Proactive Control of Affective Distraction: Experience-based but not Expectancy-based

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Abstract

Unpleasant stimuli disrupt ongoing information processing, even when they are entirely task-irrelevant. We examined whether such affective disturbances can be controlled explicitly and proactively. Specifically, we studied two different mechanisms to induce proactive control: the experience of frequent affective distraction and cueing of upcoming affective distraction. We predicted that both mechanisms would shield the attentional system from affective disturbance. Participants solved a letter classification task while being exposed to neutral or negative distractor pictures. We varied whether the proportion of negative distractors was low or high and whether cues for the upcoming type of distractor valence were informative or uninformative. In three experiments (N = 114), we found support for the notion that experience-based control shields information processing from affective disturbances, whereas distractor valence expectations were not helpful. These data suggest that there is no explicit top-down influence on attentional control settings of affective distraction, just adjustments to the context.

Keywords: attention, affect, proactive control, emotion regulation

1   Introduction

Imagine you are driving home on the motorway. Your most obvious goal is to get home as quickly and as safely as possible. Then you see a horrible accident on the opposite lane, including a burning car. The mere exposure to such an intense aversive event is likely to temporarily disrupt the pursuit of your goal of getting home quickly and safely. In fact, such distraction often leads to so-called "secondary crashes" (Karlaftis, Latoski, Richards, & Sinha, 1999). Even less affective stimuli like emotional words on billboards distract driving (Chan & Singhal, 2013). Why do affective stimuli disturb ongoing tasks and is there any way that these distractions can be controlled?

In the current study, we examined whether preparation for affective disturbances is possible. We look at two kinds of proactive control. First, experience-based proactive control, according to which experiencing several aversive events in the recent past changes attentional settings so that new aversive events are less distracting. Second, expectancy-based proactive control, meaning a change of attentional setting according to an explicit warning that something aversive is coming up. Could a warning attenuate affective distractions?

While there is a vast literature demonstrating that aversive stimuli capture attention in an automatic fashion (for an overview, see Carretié, 2014), only recently has the focus shifted to examining the role of attentional factors on the processing of emotional stimuli (Erthal et al., 2005; Foerster, Schmidts, Kleinsorge, & Kunde, 2019). Evidence for automatic processing is often based on directly threatening or evolutionary relevant material. For example, in a visual search task, participants are faster to detect fear-relevant stimuli (e.g., snakes) than neutral stimuli (e.g., mushrooms; Öhman, Flykt, & Esteves, 2001). Yet, although attentional consequences of affective stimuli arise quickly, without an explicit intention to process these stimuli, and maybe even without stimulus awareness, these consequences cannot be qualified as *automatic*, because they can be controlled to some extent (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002). For instance, although affective pictures slow down simple tasks like judging the orientation of two bars, this interference is reduced when the difficulty of the primary

task, and thus its attentional demands, increase (Okon-Singer Tzelgov, & Henik, 2007). Moreover, it is possible to use cognitive control to disengage from task-irrelevant aversive stimuli (e.g., Grimshaw, Kranz, Carmel, Moody, & Devue, 2018). Still, the question remains, which kinds of control processes are used to shield goal processing from affective intrusion.

Such control processes have mainly been investigated in the cognitive domain by looking at conflict tasks. For instance, in the Stroop task (Stroop, 1935), people have to classify the color of a color word, which can either be congruent (BLUE printed in blue) or incongruent (GREEN printed in blue). People respond slower to incongruent trials than to congruent trials (*congruency effect)*. Apart from the initial resolution of a conflict, there are several adaptations in attentional control that can happen in these conflict tasks. According to the Dual Mechanism Framework (Braver, Gray, & Burgess, 2007; Braver, 2012), the detection of conflict leads to reactive enhancement of cognitive control, which for one, contributes to the resolution of conflict in the current trial and also helps to resolve an upcoming conflict in the next trial. The latter impact reveals itself in the so-called *congruency sequence effect*, thus smaller conflict effects when the previous trial did contain a conflict than when it did not (Egner, 2017) Since this control is rather short-lived it is sometimes also called transient control (Botvinick, Braver, Barch, Carter, & Cohen, 2001). In contrast, cognitive control can also be regulated proactively. According to Braver (2012), proactive control means that goal-relevant information is held in an active state so that attentional settings are already optimally biased before a cognitively demanding event. Sustained proactive control is supposed to be invoked by a high proportion of incongruent events, which in fact reduces congruency effects compared to conditions with a lower proportion of incongruent events (Logan, & Zbrodoff, 1979). While proactive control is mostly described to be working in a sustained manner (Braver, 2012), it can also operate more transiently, such as when participants prepare to suppress the location of a distractor just before distraction.

A mechanism similar to the proactive control of conflict might attenuate affective disturbances. Kunde, Augst, & Kleinsorge (2012, Experiment 3), used a simple attentional task, in which

participants had to classify the color of a frame. The frame was arranged around images of either neutral valence, positive valence or negative valence. Participants were slower in categorizing the color of the frame of affective pictures rather than neutral pictures. Neither was the affective distraction reduced by reactive adaptions to immediately preceding disturbance nor by cueing such disturbances in advance (Augst, Kleinsorge & Kunde, 2014; Wirth, Pfister & Kunde, 2016). However, one form of control was reliably observed: With a high proportion of negative distractors, the affective distraction effect decreased (see also Grimshaw et al., 2018). As proactive control supposedly hinges on preparation for the upcoming distraction, it is curious that cueing of upcoming valence did not influence affective distraction in Augst, Kleinsorge, Kunde (2014). Explicitly expecting a certain distraction should trigger proactive control transiently to shield information processing from such a distraction (Braver, 2012). The presence of experienced-based adaptation but the absence of expectancy-based adaptation suggests that the implementation of proactive control is implicit and does not rely on explicit mechanisms.

Recent studies on cognitive conflict suggest that such expectancy-based proactive control is possible, but limited to specific conditions (Bugg, Diede, Cohen-Shikora, & Selmeczy, 2015). For instance, Goldfarb & Henik (2013) informed their participants in half of the trials of a Stroop task whether the upcoming trial would be incongruent or neutral. People showed no reduction of the Stroop effect due to cues when conflict probability was overall rather high (50%). Yet, cueing the congruency level reduced the Stroop effect when overall conflict probability was relatively low (20%). Presumably, when conflict probability is high, the attentional system is already tuned to higher sustained control. Only if the probability of conflict is low, cues are used additionally, to alter the conflict solving mechanism. Goldfarb & Henik (2013) interpret this interplay of experience- and expectancy-based control as a resource-saving mechanism. In a similar design, Bugg & Smallwood (2016) also used a Stroop task with cues about upcoming congruency. Cues only reduced conflict when they were 100% valid (but not when they were 75% valid) and presented for 2000 ms. A slightly different design was used by White, Abrams, Hsi & Watkins (2018): A picture-word interference task in which people had to pronounce the

name of a picture and distracting taboo words were displayed on top of those pictures. In their study, participants could only successfully prepare for taboo words, when the valid cues appeared in the whole block. There was no cueing effect when valid cues were intermixed with uncued trials. Altogether, it appears that expectancy about the congruency of upcoming distractors can be used to adapt control settings, as long as conflict is rare, cues are 100% valid, presented blockwise and at least 2000 ms in advance of the upcoming stimulation. Given these optimal conditions, cues inducing expectancy of distractor valence might also be beneficial to diminish affective distraction.

To conclude, two ways of establishing proactive control have been proposed, namely (i) by the experience of a high frequency of distraction and (ii) by explicitly cueing upcoming distraction in advance. In three experiments, we discern which of these ways of establishing proactive control has the potential to change affective distraction. We manipulate the proportion of affective distractors and the validity of predictive valence cues. Experience-based proactive control should shield information processing from affective distraction under a high proportion of irrelevant affective distractors. Additionally, expectancy-based proactive control should shield information processing from affective distraction after predictive valence cues.

Experiment 1

Participants solved a letter classification task that was accompanied by irrelevant neutral and negative pictures. We manipulated the proportion of these neutral and negative distractors. Moreover, cues announced the type of distraction in the upcoming trial. These cues were either informative (i.e. they perfectly predicted the upcoming picture valence) or uninformative (i.e. provided no information about the upcoming distractor valence). Based on studies concerning cognitive conflict and affective disturbances, we predicted that a high frequency of affective distractors would eliminate affective distraction. When affective distractors are scarce, predictive cues of the valence of an upcoming distractor should eliminate affective distraction.

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1.1 Methods

Participants

We could not predict the effect size of the hypothesized three-way interaction from previous studies, so we decided to strive for a power of .80 to detect a medium-sized effect ($d_z = 0.5$) in a within-subjects design with an alpha of 5%. We did a power analysis in R (version 3.5.1, package "pwr"), according to which 33 participants are needed to meet these criteria. Due to counterbalancing, we rounded up to 36 participants. This power analysis, all of the following exclusion criteria and analyses were preregistered on the Open Science Framework (osf; https://osf.io/v5bwa/). Thirty-five participants received five Euro for taking part, one person preferred to receive course credit. All participants gave written informed consent in line with the guidelines of the Deutsche Gesellschaft für Psychologie (DGPS) and the local ethics committee. Additionally, due to the aversive nature of the stimuli, the instructions on the screen and the experimenter emphasized, that they could always abort the experiment without giving any reason. One participant aborted the experiment after 5 minutes, was compensated and replaced. Another participant had to be excluded due to an excessive amount of errors (3.45 *SD*s from the mean error rate of all participants). This left 35 participants for analysis (M_{age} = 27 years, SD_{age} = 9 years*, range*$_{age}$ = 18 – 61 years), of which 27 identified themselves as female, the other eight as male.

Apparatus and stimuli

We used E-Prime 3.0 to display the stimuli on a 24-inch monitor and measured button presses on a standard keyboard. We uploaded the E-Prime files of the experiment to https://osf.io/q4ndr/. We used an affective disturbance paradigm where participants' task was to classify whether a letter precedes or succeeds M in the alphabet via button presses on a standard keyboard. We used the letters A to L and O to Z (font: Arial, size: 30). Participants had to press the "," or the "." key with their right index and middle finger. The mapping of keys to letters was counterbalanced across participants. The letters were displayed randomly

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directly above or below distractor images (see *Figure 1*). The distractor images came from the Nencki Affective Picture System (NAPS; Marchewka, Żurawski, Jednoróg, & Grabowska, 2014), which is freely accessible for non-profit academic research purposes at http://naps.nencki.gov.pl. We anticipated our participants to be majority female, so we chose the ratings for females (judged on a scale from 1 to 9). We used the horizontally arranged images (1600 x 1200 pixels) and compiled two lists of 20 images each. One list contained stimuli that were judged as neutral (close to the scale midpoint of 5) in valence and arousal ($M_{valence}$ = 5.36, $SD_{valence}$ = 0.03; $M_{arousal}$ = 4.78, $SD_{arousal}$ = 0.41) and a second list contained the most negative stimulus in the set ($M_{valence}$ = 1.72, $SD_{valence}$ = 0.19; $M_{arousal}$ = 7.53, $SD_{arousal}$ = 0.36). For the list of the exact items and their ratings, see https://osf.io/q4ndr/.

Those lists differed significantly in valence, $t(38)$ = 81.44, $p < .001$, d = 25.25, and arousal, $t(38)$ = 22.02, $p < .001$, d = 6.96. The vertical positions of the target letter and distractor image on the screen varied randomly each trial. The vertical midline of the image could appear 100 pixels above to 100 pixels below the vertical midline of the screen. The letter was always closely attached to the image. This spatial variation ensured that any effects are due to higher-order control of affective distraction and not due to either explicit strategies or a narrowing of attentional focus on one specific location (Huntsinger, 2013).

Cue
2000ms

Stimulus
≤ 2000ms

Figure 1. Exemplar trial sequence with a neutral distractor in Experiment 1. In the uninformative cue condition, the target stimulus was preceded by a "?" in a gray frame (upper left panel). In the informative cue condition, the stimulus was preceded by a „+" sign indicating an upcoming neutral picture (lower left panel). Participants had to react to the „F", by pressing the button assigned to all letters before M in the alphabet (right panel). After a response, either an error message appeared for 1500 ms or a blank screen for 500ms after which the next trial started. The depicted distractor image was not part of the actual experiments.

Procedure

Participants read instructions to react to the letters as fast and accurately as possible while ignoring the images. To make sure they learned the assignment of letters to keys, they first underwent 24 trials using every single letter with the same neutral distractor image that did not appear in experimental trials. Afterward, they were trained to associate the cues with picture valence. In the uninformative cue condition, they saw a question mark in white in a gray frame. A white plus sign in a blue or yellow frame signaled a neutral distractor. A white minus sign in a blue or yellow frame signaled a negative distractor. Mapping of color to cue valence was counterbalanced across participants. In the cue-valence association training, they were first informed about the contingencies of cues and picture valence. After that, they did 30 trials (10 of each cue) in which they saw a cue for 2000 ms, followed by a screen with a negative and a neutral picture. They had to indicate whether the left or right picture or both matched the cue by pressing the W (left), P (right) or SPACE key (both). For example, if the cue was a plus sign, and the neutral picture appeared on the left on the following screen, they had to press W. If the cue was a question mark, they had to press the SPACE key on the subsequent screen. After each button press, they got feedback either telling them they were correct or reminding them of the cue-valence mapping. To remind them of the cue-valence association they did this training at the beginning of each of the four blocks. All participants were able to reliably associate cues with valence (mean overall performance: 91% correct classifications).

The main experiment consisted of four blocks. For 17 of the participants, the first two blocks consisted of 80% neutral distractors and 20% negative distractors, whereas blocks three and four consisted of 20% neutral distractors and 80% negative distractors. The other 18 of the participants started with 20% neutral / 80% negative and ended with 80% neutral / 20% negative. In each of the experiment halves, participants randomly started with an informative-cue or uninformative-cue block of 100 trials each. Accordingly, valence frequency and cue type were manipulated blockwise, whereas distractor valence was manipulated trialwise. At the beginning of a trial, participants saw one character in a colored frame ("?", "+" or "-"). In the uninformative-cue block, each cue was a question mark. In the informative-cue block, cues were 100% predictive of the valence of the upcoming distractor (neutral cue: "+", negative cue: "-"). Experimental trials started with a cue for 2000 ms, which was immediately followed by the target letter and the distractor picture, which were displayed until participants pressed a button or 2000 ms went by. Error messages occurred for 1500 ms when participants pressed a button during the presentation of the cue, or when they pressed the wrong key in response to the target stimulus or when they failed to react within 2000 ms. The experiment took about 40 minutes.

1.2 Results

Data Treatment and Analysis

For the response times analysis, we only used correct trials (94.25%). To avoid the influence of post-error adjustments, we also excluded trials following errors (5.29%) from the analysis (Danielmeier, & Ullsperger, 2011). Response times that deviated more than 2.5 *SD*s from their individual cell mean were eliminated as outliers (2.94%). Data were submitted to a 2 x 2 x 2 repeated measures analysis of variance (ANOVA) with the factors distractor valence (negative vs. neutral), valence frequency (predominantly negative vs. predominantly neutral) and cue type (informative vs. uninformative). Following these confirmatory analyses, we did additional exploratory analyses, to evaluate potential alternative explanations. The data and the R Scripts for all reported statistical analysis are publicly available at https://osf.io/q4ndr/.

Response Times (RTs)

There was a main effect of distractor valence (see *Figure 2*), $F(1,34) = 24.57$, $p < .001$, $\eta_p^2 = .42$. Participants were slower when the distractor was a negative image ($M = 781$ ms, $SD = 131$ ms), than when it was a neutral image ($M = 752$ ms, $SD = 120$ ms). This main effect was qualified by a significant two-way interaction of distractor valence and valence frequency, $F(1,34) = 19.66$, $p < .001$, $\eta_p^2 = .37$. RTs were longer with negative distractors as compared to neutral distractors in the predominantly neutral condition, $t(34) = 5.59$, $p < .001$, $d_z = 1.34$, whereas there was no difference between negative and neutral distractors in the predominantly negative condition, $t(34) = 0.12$, $p = .907$, $d_z = 0.03$. The predicted three-way interaction was not significant, $F(1,34) = 1.40$, $p = .245$, $\eta_p^2 = .04$, and neither were any other main effects or interactions (all ps > .12).
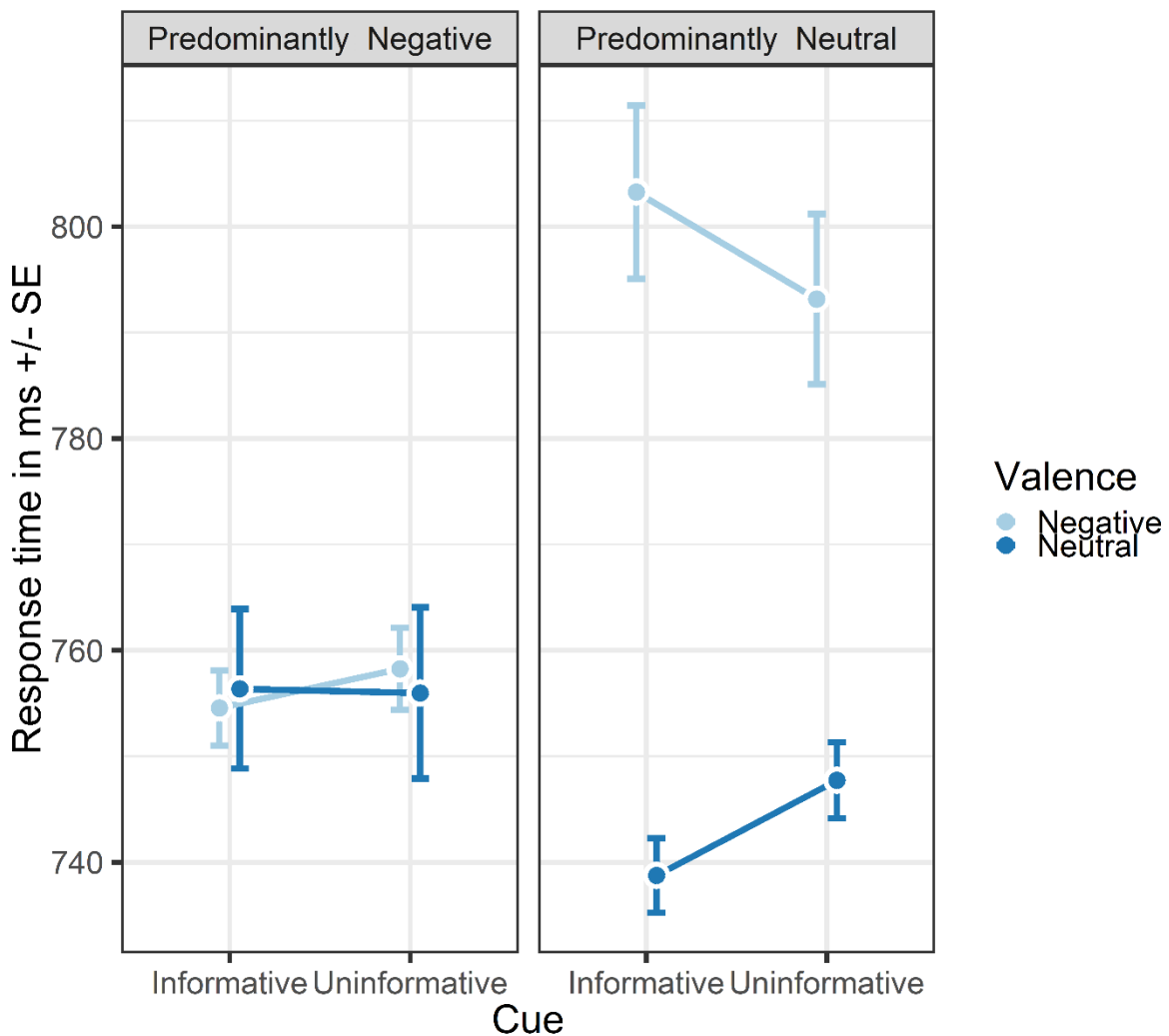
Figure 2*.* Mean response times in Experiment 1 separated by valence frequency (predominantly neutral vs. predominantly negative), cue type (informative vs. uninformative) and distractor valence (neutral vs. negative). Error bars depict the standard errors of the mean.

Errors

Participants committed more errors when the distractors were negative, than when they were neutral (see *Figure 3*), $F(1,34) = 5.26$, $p = .028$, $\eta_p^2 = .13$. Furthermore, there was a non-significant tendency for responses to be less error-prone in the blocks in which distractors were mostly negative, $F(1,34) = 3.37$, $p = .075$, $\eta_p^2 = .09$. Neither the main effect of cue type nor any of the interactions reached significance (all ps > .26).
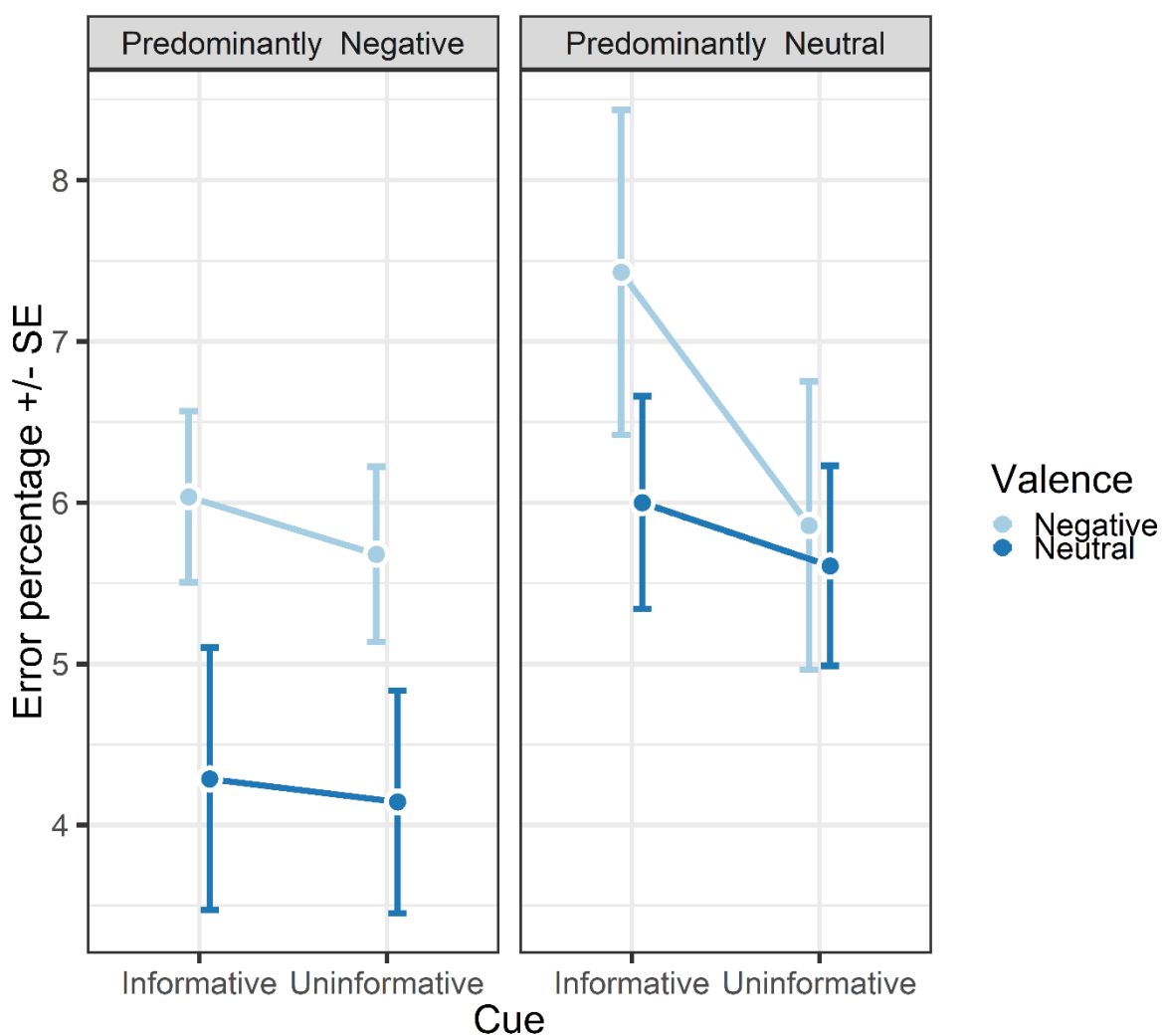

Figure 3. Error percentage in Experiment 1 separated by valence frequency (predominantly

neutral vs. predominantly negative), cue type (informative vs. uninformative) and distractor valence (neutral vs. negative). Error bars depict the standard errors of the mean.

1.3 Discussion and exploratory analysis

We found a significant affective distraction effect, so participants were slower to solve the primary task in the presence of negative distractor images, than in the presence of neutral distractor images. This was only the case when negative distractor images were relatively rare, whereas when they were frequent, there was no difference between negative and neutrals distractors in their impact on response times. However, cues did not modulate this influence of distractor valence on RTs, neither when aversive distractors were rare, nor when they were frequent. Thus, proactive control occurred due to frequent experience of negative distractors, but not due to cueing negative distractors in advance.

An alternative explanation, which does not involve proactive control, for the significant interaction between distractor valence and valence frequency is that participants might habituate to each negative stimulus and that the increased exposure to every single negative stimulus diminishes its distracting effect. Consequently, after several encounters, the capacity of an affective stimulus to elicit affect might wear off and it could have a similar impact as a neutral stimulus. This would be an incidental process without any control of attentional settings. Following this logic, the participants who started with the predominantly neutral block saw each negative picture only once in this block, so these negative pictures should still have had a large distracting effect in this block. Whereas in the following predominantly negative block, each individual affective stimulus would be less and less likely to cause any distracting affect because of habituation. Participants who started with the predominantly negative condition should not show such an interaction because habituation from the predominantly negative condition should still be effective in the predominantly neutral condition. In contrast, assuming control as the underlying mechanism predicts two-way interactions in both groups. We tested this by re-analyzing the data, dependent on whether participants started with the predominantly

neutral or negative condition[1]. Negative distractors indeed disturbed responding only when they were rare but not when they were frequent for both subgroups of participants.

This suggests, that habituation to the affective properties of each individual stimulus cannot fully account for the observed interaction between distractor valence and valence frequency.

A second possible explanation for the interaction between distractor valence and valence frequency would be that it is caused by sequential reactive control instead of proactive control. Sequential reactive control is engaged after the occurrence of an interfering event and is involved in solving said interference within a trial (Braver, et. al., 2007). Reactive control can also mean that attention is recruited after a high interference event and thus improves control over distraction for an immediately following high interference event (Braver, 2012). In our experiment, there are more trials with negative distractors that follow negative distractor trials in the predominantly negative condition than in the predominantly neutral condition. Given that reactive control could enhance performance in those negative distractor trials following negative distractor, a reactive control effect would produce the observed pattern of results unless steps are taken to control for that (e.g., Foerster, et. al., 2018). Our current experiment is not designed to disentangle reactive and proactive control, but if reactive control plays a role, there should be a smaller affective distractor effect after a negative distractor than after a neutral distractor. We did not find such a modulation, rendering sequential reactive control an unlikely explanation for the interaction between distractor valence and valence frequency in this experiment.[2] However, we cannot exclude an upregulation of within-trial reactive control. One possibility is that in the frequent negative condition, there was a sustained upregulation

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[1] We calculated a 2 (valence frequency order) x 2 (valence) x 2 (valence frequency) x 2 (cue type) ANOVA with order as between-subjects factor. The three-way interaction of valence frequency order, valence and valence frequency was not significant, but there was a tendency $F(1, 33) = 3.63$, $p = .065$, np2 = .10. Crucially, the interaction of valence x valence frequency was significant for participants who started with the predominantly neutral condition, $F(1, 16) = 17.51$, $p = .001$, np2 = .52 , and for participants who started with the predominantly negative condition, $F(1, 17) = 4.76$, $p = .043$, np2 = .22.

[2] To test this, we calculated a 2 x 2 x 2 x 2 repeated-measures ANOVA with the factors distractor valence (negative vs. neutral), previous trial distractor valence (negative vs. neutral), valence frequency (predominantly negative vs. predominantly neutral) and cue type (informative vs. uninformative). Unfortunately, after the exclusion of errors, some participants had missing cells, so these participants were excluded for this analysis. In the remaining sample, there was no evidence for an interaction of previous trial distractor valence with current distractor valence, $F(1,19) = 0.73$, $p = .402$, $\eta_p^2 = .04$, nor a main effect, $F < 1$, or any other interaction, $ps < .07$.

of reactive distractor suppression that resulted in the observed data pattern (Geng, 2014). This would not strictly be proactive control, but a sustained adjustment of control settings that benefit upcoming trials on the fly.

To sum up, we found evidence that frequently shielding the main task from irrelevant affective distractors eliminates affective distraction. This cannot be explained by a speed-accuracy-tradeoff, stimulus habituation or sequential reactive control. However, it suggests the use of experience-based proactive control. Contrary to our predictions, cues about the valence of the upcoming distractor did not enhance shielding from negative distractors, when those were relatively rare. Thus, we could not find any evidence for purely expectancy-based proactive control. If anything, the effect even went in the opposite direction descriptively, insofar as informative cues about the valence of an upcoming distractor might even harm shielding of aversive, task-irrelevant distraction, and only help performance in neutral trials. One possibility is that the cues have an ironic impact, focusing attention on affective distractors and thus increasing their distracting effects (Kleinsorge, 2007, 2009). Contrary, the cue for a neutral trial might signal safety from affective distraction and thus facilitate performance. To see whether this is true, we ran a slightly modified experiment designed to specifically test this question: Do informative distractor valence cues have a detrimental effect on the control of affective distraction?

2 Experiment 2

Apart from small changes, the general procedure of Experiment 2 closely resembles Experiment 1. Given that proactive control fully eliminated the affective distractor effect when negatives distractors were frequent in the former experiment, we dropped this condition. Moreover, we doubled the trials in the predominantly neutral condition to enhance the statistical power to detect a possible effect of cues on the shielding of negative distraction. We expected a significant interaction of distractor valence and cue type, driven by a larger affective distractor effect in the informative cue condition compared to the uninformative cue condition. We preregistered this hypothesis and the analysis plan at https://osf.io/dyb48.

2.1 Methods

To get a sense of the number of participants needed for enough statistical power, we selected the data of the people who started with the predominantly neutral condition in Experiment 1. We used the non-significantly larger affective distractor effect in the informative cue condition compared to the uninformative cue condition as an estimate for the effect size (d_z = 0.46). A sample size of 39 participants suffices to achieve a power of .80 to detect an effect of this size with an alpha level of 5%, according to the power analysis in R (version 3.5.1, package "pwr"). To fully balance the order of conditions we rounded up to 40 participants. A new sample of participants took part in Experiment 2 in exchange for 5 Euro or course credit, none of which had to be excluded according to the preregistered exclusion criteria. Of those participants, ten identified themselves as male, whereas the other 30 identified as female (M_{age} = 26 years, SD_{age} = 9 years, $range_{age}$ = 19 – 61 years). The stimuli and trial procedure were exactly as in Experiment 1. The E-Prime files of Experiment 2 can be found at https://osf.io/pzak5/.

2.2 Results

Data Treatment

For the response times analysis, we excluded errors (7.79%), trials following errors (5.93%) and outliers (2.50%). Data were submitted to a 2 x 2 repeated-measures ANOVA with the factors distractor valence (negative vs. neutral) and cue type (informative vs. uninformative). The data and the R Scripts for all reported statistical analysis are publicly available at https://osf.io/pzak5/.

Response times

We replicated the impact of distractor valence on RTs (see *Figure 4*), $F(1,39)$ = 61.41, $p <$ .001, η_p^2 = .61. Participants took longer to solve the task when the distractor was a negative image (M = 825 ms, SD = 141 ms), than when it was a neutral image (M = 772 ms, SD = 114 ms). There was no main effect of cue type, $F(1,39)$ = 0.21, p = .652, η_p^2 = .01. The predicted two-way interaction was not significant, $F(1,39)$ = 0.73, p = .397, η_p^2 = .02.

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Errors

The error rate was higher for negative distractors than for neutral distractors (see *Figure 4*), $F(1,39) = 6.44$, $p = .015$, $\eta_p^2 = .14$. Neither the main effect of cue type nor the interactions reached significance (ps > .330).
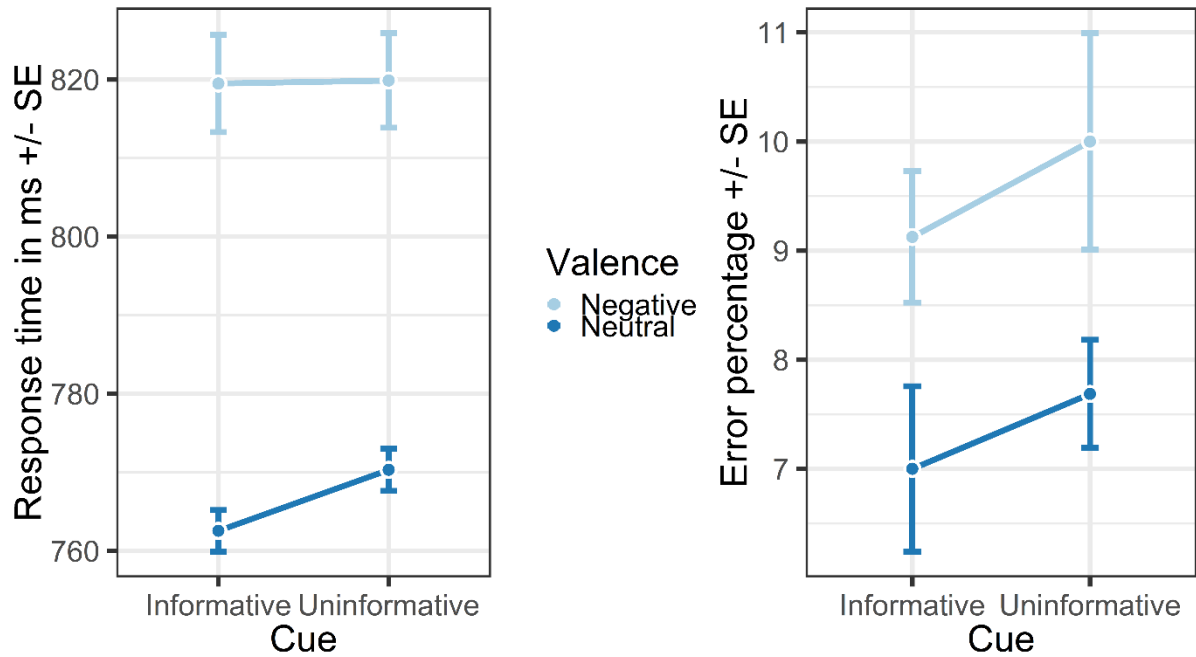

Figure 4. Left panel: Mean response times in Experiment 2 separated by cue type (informative vs. uninformative) and distractor valence (neutral vs. negative). Right panel: Error percentage in Experiment 2 separated by cue type (informative vs. uninformative) and distractor valence (neutral vs. negative). Error bars depict the standard errors of the mean in both panels.

2.3   Discussion

In Experiment 2, we replicated that participants respond slower in the presence of negative distractor images than in the presence of neutral distractor images. We did not find any impact of cues indicative of distractor valence on task performance in the presence of task-irrelevant negative distractors. The results of Experiment 3 corroborate this finding.

3   Experiment 3

We based our design on specific conditions that produced cueing benefits for cognitive control in previous studies, specifically a 20% proportion of conflicting stimuli (Goldfarb & Henik, 2013).

Nevertheless, for cueing benefits to occur, the optimal proportion of aversive stimuli may differ from the optimal proportion of conflict in comparable studies. To examine whether infrequent valence cues are helpful for cognitive control over affective distraction, we conducted an additional experiment in which we varied the levels of the proportion of infrequent negative stimuli.

3.1 Methods

To this end, we ran an experiment similar to Experiment 1, but for the following changes. Instead of a proportion of 20% negative distractors and 80% negative distractors, we now had a 15% percent negative distractor condition and a 30% negative distractor condition. Everything else stayed the same. As we wanted to keep the overall trial number the same as in the previous experiments, distractor stimuli differed in presentation frequency. However, we made sure that participants saw each individual distractor image equally often in the cued and in the uncued condition of each proportion level. We also opted to keep distractor images constant between participants, so we used the lists of our previous experiment and changed the number of times specific distractors were used. For the exact number of times they saw each individual distractor, see the experimental file at https://osf.io/bd5x7/. In the 30% negative distractor condition, we introduced an overall proportion of 30 negative to 70 neutral trials. In the 15% negative distractor condition, we had an overall proportion of 15 negative to 85 neutral trials.

Based on the power analysis reported in Experiment 2, we recruited 40 new participants for this experiment, who participated in exchange for 5 Euro or course credit. On the basis of the exclusion criteria of the previous experiments, we had to exclude one participant due to an excessive amount of errors (3.92 SDs from the mean error rate of all participants). The remaining sample consisted of 27 participants who identified as female and 12 who identified themselves as male (M_{age} = 27 years, SD_{age} = 10 years, $range_{age}$ = 19 – 67 years).

3.2 Results

Data treatment and analysis

For the response time analysis, we excluded errors (6.19%), trials following errors (5.66%), and outliers (3.22%). Data were submitted to a 2 x 2 x 2 repeated-measures analysis of variance (ANOVA) with the factors distractor valence (negative vs. neutral), valence frequency (15% negative vs. 30% negative) and cue type (informative vs. uninformative). The data and the R Scripts can be found at https://osf.io/bd5x7/.

RTs

Participants responded faster to target stimuli, when the distractor images were neutral (M = 762 ms, SD = 100 ms), than when they were negative (M = 825 ms, SD = 134 ms, see *Figure 5)*, $F(1,38)$ = 55.77, $p < .001$, η_p^2 = .59. None of the other main effects was significant (ps > .09). The two-way interaction between valence and valence frequency was significant, $F(1,38)$ = 8.27, $p = .007$, η_p^2 = .18. RTs were longer with negative distractors (M = 835 ms, SD = 255 ms) as compared to neutral distractors in the 15% condition (M = 756 ms, SD = 198 ms), $t(38)$ = 7.34, $p < .001$, d_z = 1.18, and this difference between negative (M = 815 ms, SD = 237 ms) and neutral distractors (M = 766 ms, SD = 208 ms) was smaller in the 30% condition, $t(38)$ = 5.28, $p < .001$, d_z = 0.84. Neither the other two-way interactions, nor the three-way interaction were significant (ps > .10).
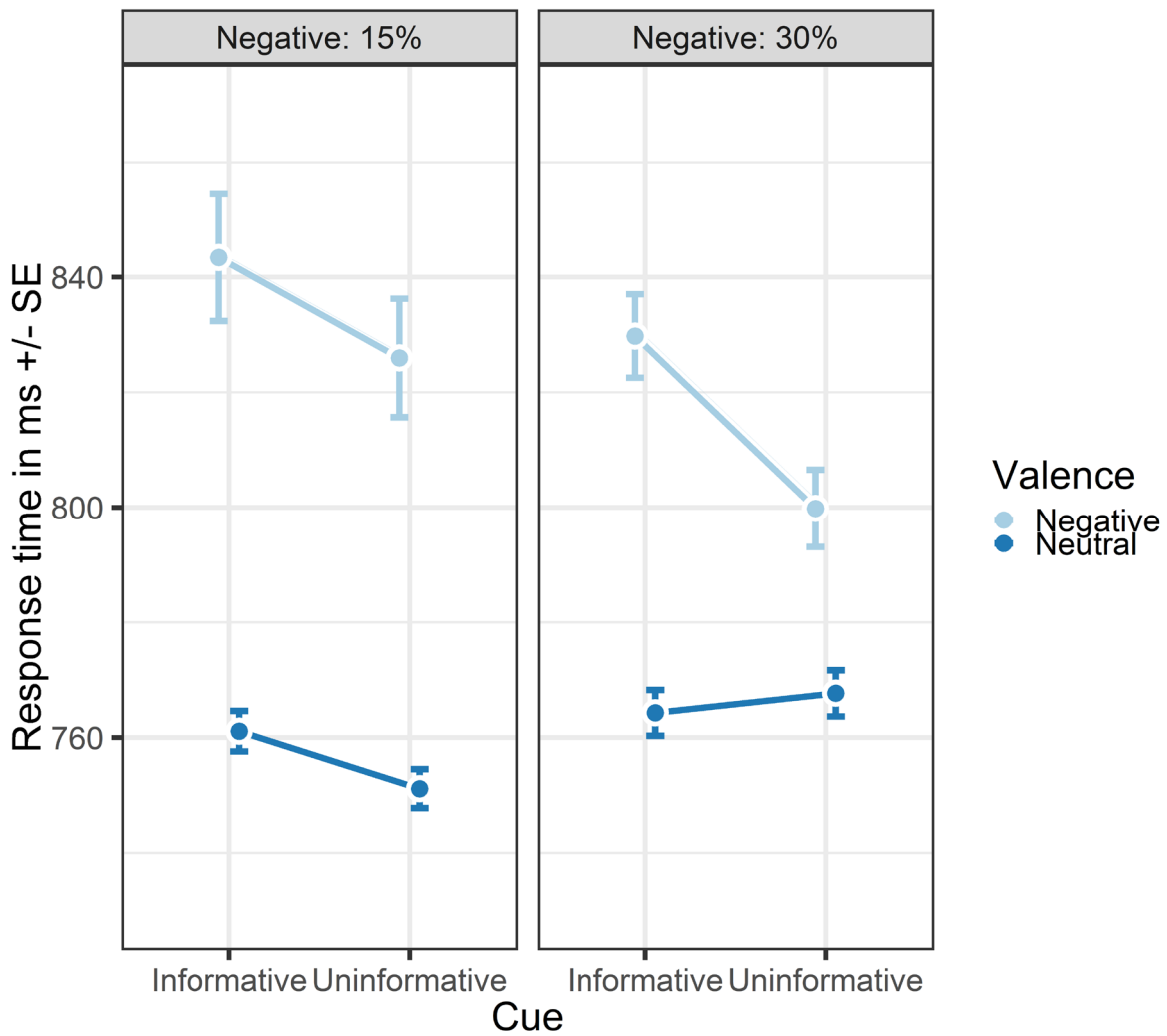
Figure 5. Mean response times in Experiment 3 separated by valence frequency (15% negative distractors vs. 30% negative distractors), cue type (informative vs. uninformative) and distractor valence (neutral vs. negative). Error bars depict the standard errors of the mean.

Errors

Participants were more accurate when the distractors were neutral, than when they were negative (*Figure* 6), $F(1,38) = 19.95$, $p < .001$, $\eta_p^2 = .34$. No other main effect, nor any of the interactions reached significance (all ps > .10).
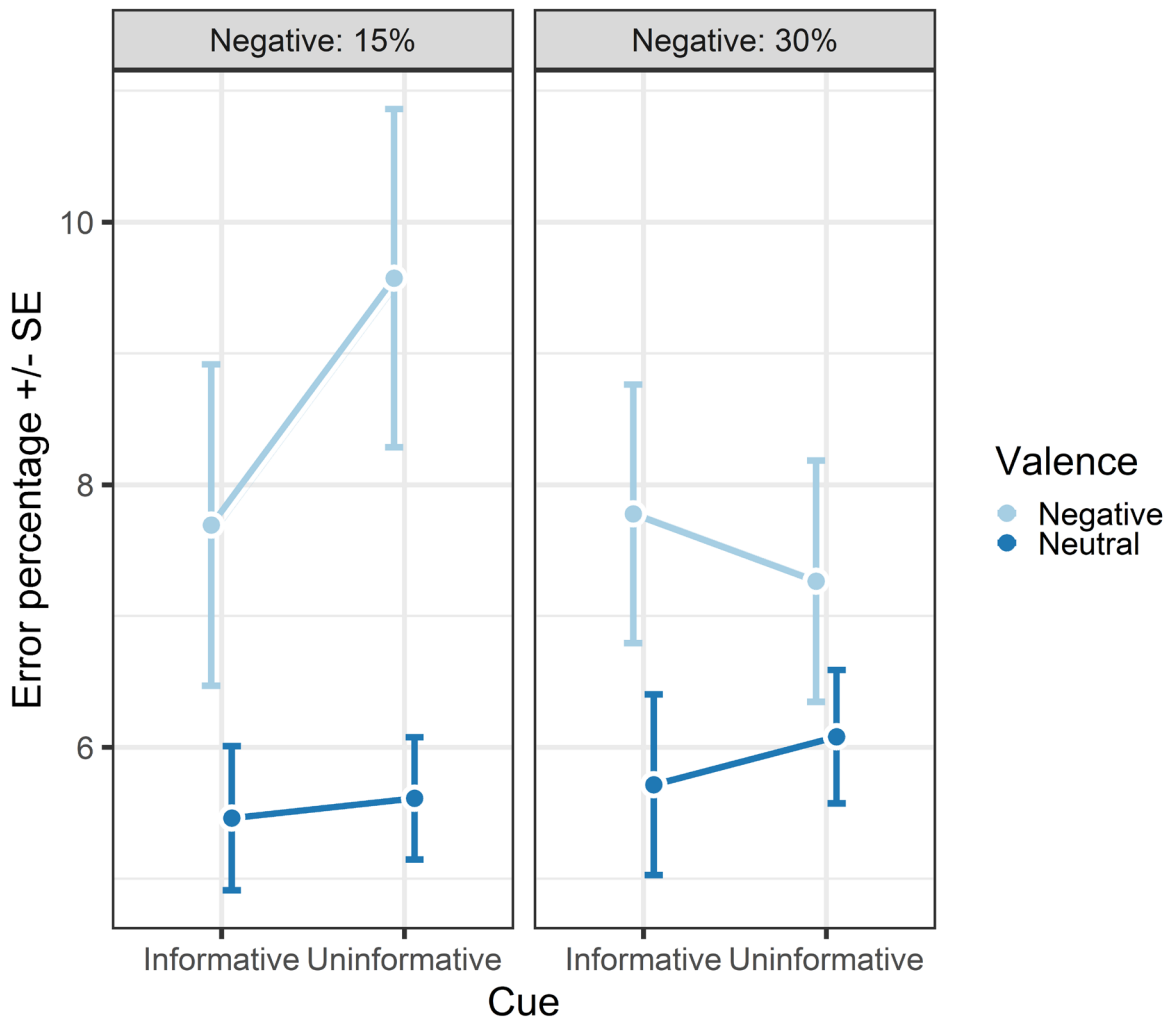
Figure 6. Error percentage in Experiment 3 separated by valence frequency (15% negative distractors vs. 30% negative distractors), cue type (informative vs. uninformative) and distractor valence (neutral vs. negative). Error bars depict the standard errors of the mean.

3.3   Discussion

We replicated the affective distraction effect, but as in the previous experiments, there was no evidence for a beneficial effect of cues on control of affective distraction. Similar to Experiment 1, we observed a descriptive, but non-significant trend of an opposite effect, suggesting that cues might harm the control of affective distraction. This would be in agreement with previous studies, which showed that performance of arithmetic verification decreased when the

occurrence of task-irrelevant emotional was announced beforehand (Kleinsorge, 2007). Such results are in line with the *Attentional White Bear Phenomenon*, which means that knowledge of the location of a distractor first leads to attention allocation to this location before it is suppressed (Tsal & Makovski, 2006). In the current study, the announcement of aversive distractors might enhance the representation of negative emotion in working memory and thus increase the allocation of attention to task-irrelevant negative distractors when they actually appear. However, for the current study, the most important take-away is that proactive control of task-irrelevant aversive distractor is not triggered by 100% valid valence cues.[3] Interestingly, even with this small variation of the frequency of negative distractors (15% vs. 30%), we found an interaction with valence, showing smaller affective distraction effects with a higher proportion of negative distractors. In line with the results of experiment 1, this points to the recruitment of experience-based proactive control, when negative stimuli are more frequent.

4   General Discussion

In three experiments, we found that task-irrelevant affectively negative images slow down responding in a primary task compared to neutral images, at least when they are relatively rare. In Experiment 1, we manipulated distractor proportion and cue validity and showed that only distractor proportion influences control of affective distractors. A higher proportion of aversive distractors is associated with smaller aversive distraction. If anything, there was a harmful effect of cues for affective distractors. Given that the data pattern was inconclusive concerning this unexpected, paradoxical cue effect, we replicated this condition in Experiment 2 with higher statistical power (more trials and more participants). There was no influence of predictive cues on attentional control. To consolidate this finding, we conducted an additional experiment, in which we varied the proportion of infrequent negative distractors (15% vs. 30%).

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[3] We calculated the following analysis across the participants of all three experiments in which we included only blocks in which there was a significant affective distraction effect ($RT_{negative} - RT_{neutral}$). This means we excluded the predominantly negative condition of Experiment 1 and collapsed the valence frequency conditions in Experiment 3. In a 2 (valence) x 2 (cue type) ANOVA there was a significant interaction, $F(1, 113) = 5.90$, $p = .017$, $\eta_p^2 = .05$. Contrary to our hypothesis there was a larger affective distraction effect in cued blocks ($M = 53$ ms), than in in uncued blocks ($M = 38$ ms). This suggests that while there is no beneficial effect of cues on control of affective distraction, cues might rather increase affective distraction (Kleinsorge, 2009).

We replicated the result of the first study, that a higher proportion of aversive distractors is associated with smaller affective distraction effects. Furthermore, predictive valence cues did not help the control of affective distraction in either proportion condition. The data pattern thus suggests that attentional control of negative distraction can be influenced by experience-based proactive control triggered by encountering a high proportion of negative distractors. However, expectancy-based proactive control, triggered by an explicit expectation of the negative valence of an upcoming distractor, is not helpful in shielding from its harmful impact on the primary task.

Effects of control adaptation due to explicit expectations would deliver the strongest argument that proactive control of affective distraction is voluntary. However, the results of the current study are more in line with the assumption that experiences of distraction adapt attention implicitly (see also Augst et al., 2014; Wang and Theeuwes, 2018a, 2018b). Proactive control is often referred to as voluntary control, in which an agent adapts willingly in anticipation of future challenges (Theeuwes, 2019), but the concept can be construed more broadly. Proactive top-down control can operate involuntarily including all processes in which (implicit or explicit) expectations guide control of sensory information (Gaspelin & Luck, 2018). Others also argue that some control adaptations are triggered by the stimulus and happen more or less automatically when an organism encounters an environment shaped in a certain way (Chiu & Egner, 2017). This complicates the juxtaposition between automatic and controlled processes. When proactive control operates automatically, why should these bottom-up adjustments be called control? In a review of the proportion congruency effect in conflict tasks, Bugg & Crump (2012) called such automatic control adaptions stimulus-driven control. Interestingly, they argue that list-wide manipulations of proportion, which are comparable to the one we employed here, are based on anticipatory information and index voluntary control. However, our results suggest that specific anticipatory information about the nature of an upcoming rare distraction is not used at all in controlling such a distraction. So if list-wide anticipation of a high proportion of distraction leads to the employment of voluntary control, why should trial-wise anticipation not trigger voluntary control?

The easiest explanation is to assume that neither reflects voluntary control and that adaption due to the proportion of aversive distractors are not based on explicitly formed expectations, but merely on the implicit experience of those distractors. Thus, these adaptions do probably not reflect voluntary, proactive control, but sustained, learned adaptations of either proactive or reactive top-down control processes. This fits well with a conceptualization of adjustment in top-down control being a consequence of the detection of 'control prediction error' (Chiu & Egner, 2019). The assumption is that adjustments in control are based on a learning process. Whenever incompatible response activation is detected, there is a discrepancy between the current amount of cognitive control and the required amount of cognitive control. The experience of conflict changes the prediction of the amount of control needed in the next task, which in turn leads to an adjustment of attentional control. The same is true for the repeated experience of conflict, which slowly drives a change in predicted conflict and thus attentional settings. It is possible that explicit information is not used to update a prediction about the potential level of upcoming distraction and that such predictions are fully relying on the experience of interference. Our results suggest that at least for affective interference when cues are given, there is no short-term adjustment of control, even though control can, in general, be adjusted, namely by the frequent experience of affective interference. On the other hand, our results support the dual mechanisms framework insofar as we found no sequential modulation (generally seen as evidence for reactive control), but we did find an influence of distractor valence proportion. Hence, this is compatible with two largely independent mechanisms. Nevertheless, our results do not support the idea that the distractor valence proportion manipulation reflects any voluntary control.

We found evidence for an influence of the proportion of aversive distractors, but no sequential reactive control in the sense that the distractor valence of the previous trial has any influence on the interference in the current trial. An interpretation of these data might be, that adaptions to control of affective distractors do not happen on such a short time scale (Augst, Kleinsorge & Kunde, 2014). Control of affective distraction might differ in this regard from the control of conflicting information, where reactive control adaptions are well documented and there is

some evidence for a congruency cueing benefit (Egner, 2017; Bugg & Smallwood, 2016). It should be noted though, that even information conflict is not easily overcome by cueing such conflict in advance (Wühr & Kunde, 2008).

There are some limitations to the interpretation of the results of the current study. First of all, the letter task itself and especially holding the cues in mind affords a higher working memory load than some previous emotional distraction experiment (e.g., Grimshaw et al., 2018). With relatively higher working memory load, participants may be unable to use predictive cues. In addition, motivation may play a role in whether people actually use cues to exert proactive control. Given that proactive control requires cognitive effort, people might compare the cognitive costs of proactive control to its benefits, and only decide to use it, if this analysis results in an overall positive result (Botvinick & Braver, 2015; Shenhav et al., 2017). There is evidence that the use of incentives improves the use of predictive cues to control conflict (Bugg, Diede, Cohen-Shikora, & Selmeczy, 2015), and improves control of affective distraction (Padmala & Pessoa, 2014). In our study, people could shorten their exposure to aversive images by responding very quickly, which should be a motivation for cue use, but we did not provide additional incentives. It might very well be that increasing motivation by performance incentives causes people to use predictive valence cues to control affective distraction.

The use of valence cues brings to mind a currently debated topic, namely so-called trigger warnings. Trigger warnings inform people that media content they are about to perceive contains "potentially distressing material" (Bridgland, Green, Oulton and Takarangi, 2019). These warnings make it possible to avoid such content or to prepare for it. If expectations of aversive stimuli would trigger proactive control and if proactive control were helpful in shielding from aversive consequences, this would speak for the use of trigger warnings. The results of the current study suggest that such preparation and shielding does not occur, but that these warnings do not have a strong immediate paradoxical effect either, as some opponents seem to suggest (Lukianoff & Haidt, 2015). In our study, participants could not avoid the aversive stimuli, so we cannot make any statement concerning the long-term effects of warnings about distressing material. If given the choice to avoid stimuli, like the ones in the current study, which

serve no function, but cause an intense negative affect, the rational choice would be to avoid them. If your goal is to reduce the overall negative affect by distressing material, then repeated exposure is counterproductive. However, if your goal were to reduce the impact of each individual aversive stimulus, then the best way is repeated exposure to increase proactive control. This is very well established in contemporary models of exposure therapies for phobias. Repeated exposure to specific stimuli without experiencing harmful effects creates an association representing safety and thus decreases fear response (Craske, Liao, Brown & Vervliet, 2012). Nevertheless, our proactive control model suggests that repeated exposure does not only permanently change specific stimulus associations, but also temporarily adjusts a general attentional mechanism that avoids unwanted influences of aversive stimuli. Concerning the short-term effects of warnings, our results are in agreement with recent studies examining the impact of trigger warnings on explicit variables in healthy participants. Trigger warnings have no effect on anxiety responses to distressing material (Bellet, Jones and McNally, 2018), do not change negative interpretations of ambiguous images (Bridgland, Green, Oulton and Takarangi, 2019) and have only small influences on negativity ratings of affective stimuli (Sanson, Strange, and Garry, 2019). Taken together, our study is in line with the current state of the research, which shows no evidence for consistent harmful or beneficial effects of trigger warnings on preparation for distressing material.

To conclude: An explicit warning of upcoming aversive stimuli does not help shielding from their distracting influence. Frequent experience of successfully ignoring aversive stimuli, on the other hand, does decrease their impact. According to Braver (2012), "proactive control relies on the anticipation and prevention of interference before it occurs" (p. 106). In the current study, explicit anticipation of interference could not be utilized to prevent its occurrence. Only when detecting and resolving a large number of interfering events did participants show a smaller interference effect. This suggests an experience-based learning mechanism in reaction to affective distractors.

5 Acknowledgments

6 Supplemental material

The experiment files, the data, and the analysis scripts are available on the Open Science Framework (https://osf.io/q4ndr/)

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