varied by mapping four colours on two response keys. As a result, we can analyse flanker interference at the level of stimulus congruence (difference congruent/compatible versus incongruent/compatible) and at the level of response compatibility (incongruent/compatible versus incongruent/incompatible). Essentially the same logic holds for EC effects, that is, we can analyse whether integrating the US and CS in a selection task is furthered by stimulus congruency or response compatibility.

Method

Participants and design

A total of 95 students (80 women) from various disciplines at the University of Trier participated in a study on the relationship between “colours and perception”. Participants were randomly assigned to a 2 (US valence: positive vs. negative) × 3 (congruence/compatibility relation of the CS and US frame: congruent/compatible vs. incongruent/compatible vs. incongruent/incompatible) repeated measures design. Participants received course credit for their participation. From these 95 participants a total of five participants had to be excluded for the following reasons. One participant’s average RTs were an outlier when compared to the average RT of the sample. Moreover, the experimenters identified two participants who did not follow instructions. Finally, two participants showed a particularly pronounced left-key response bias (two standard deviations above sample mean; cf., Chan et al., 2009).

Procedure

Participants were welcomed by the experimenter and seated in front of a 19-inch LCD screen at a distance of 60 cm and administered a consent form to sign before beginning the experiment. The experiment was conducted using E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002). The procedure was essentially the same as in Experiment 1 except for the conditioning phase, which will therefore be described in more detail.

Conditioning phase. In order to increase equivalence of the adapted Flanker paradigm introduced in Experiment 1 to the original Flanker task of Eriksen and Eriksen (1974) the following modifications were made (for an overview see Figure 1(b). CSs were presented centrally and flanked by the respective US from both sides (instead of being flanked by a US from just one side as in Experiment 1). Moreover, CS–US strings were moved on the horizontal axis in a varying interval of 0.60–1.00 degrees of visual angle either to the left or right side of the screen. This variation was meant to increase uncertainty about target location thereby furthering the operation of selective attention processes. Altogether participants were presented with a total of 32 CS–US pairs during the conditioning phase. The 32 CS–US pairs comprised 32 fictitious water brands (e.g. Abrizzo, Helvipo, Insente, Ustia, Lurent) as CSs as well as 16 positive and 16 negative pictures as USs. These pictures included the 16 pictures from Experiment 1 and an additional 16 pictures from the internet that had been pretested for their valence and arousal.[4] In order to manipulate stimulus congruence independent of response compatibility, CSs and USs varied with respect to four different frame colours (yellow, green, pink and violet) being mapped on two response keys. Depending on frame colour congruence between CS and US and the assignment of the respective colours to the same or different response keys, three conditions were realised. In the congruent/compatible condition CS- and US-frame colour as well as the responses indicated by CS and US were identical while in the incongruent/incompatible condition both frame colour and responses differed. These two conditions were thus equivalent to the congruent and incongruent condition realised in Experiment 1. Besides these two conditions, we also realised an incongruent/compatible condition wherein CSs and USs had incongruent frame colours but were compatible with respect to the response insofar as both frame colours were mapped on the same response key. Consequently, the congruence effect could be determined by comparing the congruent/compatible condition to the incongruent/compatible condition while the compatibility effect could be assessed by the comparison between the incongruent/compatible and the incongruent/incompatible condition. In order to realise a balanced distribution of CS–US pairs across the conditions the following assignment was realised. While 50% of the CS–US pairs (i.e. 16 CS–US pairs) were distributed equally between the congruent/compatible and incongruent/compatible condition (i.e. eight CS–US pairs in each condition) the remaining 50% were assigned to the incongruent/incompatible condition. The assignment of the 32 CSs to congruence/compatibility conditions and US valence conditions was fixed for a given participant. In order to avoid confounding among CS–US assignment and conditions, the assignment of the 32 CSs to the 32 USs was counterbalanced across US valence and congruence/compatibility conditions (as a resultant of counterbalancing the four different CS- and US-colours) resulting in a total of 32 conditions. Similar to the selection condition of Experiment 1 participants were asked to classify the CS with respect to its frame colour. Specifically, participants were asked to press the left white marked key in response to water brands with a yellow or violet frame and the right white marked key for water brands with a green or pink frame. As in Experiment 1 each correct response was followed by a "correct" feedback and each incorrect response was followed by an "incorrect" feedback remaining on the screen for 1000 ms. Stimulus presentation time as well as response time window and ITI were also the same as in Experiment 1 (i.e. 1000 ms, 1500 ms and 500 ms, respectively). However, deviating from Experiment 1 participants were not presented with a grey dot during ITI but with a centrally presented fixation cross subtending visual angles of 1.6 degrees horizontally by 1.3 degrees vertically. CS and US pictures subtended visual angles of 12.0 degrees horizontally by 9.6 degrees vertically. The stimuli's centre-to-centre difference was 16.06 degrees each. Each of the 32 CS–US pairs was repeated 12 times resulting in a total of 384 trials.

Results and discussion

Manipulation checks – response interference

In order to test to what extent selection speed of the correct CS response is influenced by response compatibility and stimulus congruence, participants' RTs of the three conditions were submitted to a one-way repeated measures ANOVA.[2] Comparable to Experiment 1 only response times longer than 300 ms were considered. The analysis revealed a significant main effect of condition, $F(2, 89) = 8.85$, $MSE = 400.56$, $p < .001$, $\eta_p^2 = .09$. In order to determine whether this effect was due to response compatibility or stimulus congruence two flanker effects were computed. Flanker effects at the perceptual level were computed by subtracting RTs on those trials with perceptually congruent CS and US frames (identical trials) from the RTs on those trials in which the CS and US frames were perceptually different but response compatible (incongruent/compatible trials). To compute flanker effects at the response level irrespective of stimulus congruence, the RTs on incongruent trials in which the CS and US frames were response compatible were subtracted from the RTs on incongruent trials in which they were response incompatible. The perceptual flanker missed significance, $M = 2.70$ ms, $SD = 27.58$ ms, $t(89) = 0.93$, $p = .356$ while the response flanker was significant, $M = 9.27$ ms, $SD = 27.11$ ms, $t(89) = 3.24$, $p = .002$, $d = 0.13$ (for means and standard deviations of raw RTs in all conditions see Table 2).

In order to analyse the impact of response compatibility and stimulus congruence on the accuracy of CS-response selection, mean response accuracy within the three conditions was compared via a one-way repeated measures ANOVA. The analysis revealed a significant main effect of condition, $F(2, 89) = 3.99$, $MSE = 0.001$, $p = .020$, $\eta_p^2 = .04$. In order to determine whether this effect was due to response compatibility or stimulus congruence two flanker effects were computed. Similar to the reaction time analysis, flanker effects at the perceptual level and response level were computed. Once more the perceptual flanker was not significant, $M = -0.0004$, $SD = 0.04$, $t(89) = -0.09$, $p = .932$ while the response flanker was significant, $M = -0.009$, $\mathrm{SD} = 0.03$, $t(89) = -2.45$, $p = .016$ (for means and standard deviations of raw accuracy rates in all conditions see Table 2). In conclusion, the results on RTs as well as response accuracy suggested that CS-response selection is more strongly influenced by CS–US response compatibility as compared to CS–US stimulus congruence.

Conditioning effect

In order to test for an overall EC effect, ratings for CSs paired with positive USs and ratings of CSs paired with negative USs were submitted to a paired *t*-test. The analysis revealed a significant conditioning effect, $t(1, 89) = 5.71$, $p < .001$, $d = 0.85$, indicating that CSs paired with positive USs were evaluated more positively ($M_{pos} = 7.29$, $SD = 15.49$) than CSs paired with negative USs ($M_{neg} = -6.03$, $SD = 16.06$;

Table 2. Overview of the means and standard deviations of CS evaluations, response times and accuracy rates (Experiment 2).

	Compatible				Incompatible	
	Congruent		Incongruent		Incongruent	
US valence	*M*	SD	*M*	SD	*M*	SD
Positive	9.11	20.29	4.79	22.48	7.99	17.89
Negative	−9.13	22.63	−5.06	21.38	−3.89	17.61
Accuracy rates (proportion correct)	0.92	0.05	0.92	0.05	0.91	0.05
Response times (ms)	692.40	77.86	695.10	74.56	704.36	71.04

for means and standard deviations in all conditions see Table 2).

The influence of response compatibility and stimulus congruence on conditioning

In order to test for the influence of response compatibility and stimulus congruence on EC, we first computed EC difference scores for the three congruence/compatibility conditions. Submitting these EC scores to a one-way repeated measures ANOVA revealed a significant main effect, $F(2, 89) = 3.52$, $MSE = 491.04$, $p = .032$, $\eta_p^2 = .04$.[3] Simple contrast analyses revealed that EC was significantly more pronounced in the congruent/compatible condition ($M = 18.25$, $SD = 29.65$) than in the incongruent/compatible condition ($M = 9.84$, $SD = 31.17$), $F(1, 89) = 4.80$, $MSE = 1322.89$, $p = .031$, $\eta_p^2 = .05$, and the incongruent/incompatible condition ($M = 11.88$, $SD = 24.51$), $F(1, 89) = 4.79$, $MSE = 761.55$, $p = .031$, $\eta_p^2 = .05$. There was however no difference in EC between the latter two conditions, $F(1, 89) = 0.43$, $MSE = 861.77$, $p = .512$. That is, the integration of CS and US and thus EC seems to be more strongly influenced by CS–US stimulus congruence than CS–US response compatibility (see Figure 2).

However, it has to be noted that CS–US stimulus congruence only modulates EC and does not prevent its occurrence. In particular, EC in the congruent/compatible condition was significantly different from zero ($t(90) = 5.84$, $p < .001$, $d = 0.61$), but also in the incongruent/compatible and incongruent/incompatible conditions ($t(90) = 2.99$, $p = .001$, $d = 0.31$ and $t(90) = 4.60$, $p < .001$, $d = 0.48$, respectively).

In order to test whether the modulating influence of CS–US stimulus congruence on EC is due to differential selective processing, a simple linear regression was calculated to predict the respective contrast in EC based on the perceptual Flanker effect. A significant regression equation was found, ($F(1, 88) = 5.26$, $p = .024$), with an R^2 of .06, indicating a positive relationship ($\beta = .237$) between the perceptual Flanker and the respective contrast in EC.

These findings provide one more indication for our hypothesis that selective processing of the US results in a substantial modulation of EC. Most importantly, however, results of the second experiment indicate that selective attention processes do not exert their moderating influence on EC at the level of response selection but rather at the level of perceptual selection. In particular, finding more pronounced EC in the congruent/compatible condition as compared to the incongruent/compatible condition clearly indicates that it is interference at the stimulus selection level that modulates the integration of CS and US. This finding is further substantiated by the significant positive relation between the perceptual Flanker effect and the respective contrast in EC. Moreover, there was no significant difference in EC between the incongruent/compatible and incongruent/incompatible condition, further emphasising the unique explanatory value of perceptual selective attention processes for the integration of CS and US in evaluative learning.

General discussion

Although EC has been intensively investigated in recent years (for a review see, Hofmann et al., 2010), evidence for selective attentional processes underlying this form of learning is still scarce. In order to address this issue two experiments were designed in which a variant of the Eriksen flanker task was integrated into a standard EC paradigm. Specifically, we implemented a target-distracter logic by introducing the CS as the target and the US as a task-irrelevant distracter. Selective attention was varied by instructing participants to selectively respond to the CS while ignoring the US, or in the control condition to respond to both stimuli. Results of Experiment 1 provided first evidence that selective processing of the US relative to the CS modulates EC effects. In Experiment 2, we replicated this finding and pinpointed the level at which selection processes modulate EC effects by disentangling stimulus congruence and response compatibility. Overall, our findings provide compelling evidence for a moderation of EC via selective attention processes on a perceptual level.

In particular, EC was more pronounced when CSs had to be selected against congruent USs as when they had to be selected against incongruent USs. Given that EC always refers to the valence transfer from the US to the CS, these findings support the theoretical notion that, in perceptually incongruent trials, selectively ignoring the US impairs the internal representation of the US features (Friedman & Miyake, 2004; Frings, Wentura, & Wühr, 2012). According to our hypothesis, limited access to the US's internal representation and thus to its valence reduces the probability for the integration of the CS with the valence feature of the US, and, therefore the probability for EC. In contrast, in congruent trials selective processing of the US relates positively to processing the CS which is why EC should remain unimpaired in this condition. Most importantly, there was no influence of stimulus congruence on EC if the CS had not to be selected against the US. Thus our findings are clearly in favour of a modulating influence of the selective processing of the US on EC and cannot be reduced to a simple perceptual similarity explanation (see Experiment 1).

It should be noted, however, that our variant of the flanker task differed in an important aspect from the original task. In fact, in the standard flanker task, participants select the target object against distracting flanker objects. In our paradigm, participants selected the frame of an object (the CS) against the frame of another object (the US). Thus, one might wonder whether selective attention affected the CS and US or only their frames, respectively. Yet it is quite unlikely that participants only processed the frames because otherwise there would have been no differences in EC.

Moreover, it might be questioned, whether the perceptual congruence effect found for EC is actually due to differences in selective attention given that there was only a response-based flanker effect, but no perceptual flanker effect. Yet, we would argue that the manifestation of interference mainly at the level of responses, which is typical for an Eriksen flanker task (see Eriksen, 1995, for a review), shows that participants processed the flankers – otherwise we would not have obtained any flanker effect at all. Because participants were nevertheless able to correctly respond in most trials (despite response incompatible flankers) attentional selection was successful. Generally speaking, selective attention is typically investigated in the so-called filtering tasks or interference tasks (see Luck & Vecera, 2002, for a review). The basic structure of these tasks is to present participants with a relevant stimulus (target) and an irrelevant stimulus (distractor), and to vary the compatibility or congruence between features of the distractor and features of the response to the target. The size of the compatibility or congruency effect (i.e. the impact of the distractor stimulus on performance) reflects the quality of selective attention towards the target. Thus, the observed flanker effects are indicative for attentional selection.

It also has to be noted that our findings cannot be explained via distractor devaluation (Fenske & Raymond, 2006) which would have resulted in a general negativity bias for CS evaluations in the incongruent conditions. Insofar as EC is mainly driven by selection at the perceptual level it seems plausible that affective consequences that have been traced back to selection at the response level (cf., Kiss, Raymond, Westoby, Nobre, & Eimer, 2008) have a negligible or no influence on these preferences. Therefore, future research should probably not only differentiate between stimulus (perceptual) and response level regarding the representation of preferences but also with respect of the encoding processes (i.e. selection processes) underlying preference formation.

Our findings are important because they shed light on the hitherto neglected stimulus-integration process involved in evaluative learning. In conditioning research it is a widely-shared assumption that USs are automatically processed due to their affective nature (e.g. Fazio et al., 1986; Pratto & John, 1991; Wentura et al., 2000). Yet, our findings indicate that processing of the US is modulated by the operation of selective attention processes on a perceptual level. In particular the modulation of EC via stimulus congruence indicates that the integration of the valence of the US with the CS can be substantially influenced by variations in the selective perceptual processing of the US. Consistent with recent theoretical arguments, however, it can be assumed that automaticity is not an all-or-none process in which all four horsemen of automaticity (Bargh, 1994) are simultaneously at work. Instead automatic processes may have controlled aspects that need a thorough analysis of their operating conditions (Gawronski & Bodenhausen, 2014). Whereas US processing can be assumed to be unintentional, in that no goal is needed to start the process, it might be controllable to some extent. That its controllability is not perfect is supported by the fact that we nevertheless obtained at least one-tailed significant EC in the incongruent selection condition of Experiment 1 and significant EC in the incongruent and incompatible condition of Experiment 2.

Cognitive psychologists have argued for decades that attention may be important in the acquisition of conditioned reactions (Kruschke, 2001; Mackintosh, 1975; Rescorla & Wagner, 1972). Surprisingly, the influence of the selective processing of the US on EC has not yet been addressed. While previous studies have mainly investigated attention as a limited resource in the context of contingency memory (Field & Moore, 2005; Kattner, 2012; Pleyers et al., 2009), we addressed a different attention process, namely the influence of selective processing of the US on EC. If the accessibility of the US valence is experimentally increased/ decreased by means of being a congruent versus incongruent distracter in a selection task, the probability for the integration of the CS with the US and its evaluative response changes accordingly and so does EC. It might be an interesting avenue of future research to address the role of contingency memory in this process.

Selective attention is one of the basic mechanisms by which organisms control their sensory input from the environment. Because the sensory input is the basis of what is learned in an environment, investigating selective attention processes in the context of evaluative learning would seem to be mandatory. Although EC research has recently elicited increasing interest in social (Hofmann et al., 2010), clinical (Schienle, Walther, Schäfer, Stark, & Vaitl, 2005), cognitive (Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012) and consumer psychology (Brendl, Nijs, Möller, & Walther, 2015) comparatively little is known about the processes determining the integration of CS and US. Taking a recently proposed distinction into account (Gawronski & Bodenhausen, 2014), it is not well known either *what* processes are involved in evaluative learning (e.g. propositional, associative, or attributional) or *when* these processes operate (i.e. under which conditions there is a possibility to inhibit or stop the process). The present research contributes to the *when* question by providing evidence for the impact selective attention has on evaluative learning.

Notes

1. We report how we determined our sample size, all data exclusions (if any), all manipulations and all measures in the study.
2. Note that there was no influence of US valence on response times, neither in Experiment 1 nor in Experiment 2 (all $Fs < 1$). Therefore response times were collapsed across US-valence.
3. Note that the effects in the simplified analysis reported are the same as those resulting from the more complex analysis including US valence as another within-subjects factor. Effects differ only with respect to the size of the MSE values, which is due to the varying computation of MSE-values in these analyses.
4. The 16 additional USs in Experiment 2 included eight positive and eight negative pictures with mean valence ratings of $M_{pos} = 64.34$ ($SD_{pos} = 29.93$) and $M_{neg} = -62.36$ ($SD_{neg} = 33.96$), respectively. Mean arousal ratings were $M_{pos} = -16.09$ ($SD_{pos} = 47.26$) and $M_{neg} = 32.48$ ($SD_{neg} = 36.15$). While valence ratings were assessed by means of the same rating scale used in the current experiments arousal ratings were assessed on a slightly adapted graphic rating scale. In particular endpoints of the scale were entitled calmness on the left and activation on the right. In order give participants a further anchor on this decision a Self-Assessment Manikin (SAM; Bradley & Lang, 1994) scale for arousal was presented above the graphic rating scale. Comparable to the valence assessment the computer program recorded calmness judgments on the left side from −1 to −100, and activation judgments on the right side from +1 to +100.

Disclosure statement

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