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BRIEF REPORT

Affective Modulation of Memory-Based Guidance in Visual Search: Dissociative Role of Positive and Negative Emotions

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Emotions can either facilitate or hamper the allocation of attention and the extraction of statistical regularities from perceptual input. In the present study, we investigated whether context memory of spatial target–distractor relations in visual search is influenced by task-irrelevant affective stimuli. In Phase 1 of the study, positive, negative, or neutral images (randomly selected) were presented in the background of a given repeated (fixed target–distractor arrangement) or nonrepeated (random arrangement) search array. We found that the "contextual cueing" effect (RTs to nonrepeated minus repeated arrays) was enhanced for repeated displays associated with negative- (vs. neutral-) picture backgrounds, while it was substantially reduced for repeated displays paired with positive (vs. neutral) backgrounds. This emotional modulation of the contextual cueing effect remained intact even when the irrelevant affective background images were removed from the search displays in Phase 2 of the study. Together, these findings suggest that emotions have valence-specific effects on attention that influence the encoding of spatial target–distractor relations and thus the build-up of spatial context memory from the visual search environment.

Keywords: statistical learning, contextual cueing, selective attention, negative emotion, positive emotion

Supplemental materials: http://dx.doi.org/10.1037/emo0000602.supp

The visual system uses statistical regularities in the environment to optimize goal-directed behavior (Kersten, Mamassian, & Yuille, 2004). For instance, visual search becomes more efficient over time for targets presented repeatedly at the same location within invariant (vs. random) spatial target–distractor arrangements. Chun and Jiang (1998) termed this effect *contextual cueing* (CC), that is, acquired context memory of repeated stimulus arrangements can guide, or cue, attention to the target location, thus expediting search.

While CC is often thought to reflect some unintentional learning of statistical regularities, subsequent studies revealed the effect to be modulated by dispositional factors, including moods and emotions. For instance, Kunar, Watson, Cole, and Cox (2014) showed that a relatively brief negative (relative to neutral) mood induction phase impacted the acquisition of repeated target–distractor associations, evidenced by a diminished CC effect in a subsequent search task. By contrast, Yamaguchi and Harwood (2017) reported that presenting task-irrelevant, emotionally charged images inside the (Landolt-type) objects in the search array did not impact the acquisition of spatial context cues—if anything, threatening images led to a larger CC effect than neutral stimuli. Thus, while there is evidence that statistical context learning is modulated by emotions, it remains unclear in which way task-irrelevant emotional stimuli influence contextual learning and memory.

In fact, induced emotions may give rise to rather specific and potentially opposing outcomes depending on the time at which the stimuli are presented. For instance, emotional stimuli may act as

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salient distractors when presented before a given trial (Hart, Green, Casp, & Belger, 2010), but they may also facilitate performance when presented within a trial, for example, by enhancing alertness (Zinchenko, Kanske, Obermeier, Schröger, & Kotz, 2015). Similar principles may apply to CC: Spatial context learning may be reduced when emotional images are presented prior to the search trials (Kunar et al., 2014), but it may also be enhanced when the images are presented within a given search trial. The aim of the present study was to examine for the latter possibility, by presenting emotional stimuli concurrently with the search displays.

In addition, differential effects on CC have been reported between the initial learning of repeated display layouts and the retrieval of acquired context cues later on (e.g., Conci & von Mühlenen, 2011; Jiang & Leung, 2005). Accordingly, affective stimuli might influence either the initial acquisition or the later retrieval of learnt context cues. Critically, if emotions affect context retrieval, any impact of emotions on CC should be abolished when the affective stimuli are removed (after initial learning); by contrast, if emotions modulate contextual learning itself, their impact should persist even after removal of the affective stimuli. To distinguish between these alternatives, the present experiment was divided into two phases: an initial learning phase, in which the search displays were presented with emotional stimuli; and a test phase, in which the search displays were presented without emotional stimuli. Finally, going beyond previous studies, the present experiments also examined for effects of positive emotions on CC (in addition to those of negative emotions).

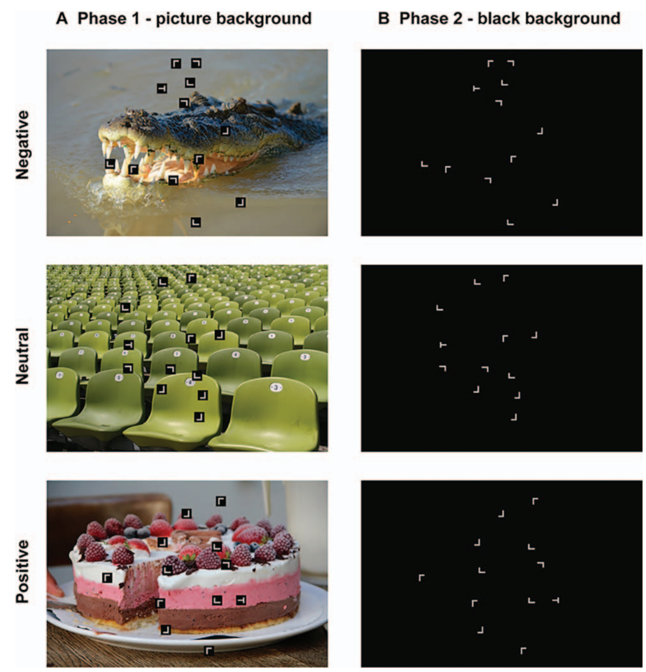

Figure 1. Illustration of the search displays presented on (A) negative, neutral, and positive emotion backgrounds (top to bottom panels, respectively) in Phase 1 and (B) a black background in Phase 2. Repeated display arrangements were kept constant across Phases 1 and 2 (as in the example displays depicted). Note that (copyright-free) images are shown in this figure for illustration purposes (the actual experiment presented original International Affective Picture System pictures). See the online article for the color version of this figure.

Method

Participants

Twenty-five healthy observers (M_{age}= 24.04 years, 13 males, six left-handed) with normal or corrected-to-normal vision participated in the experiment. They gave written informed consent; the experimental protocol was approved by the local ethics committee. On the basis of previous effect-size measures (e.g., Kunar et al., 2014, reported a η_p^2 of .071 for an interaction of context by emotion), we determined a priori that our sample size would be appropriate to detect an $f(U)$ effect size of 0.28 with 85% power (η_p^2 = 0.071, groups = 2, measurements = 4), given an alpha level of .05 and a nonsphericity correction of 1. The raw data are available at the Open Science Framework: osf.io/d58js.

Apparatus, Stimuli, and Trial Sequence

The experimental routine was programmed in MATLAB with Psychtoolbox extensions (Brainard, 1997; Pelli, 1997). Search displays consisted of 12 gray items (luminance: 1.0 cd/m^2; one *T*-shaped target, oriented left or right; and 11 *L*-shaped distractors, oriented orthogonally at random) presented against either a black background (0.11 cd/m^2) or a picture background (see details that follow and Figure 1). With picture backgrounds, the target and distractor stimuli were presented on a small black square (0.4° × 0.4°; cf. Jiang, King, Shim, & Vickery, 2006), ensuring a constant local stimulus/background contrast. To probe contextual memory of statistical regularities, a set of 12 repeated-context displays was generated for each observer and repeated throughout the experiment, with an invariant arrangement of the target and distractor items on every presentation. These repeated layouts were compared to 12 nonrepeated contexts, in which distractor layout was generated randomly on each trial. For repeated and nonrepeated displays, 2 × 12 different target locations were preselected to avoid location probability effects (see Zinchenko, Conci, Müller, & Geyer, 2018).

A trial started with the presentation of a central fixation cross (size: 0.10°; luminance: 1.0 cd/m^2) for 500 ms, followed by a blank interval of 200 ms before the search display was presented. Observers were instructed to respond as quickly and accurately as possible to the left versus right orientation of the target T. The intertrial interval was 1,000 ms.

The experiment was split into a negative- and a positive-emotion session, conducted on 2 separate days (with a minimum break of 3 days) and administered in counterbalanced order ("order" did not interact with any other experimental factors, $ps > 0.1$, and was therefore ignored in subsequent analyses). To assess whether the emotional pictures affected anxiety levels, the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was administered before and after each session (see the online supplemental material). Each session was subdivided into two phases, each of 16 blocks × 24 (= 384) trials per phase.

In Phase 1, contextual learning, 192 different images from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008)—depicting people, animals, food, vehicles, and tools (see the online supplemental materials for the list of images)—

were presented twice as background to the search arrays. There were equal numbers of emotional and neutral images, negative-emotion session: 96 negative (valence = 2.64, arousal = 5.82) and 96 neutral (valence = 5.41, arousal = 3.68) images; positive-emotion session: 96 positive (valence = 7.43, arousal = 4.77) and 96 different neutral (valence = 5.38, arousal = 3.67) images (see Figure 1). To control for potential differences in low-level saliency between emotional and neutral pictures in repeated versus nonrepeated search layouts, each of the 192 images was shown twice: in random order once in the background of a repeated and once that of a nonrepeated display. Importantly, half of the repeated ($N = 6$) and nonrepeated ($N = 6$) search arrays were consistently paired with random emotional images, while the other half were consistently paired with random neutral-image backgrounds.

In Phase 2, designed to examine retrieval of context memory, participants completed another 16 blocks of the CC task, but this time the search items were presented on a black, rather than a picture, background. The same repeated displays shown in Phase 1 were again presented in Phase 2, while nonrepeated displays were generated anew on each trial. Finally, to assess whether the repeated layouts were explicitly recognized, a recognition test was performed at the end of experiment (see the online supplemental materials).

Results

Negative Session

After the removal of errors and outliers (reaction times [RTs] ± 2.5 *SD* from mean; overall 2% of all trials), a 2 × 3 × 2 repeated-measures analysis of variance was performed on the RTs (averaged across all 16 blocks)[1] with the factors phase (1, 2), emotion (negative, neutral), and context (repeated, nonrepeated).

There was a significant emotion by context interaction, $F(1, 24) = 8.09$, $p < .01$, $\eta_p^2 = .25$, 95% confidence interval [CI] [.02, .48], due to the CC effect (i.e., the difference in RTs to nonrepeated minus RTs to repeated displays) being substantially larger with negative-emotion backgrounds (115 ms), $F(1, 24) = 23.84$, $p < .0001$, $\eta_p^2 = .5$, 95% CI [.18, .66], than with neutral-emotion backgrounds (29 ms), $F(1, 24) = 4.31$, $p < .05$, $\eta_p^2 = .15$, 95% CI [0, .39]. Importantly, the Phase × Emotion × Context interaction was nonsignificant, $F(1, 24) = 0.32$, $p > .5$, $\eta_p^2 = .01$, 95% CI [0, .19], that is, the CC effects in Phases 1 and 2 (with vs. without picture background) were equivalent in both the negative-emotion condition (118 ms vs. 112 ms), $t(47.9) = 0.17$, $p > .8$, $d = 0.049$, 95% CI [−0.5, .6], and the neutral condition (23 ms vs. 35 ms), $t(47.9) = -0.52$, $p > .6$, $d = -0.15$, 95% CI [−0.7, .4]. In other words, the negative-emotion effect on the processing of repeated displays was manifest even after the removal of the emotional background in Phase 2 (see Figure 2, top row).

Positive Session

An analogous analysis of variance on RTs in the positive session again revealed a significant Emotion × Context interaction, $F(1, 24) = 6.62$, $p = .017$, $\eta_p^2 = .22$, 95% CI [0.01, .45]: CC was reliable with neutral-picture backgrounds (69 ms), $F(1, 24) = 17.68$, $p < .001$, $\eta_p^2 = .42$, 95% CI [0.12, .61], but not with positive-picture backgrounds (−12.5 ms), $F(1, 24) = 0.46$, $p > .5$, $\eta_p^2 = .02$, 95% CI [0, .21]. The three-way interaction was nonsignificant, $F(1, 24) = 3.74$, $p > .05$, $\eta_p^2 = .13$, 95% CI [0, .37]. For neutral-emotion trials, the CC effect was comparable between Phases 1 and 2 (i.e., with vs. without neutral-emotion picture background: 59 vs. 79 ms), $t(47.3) = -0.75$, $p > .45$, $d = -0.22$, 95% CI [−0.76, .34]. For positive-emotion trials, there was a persistent lack of CC in both phases (i.e., with vs. without positive-emotion picture background: 2 ms vs. −27 ms), $t(47.3) = 1.04$, $p > .3$, $d = 0.30$, 95% CI [−0.26, .8] (see Figure 2, bottom row).

Contextual Cueing With Negative and Positive Emotion Backgrounds

Additional analyses were performed to directly compare context memory across negative and positive emotions (see also the online supplemental materials). For these, the data were collapsed across the two phases (given the lack of interactions involving "phase"; see results above). First, CC effects were revealed to be reliably larger with negative than with positive emotions (115 ms vs. −12.5 ms), $t(24) = 4.49$, $p < .001$, $d = 1.83$ (see Figure 2C). Second, for the neutral-emotion "baseline" trials (presented along with negative- and positive-emotion trials, respectively, in the two sessions), CC was comparable between the two sessions: although being numerically larger in the positive than in the negative session (69 ms vs. 29 ms), this difference was nonsignificant, $t(24) = -1.880$, $p > .05$, $d = -0.76$.

Arousal Levels and Contextual Cueing

To examine for arousal confounds, we calculated the mean CC effects for each emotional image (presented once with a repeated and once with a nonrepeated display) and then correlated the resulting scores (from the negative- and positive-emotion sessions, including both the emotional and neutral images) with their corresponding normative arousal ratings.[2] The correlations were nonsignificant for both negative- and positive-emotion sessions (negative: $r = .13$, $p > .05$; positive: $r = .01$, $p > .8$).

Discussion

The present study examined how emotions influence CC of visual search. Our results demonstrate a reliable CC effect, of 49 ms, with baseline (neutral) emotional backgrounds, which is comparable to findings from previous CC studies that used emotionally neutral, everyday scenes as background images (Rosenbaum & Jiang, 2013). However, relative to baseline pictures, negative backgrounds substantially enhanced contextual learning (115 ms), whereas positive backgrounds yielded no CC effect at all (−12 ms). Importantly, this interactive pattern cannot be attributed to specific image characteristics, as each picture (neutral, negative, positive) was presented two times per phase (and observer), once with repeated and once with nonrepeated contexts. This pattern of results demonstrates that emotional valence specifically modulates CC, even though some small part of the increased CC scores with

[1] A corresponding block-wise analysis is provided in the online supplemental materials.

[2] Owing to a programming error, the arousal ratings from three observers were not available and had to be excluded from this analysis.

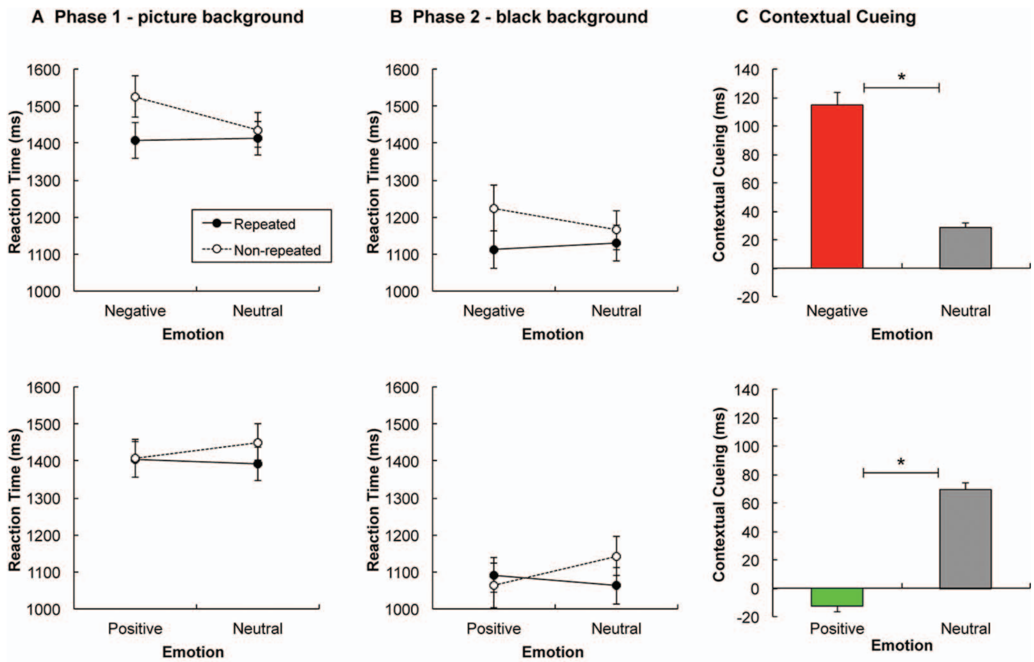

Figure 2. Mean reaction times and standard errors (in ms) for (A) repeated and nonrepeated displays in the negative (top row) and positive (bottom row) session for emotional versus neutral images in Phase 1, and (B) after the removal of the picture backgrounds in Phase 2. (C) Corresponding mean contextual-cueing effects (reaction time [nonrepeated] – reaction time repeated]) in the negative and positive sessions (top and bottom panels, respectively; data collapsed across phases). See the online article for the color version of this figure.

negative emotions might still be attributable to increased arousal (i.e., arousal covarying with valence).

Because the modulation of CC was comparable in the two experimental phases, we propose that it is specifically the encoding (learning) of a given spatial target–distractor arrangement (Conci, Müller, & von Mühlenen, 2013; Conci & von Mühlenen, 2011; Geyer, Shi, & Müller, 2010) that was enhanced [weakened] by the negative [positive] emotional valence of the background images. The most straightforward account of this is that negative information, which is highly relevant for survival, up-regulates the encoding of search arrays associated with negative emotions, enhancing contextual learning. By contrast, arrays processed under the influence of positive emotions would be regarded as less critical and thus assigned a lesser "executive weight," yielding reduced learning. In line with these assumptions, a recent study also showed that induced negative, but not positive, emotions improve memories of realistic visual scenes (Baumann, 2018). In the current study, this "learning" account would parsimoniously explain why we continue to see a modulation of the CC effect even the emotional stimuli are removed in Phase 2 of the experiment.

An interesting, though not completely unexpected finding for the negative emotional pictures was that the effect pattern was actually opposite to that of Kunar et al. (2014), who reported reduced, rather than increased, CC for negative (vs. neutral) emotions. While Kunar et al. induced negative mood in participants by presenting emotional images repeatedly before the actual search experiment, in the current study, the emotional images were presented within a given trial, as background of the search array. While this difference may, at first sight, not appear important, previous studies have revealed a comparable within/between-trial modulation of cognitive control by emotions (Hart et al., 2010; Most, Chun, Widders, & Zald, 2005; Padmala, Bauer, & Pessoa, 2011).

Conclusion

Emotions signal behavioral relevance and facilitate learning. In the current study, we show that negative (but not positive) emotions enhance the learning of spatial target–distractor associations, rather than modulating their retrievability from context memory. Accordingly, the current findings make a novel contribution to our understanding of the role affective information plays for the incidental spatial learning of, in themselves, meaningless visual search arrays.

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Supplementary Information

Zinchenko, A., Geyer, T., Müller, H.J., & Conci, M. Affective modulation of memory-based guidance in visual search: dissociative role of positive and negative emotions, *Emotion*.

Additional analyses

To complement the results presented in the main manuscript, this supplement reports a number of additional analyses on various measures, thus providing an additional, more detailed overview of the observed pattern of results.

Arousal and valence of the IAPS picture selection

As described in the main manuscript, the negative-emotion session of the experiment presented two sets of 96 negative and neutral images each, while the positive-emotion session presented a different set of 96 neutral images along with a set of 96 positive images. All images and the corresponding ratings of their valence and arousal levels were obtained from the IAPS picture database (Lang, Bradley, & Cuthbert, 2008). Comparisons of these image sets showed that the valence ratings of negative pictures were overall more negative (2.64; $t(95) = -24.11$, $p < 0.0001$, Cohen's $d = -4.94$), and those of the positive pictures more positive (7.43; $t(95) = -27.92$, $p < 0.0001$, Cohen's $d = -5.72$), compared to the respective set of neutral pictures (5.41 and 5.38, respectively), while there was no difference in the valence ratings between the two sets of neutral images ($t(95) = 0.309$, $p > 0.7$, Cohen's $d = 0.06$). Moreover, negative images were more arousing than positive images (5.82 vs. 4.77; $t(95) = 7.66$, $p < 0.01$, Cohen's $d = 1.57$), and both negative and positive pictures were more arousing than the corresponding sets of the neutral pictures (3.68 and 3.67, respectively; both t's$(95) > 9$, p's < 0.001, Cohen's $d > 1.84$), while, again, the two sets of neutral images did not differ in their level of arousal ($t(95) = 0.114$, $p > 0.9$, Cohen's $d = 0.02$).

State and trait anxiety

We compared participants' STAI state anxiety scores prior to and after performing the experiment across the two emotion conditions. Higher scores indicate a higher level of state anxiety. Two paired-sample, two-tailed t-tests showed that state anxiety scores decreased in the positive condition from the pre- to the post-experimental test (mean difference = -3.2 [SD 12 = -3.4]; $t(24) = 2.31$, $p < 0.015$, Cohen's $d = 0.94$), while they increased in the negative condition (mean difference = 5.2 [SD = 3.1]; $t(24) = 2.91$, $p < 0.004$, Cohen's $d = 1.18$). This finding corroborates that the task-irrelevant background images were effective in modulating participants' affective states during the experiment in the intended direction. Finally, we also measured the level of participants' trait anxiety on day 1 prior to testing. These individual measures of trait anxiety did not correlate with the contextual-cueing effects in either session (r's < .1, p's > 0.05), indicating that any differences between the emotion conditions are primarily due to the specific experimental manipulations implemented.

Response accuracy

Negative emotions: The mean error rate in the negative session was very low (< 2%). A 2 x 2 x 2 repeated-measures analysis of variance (ANOVA) was computed on the mean error rates using a phase (picture, blank background) x emotional valence (negative, neutral background pictures) x context (repeated, non-repeated configurations) factorial design. This analysis revealed no significant main effects or interactions (all p's > 0.1).

Positive emotions: The mean error rate in the positive session was again low (< 2%). An analogous ANOVA to that reported above again revealed no significant main or interaction effects (all p's > 0.1).

Contextual cueing with negative and positive emotion backgrounds

An additional analysis was carried out to further examine the effects of negative- and positive- relative to neutral-emotion backgrounds on context learning. As reported in the analyses presented in the main manuscript, contextual cueing with neutral-picture backgrounds was numerically somewhat larger in the positive compared to the negative session (69 vs. 29 ms), which may in turn impact the cueing effects arising from positive vs. negative pictures. For this reason, we averaged RTs across all neutral-emotion trials (in the positive and negative session) to examine whether an up- vs. down-modulation of context learning by negative vs. positive pictures was still present when using statistically more powerful (averaged) neutral-image baseline RTs. A comparison of (averaged) RTs to neutral pictures with that of negative pictures revealed an interaction of emotion by context ($F(1, 24) = 6.06$, $p = .021$, $\eta_p^2 = 0.2$, 95% CI[0.002, 0.43]), with a larger contextual-cueing effect with negative- vs. (averaged) neutral-emotion displays (115 ms vs. 49 ms). Likewise, a comparison of averaged RTs to neutral displays against the positive-emotion displays also revealed an interaction of emotion and context ($F(1, 24) = 5.1$, $p = .033$, $\eta_p^2 = 0.18$, 95% CI[0, 0.41]), with smaller contextual cueing with positive- vs. neutral-emotion displays (-12.5 ms vs. 49 ms). This pattern of results suggest that the contextual-cueing effects presented in the main manuscript were driven by the negative vs. positive emotional quality of the images presented in the background of the repeated search layouts, rather than being attributable to minor numerical differences between different sets of neutral-emotion pictures[1].

Recognition memory

The finding of an emotion-specific effect on contextual cueing in visual search may be taken to indicate that the emotional manipulation also had an effect on the observers' explicit knowledge about the repeated search layouts. In contextual cueing studies, usually a short recognition test is performed immediately after the search task in order to examine observers'

[1] Of note, these findings are rather emotion-specific and do not necessarily transfer to other forms of motivational manipulation, notably, punishment (e.g., Murty, LaBar, Hamilton, & Adcock, 2011) or (monetary) reward (e.g., Schlagbauer, Geyer, Müller, & Zehetleitner, 2014). These 'utility' factors have been reported to modulate spatial learning in the opposite direction to the negative and positive emotions in the current study, indicative of separable mechanisms for the processing of emotional vs. motivational values in spatial learning (though these mechanisms might be linked within MTL/hippocampal structures; cf. Murty, LaBar, & Adcock, 2016; see also Geyer, Baumgartner, Müller, & Pollmann, 2012).

explicit knowledge about the repeated displays (e.g., Goujon, Didierjean, & Thorpe, 2015, for review). Thus, to assess whether the repeated layouts were explicitly memorized, 12 repeated and 12 randomly generated displays were presented in a final ("old" vs. "new") recognition test. The 12 repeated and 12 non-repeated displays were presented in random order for four times (in 4 separate blocks), yielding 96 recognition trials. Subsequently, explicit memory for repeated search displays was examined by comparing observers' hit rates (repeated display correctly judged as repeated) with their false-alarm rates (non-repeated display incorrectly judged as repeated) by means of a 2 (emotion: negative/positive, neutral) x 2 (recognition response: hits, false alarms) repeated-measures ANOVA with the factors emotion (negative/positive, neutral) and recognition response (hits, false alarms). Separate analyses were performed for the negative and positive emotion sessions of the experiment. In the negative emotion session, observers correctly recognized repeated displays in 44.6% of the trials, while they made a false alarm in 41.1%. In the positive emotion session, observers correctly recognized repeated displays in 48.5% of the trials, while they made a false alarm in 45.6%. The corresponding repeated-measures ANOVAs did not reveal any significant main effects or interactions for either emotion session (all $Fs < 1.3$, $p\text{'s} > 0.3$), that is: there was no evidence of emotion-induced explicit context memory in the current experiment.

Block-wise analysis

To track the development of contextual learning across the sequence of trial blocks, 2 x 32 repeated-measures ANOVAs were performed on mean RTs with the factors context (repeated, non-repeated configurations) and block (1-32), separately for the negative, positive, and neutral emotion conditions (for neutral emotions, the RTs were averaged across the two [negative and positive] experimental sessions). Note that these group mean values (for each block) are based on only six observations per individual participant in the positive and negative emotion conditions, and twelve in the neutral emotion condition. Given this, a certain amount of fluctuation in performance was to be expected.

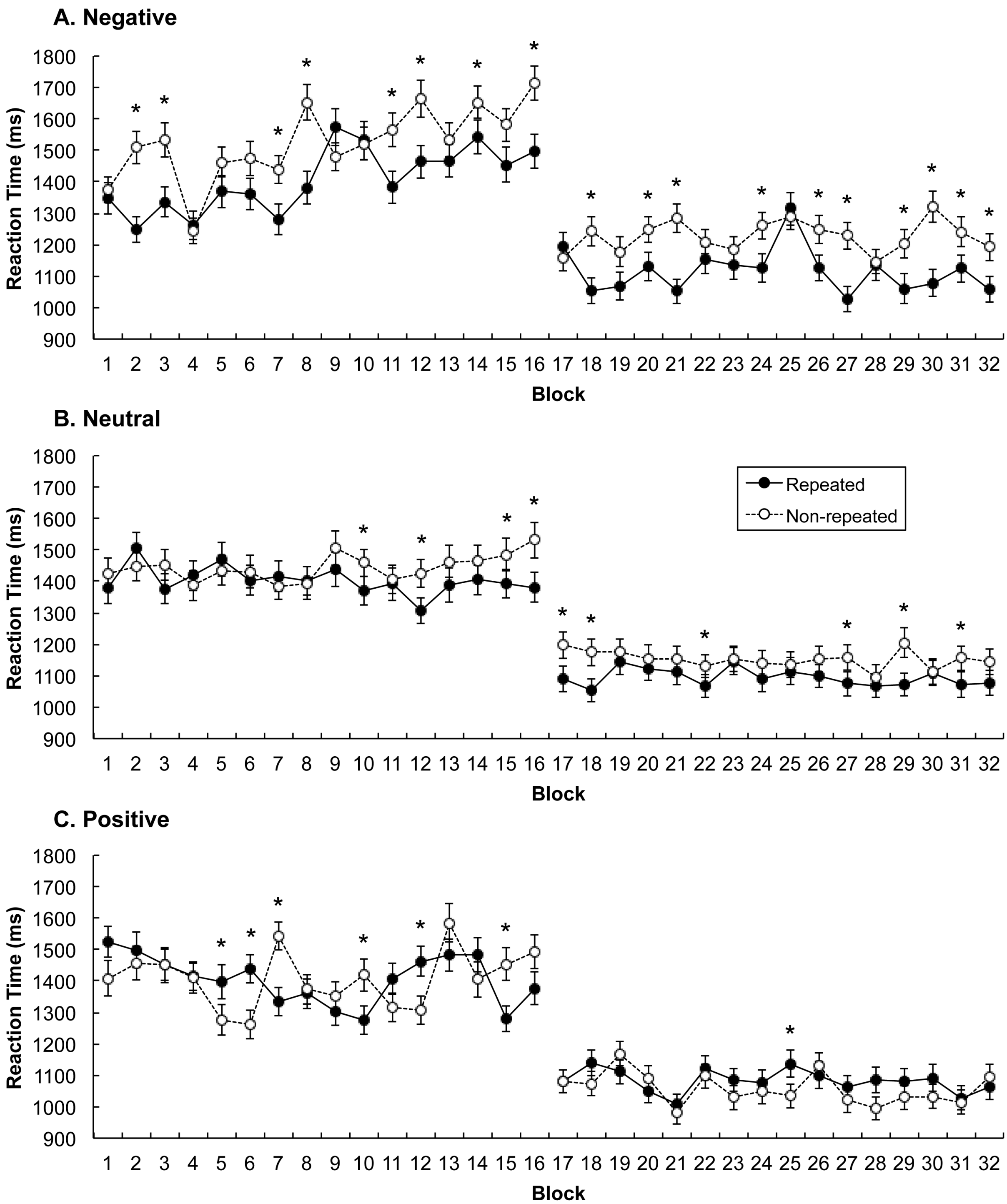

Figure S1. Mean RTs and standard errors (in ms) for repeated and non-repeated displays in the negative (A), neutral (B) and positive (C) emotion condition as a function of block (blocks 1-16: phase 1 –picture background, blocks 17-32: phase 2 – black background).

Negative Emotions: For the negative emotions (Fig. S1A), all effects were significant: main effect of context, $F(1, 24) = 17.51$, $p < .001$, $\eta_p^2 = 0.42$, 95% CI[0.11, 0.61]; main effect of block, $F(15, 360) = 2.39$, $p = .003$, $\eta_p^2 = 0.09$, 95% CI[0, 0.32]; interaction, $F(15, 360) = 3.1$, $p < .001$, $\eta_p^2 = 0.11$, 95% CI[0, 0.35]. Direct comparisons between repeated and non-repeated contexts in each block revealed contextual cueing to emerge already in blocks 2 and 3 of the search task, that is: after 2-3 repetitions of each individual display – which is comparable to previous findings (Conci & von Mühlenen, 2009; Conci, Sun, & Müller, 2011).

Neutral emotions: The block-wise mean RTs for the neutral emotion trials are depicted in Fig. S1B. The main effect block was significant ($F(31, 744) = 36.59$, $p < .001$, $\eta_p^2 = 0.6$, 95% CI[0.03, 0.74]), as was the interaction of context and block ($F(31, 744) = 3.13$, $p < .001$, $\eta_p^2 = 0.12$, 95% CI[0, 0.35]): the cueing effect was manifest from block 10 onwards (i.e., after 10 repetitions of each individual display).

Positive emotions: For the positive emotions (see Fig. S1C), again, there were main effects of context ($F(1, 24) = 4.31$, $p = .049$, $\eta_p^2 = 0.15$, 95% CI[0, 0.39]) and block ($F(15, 360) = 2.12$, $p = .009$, $\eta_p^2 = 0.08$, 95% CI[0, 0.31]), and the interaction was significant ($F(15, 360) = 1.89$, $p = .023$, $\eta_p^2 = 0.07$, 95% CI[0, 0.30]). Block-wise comparisons of RTs between repeated and non-repeated displays showed that a cueing effect became measurable in block 5 of the search task (i.e., after 5 repetitions of each individual repeated search layout), though it was rather variable thereafter and did not show consistent facilitation for the repeated layouts (thus mirroring the basic findings as reported in the main manuscript).

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