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Blame everyone: Error-related devaluation in Eriksen flanker task[☆]

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ABSTRACT

Preferences are determined not only by stimuli themselves but also by the way they are processed in the brain. The efficacy of cognitive processing during previous interactions with stimuli is particularly important. When observers make errors in simple tasks such as visual search, recognition, or categorization, they later dislike the stimuli associated with errors. Here we test whether this error-related devaluation exists in Erisken flanker task and whether it depends on the distribution of attention. We found that both attended stimuli (targets) and ignored ones (distractors) are devaluated after errors on compatible trials but not incompatible ones. The extent of devaluation is similar for targets and distractors, indicating that distribution of attention does not significantly influence the attribution of error-related negative affect. We discuss this finding in light of the possible mechanisms of error-related devaluation.

1. Introduction

A softness of touch, a pleasant taste, or an elegant shape – all these qualities could be legitimate reasons for preferring one thing over the other. Yet, previous studies show that preferences depend on cognitive processing as much as on the intrinsic qualities of stimuli (Albrecht & Carbon, 2014; Chetverikov & Kristjánsson, 2016; Muth & Carbon, 2013; Reber, Schwarz, & Winkielman, 2004; Van de Cruys & Wagemans, 2011). The efficacy of cognitive processing is particularly important: errors result in a negative affect and devaluation of stimuli associated with errors even when participants do not receive any feedback about their accuracy (Aarts, De Houwer, & Pourtois, 2012; Chetverikov, 2014; Chetverikov & Filippova, 2014; Schouppe et al., 2014). Physiological studies also show that activation of reward-related brain regions, such as ventral striatum, depends on response accuracy even when no external feedback is provided (Daniel & Pollmann, 2014; Satterthwaite et al., 2012). Similarly, a fast error-related response-locked negative deflection of brain electrical activity known as error-related negativity (ERN) consistently correlates with negative affect (Aarts, De Houwer, & Pourtois, 2013; Hajcak, McDonald, & Simons, 2004; Luu, Collins, & Tucker, 2000; Moser, Moran, Schroder, Donnellan, & Yeung, 2013; Schroder, Moran, Infantolino, & Moser, 2013). One possible interpretation of this phenomenon is that "marking" error-related stimuli with negative affect might help guide future behavior (Chetverikov & Kristjánsson, 2016). In real life, however, there is usually more than one object present at a time. It is not clear how the negative affect resulting from an error becomes associated with a particular stimulus. Filling this gap is important to understand better both how the preferences are formed in general and how people learn from their errors.

In previous studies of error-related negative affect, usually, only a single stimulus was presented on the screen when an error occurred. For example, Chetverikov (2014) demonstrated that preferences towards previously shown stimuli depend on whether or not observers recognize these stimuli in an unexpected recognition test before preferences were rated. This in sharp contrast to a well-known mere exposure effect suggesting that previously seen stimuli are preferred to novel ones even when they were not consciously perceived (Bornstein, 1989; Zajonc, 1980, 2001). In a meta-analysis of previous studies and several new experiments, Chetverikov (2014) found a typical mere exposure effect only when observers recognized the stimuli. But in case of recognition failure, that is, when observers erroneously thought that the stimulus they are asked to recognize was not presented before, the preferences became more negative as the number of previous exposures increased. This phenomenon was coined error-related devaluation: recognition error results in negative affect that counteracts positive

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effects of mere exposure. Later, similar negative effects of errors on preferences were found in visual search (Chetverikov, Jóhannesson, & Kristjánsson, 2015) and categorization tasks (Chetverikov & Filippova, 2014).

The main question of the present study is how error-related devaluation is distributed between stimuli present at the moment of error. In the real world, observers always perceive more than one stimuli. How do they determine which one is to “blame” for the error? Studies of affective misattribution (Payne & Lundberg, 2014; Schwarz & Clore, 1983) demonstrate that affect can automatically spread from one stimulus to another when they are close in time. Then, error-related devaluation might be not limited to stimuli evoking the errors. In support of this hypothesis, Aarts et al. (2012) found that false alarms in a Go/NoGo task speed up subsequent evaluative categorization of negative words compared to positive words. Using similar evaluative categorization procedure to measure affect, Schouppe et al. (2014) found that after errors in Eriksen flanker task (Eriksen & Eriksen, 1974) observers tend to categorize the subsequently presented words as negative more often. These findings indicate that error-related negative affect might diffuse from one stimulus to another. Notably, in these studies both error-related stimuli and subsequently presented words are attended. However, Chetverikov et al. (2015) found that in the visual search task errors do not affect the evaluation of distractors. While liking ratings of the targets became more positive with an increase in search time on correct trials and more negative on error trials, for distractors search time was positively correlated with liking independent of trial accuracy.

We hypothesized that attention might play an important role in error-related devaluation such that only attended stimuli are devaluated. To test this hypothesis, in the present study we conducted an experiment utilizing a modified Eriksen flanker task. In the flanker task, observers had to make decisions about the stimulus presented in the center (target) while surrounding stimuli (distractors, or flankers) were to be ignored. We expected that targets would be devaluated more than distractors following incorrect responses due to the distribution of attention.

In addition, we wanted to test if response accuracy would interact with the trial compatibility. Chetverikov and Kristjansson (2016) suggested that error-related devaluation can result from inconsistency between predictions based on a variety of cues involved in decision-making process. Each decision can utilize different cues: recognition, for example, can be based on shape, colour, semantics, and many other aspects of stimuli. Monitoring this consistency can then help to monitor response accuracy even in the absence of external feedback. Similar ideas were proposed within conflict-monitoring theory (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Yeung, Botvinick, & Cohen, 2004; Yeung & Summerfield, 2012) and self-consistency model of confidence (Koriat, 2011, 2012). In support of this idea, previous studies indicate that the amount of information available for correct responses correlates with the post-error devaluation. For example, longer gaze times on target stimuli in visual search (Chetverikov et al., 2015) or more exposure (Chetverikov, 2014) result in more pronounced post-error devaluation. In the flanker task, compatible trials provide more cues for a correct response than incompatible ones and hence error-related devaluation also should be stronger in the former case than in the latter.

Affective responses to stimuli in a flanker task were studied before by Martiny-Huenger, Gollwitzer, and Oettingen (2014). They found that distractors used in incompatible trials were disliked compared to targets or novel stimuli. Targets, however, were rated similarly regardless of trial compatibility. A subsequent recognition test did not indicate that observers remember the stimuli from the flanker task despite the fact that distractors were devaluated. However, Martiny-Huenger et al. (2014) did not analyse the response accuracy. Thus, while their study provides data regarding the effect of compatibility on preferences, it does not help understand how observers associate error-related negative affect with particular stimuli. Answering this question will reveal the mechanisms of error-related devaluation and the involvement of attention in this process. In the present study, we fill this gap and describe the preferences towards targets and distractors as a function of trial compatibility and response accuracy.

2. Method

2.1. Participants

Sixty-one observer (44 women, 18–31 years old, age *Mdn* = 21) at Saint Petersburg State University voluntarily participated. They were not paid for participation. All reported normal or corrected-to-normal visual acuity. Three participants were excluded because of very long response times on evaluation trials (5.6, 8.8, and 10.3 s as compared to the average of 1.7 s).

2.2. Materials

The experiment was run using PsychoPy 1.81.02 (Peirce, 2007, 2009). Observers sat at approximately 50 cm distance from a 17 in. LCD display with 1280 × 1024 resolution (LG Flatron L1718S). Both target and distractors in the flanker task were grayscale female or male faces tinted with 50% transparent green or blue colours ([0, 1, 0] or [0, 0, 1] in − 1 to 1 RGB colour space). For each observer, twenty-four target-distractor pairs were chosen randomly from a set of 32 male and 32 female faces obtained from Facial Recognition Technology database[1] (Phillips, Moon, Rizvi, & Rauss, 2000; Phillips, Wechsler, Huang, & Rauss, 1998). The same stimuli without tint were used in the subsequent preference task. For the training session, a different set of 40 faces randomly selected for each observer from the same database were used.

2.3. Procedure

The experiment was split into two blocks.[2] In each block observers first completed flanker task and then evaluated the stimuli (Fig. 1). In the flanker task on each trial first the fixation cross was shown for 500 ms. Then a target (in the centre) and four identical distractors (on each side of target) were shown. Response time was limited to 600 ms. Response time was limited to ensure that there will be enough errors for analyses. If observers did not respond within the allocated time, a feedback “TOO LATE” appeared for 500 ms after the response (this response was not included in the following analyses). The stimuli were either 2 or 3° of visual angle (v.a.). On each trial, stimuli sizes were selected randomly to increase the probability of object-based or feature-based inhibition instead of location-based inhibition. Centre-to-centre distance between target and flankers was either 2.5 or 3.8° for smaller and larger stimuli, respectively. Distance depended on size – larger distance (3.8°) was used for larger stimuli. The observers had to determine the colour of a centrally presented face while ignoring the rest of the stimuli by pressing ‘A’ or ‘D’ key marked with green or blue colours, accordingly.

Twenty-four target-distractor pairs were repeated five times each resulting in a total of 120 trials. On compatible trials, target and distractors had the same tint (irrespective of their gender) while on incompatible trials the colours of target and distractors were different. Trial compatibility, target colour, and target gender were counterbalanced.

In the second part of the block on each of 24 trials observers were

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[1] Portions of the research in this paper use the FERET database of facial images collected under the FERET programme, sponsored by the DOD Counterdrug Technology Development Program Office.

[2] We have tested for the effect of Block along with its interactions in the analyses reported in this paper but neither Block nor its interactions were significant. The inclusion of Block in analysis also did not affect any conclusions regarding the other effects. Thus, the models reported here do not include Block.