Attentional bias towards happy faces in the dot-probe paradigm: It depends on which task is used

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Abstract

Two recent articles (Gronchi et al., 2018; Wirth & Wentura, 2020) report attentional biases for happy facial expressions in the dot-probe paradigm, albeit in different directions. While Wirth and Wentura report a bias towards happy expressions, Gronchi et al. found a reversed effect. A striking difference between the two studies was the task performed by the participants. While in Wirth and Wentura, participants performed a target discrimination task, they performed a target location task in Gronchi et al. In Experiment 1, we directly compared the two versions of the dot-probe paradigm. With the discrimination task, the bias towards happy faces was replicated. However, the location task yielded a null effect. In Experiment 2, we increased the perceptual salience of the cue by making it an abrupt onset cue. Due to the salience of this abrupt onset cue, we found a cueing effect in both tasks. However, only for the location task a congruence-sequence effect (a typical characteristic of response-priming processes) occurred. This result suggests that in the location task, attentional processes are confounded with response-priming processes. Due to this confound and the unreliable (i.e., not replicable) effects often found with the location task, we recommend to generally use discrimination tasks.

Keywords: Attentional bias; dot-probe task; spatial attention; happy faces; response priming

Attentional bias towards happy faces in the dot-probe paradigm:

It depends on which task is used

A well-known paradigm for studying biases in spatial attention to emotional stimuli is the dot-probe paradigm. Participants are asked to categorize target stimuli presented unpredictably at either of two possible positions (e.g., left or right of fixation). The target stimuli are preceded by two briefly presented cues, one at each potential target position. The two cues differ in their emotional valence: for example, one cue would be a happy face, while the other would have a neutral expression. If the emotional face attracts attention, target processing should be facilitated when the target is presented at the emotional face position (because spatial attention is already at the correct position; valid condition), and target processing should be delayed when the target appears at the neutral face position (because spatial attention has to be switched to the target position first; invalid condition).

While previous studies using the dot-probe paradigm frequently found an attentional bias towards negative emotional expressions such as anger or fear (e.g., Brosch et al., 2008; Cooper & Langton, 2006; Holmes et al., 2005), attentional bias towards happy faces seemed to be consistently absent (e.g., Baum et al., 2013; Bradley et al., 1997; Cooper & Langton, 2006; Klumpp & Amir, 2009; Mogg & Bradley, 1999a; Pourtois et al., 2004; Puls & Rothermund, 2017). Recently, however, Wirth and Wentura (2020) found a significant attentional bias towards happy faces in three experiments. This effect was surprisingly robust, given the absence of attentional bias towards happy faces in previous studies.

Of note, the attentional bias towards happy faces was found with a cue-target asynchrony (CTA) of 100 ms. From basic attention research it is known that stimulus-driven covert orienting effects peak at 100-150 ms (Müller & Rabbitt, 1989) and CTAs of 200 ms and more possibly tap into shifts of overt attention (Petrova et al., 2013; Stevens et al., 2011; Weierich et al., 2008); moreover reversed effects (inhibition of return) are typically observed with longer CTAs (e.g., Klein, 2000; Lupianez & Milliken, 1999; Samuel & Kat, 2003). Thus, the brief CTA of 100 ms allows to meaningfully interpret positive cueing effects as attentional capture effects.

However, there is another study from recent years that stands in stark contrast to our findings. Gronchi et al. (2018) found a significant *reversed* cueing effect for happy faces, that is, a result that *prima facie* seems to indicate a kind of attentional avoidance of happy faces.[1] This result is remarkable because it was also found with a cue-target asynchrony (CTA) of 100 ms (see above). Thus, it appears *as if* the younger adults in the study by Gronchi and colleagues showed a bias *away* from happy faces, which is *per se* not a plausible assumption for short CTAs.

There is one fundamental difference between the studies of Gronchi and colleagues (2018) and Wirth and Wentura (2020). Wirth and Wentura used a standard *discrimination task* (i.e., the target stimulus had to be categorized in a binary decision task according to a feature that was orthogonal to the cue and target locations), whereas Gronchi and colleagues used the *location task* (i.e., the location of the target had to be indicated).

Cueing effects obtained with the discrimination task can unambiguously attributed to attentional capture processes: This means in our case, attention is preferentially shifted to the happy face. If the target appears at this location, it can be immediately processed; if it appears at the opposite location, attention has to be shifted to that location first before the target can be processed. Because this shift in attention takes time, response times on valid trials are shorter than response times on invalid trials.

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[1] To be more precise, the authors found this surprising effect within a sample of younger participants, that is, a sample comparable to those of Wirth and Wentura (2020) and to the *de facto* standard samples in psychological experiments. This sample was compared with a sample of older participants (who showed a typical bias towards happy faces) in order to test a hypothesis relating to life-span psychology. (We will elaborate on this issue in the *General Discussion.*) Moreover, the authors varied the cue-target asynchrony (CTA) block-wise(100 ms vs. 500 ms).

The same process logic is typically assumed when using the location task. However, although the location task is used surprisingly often in dot-probe research, it can be criticized for two reasons. First, a simple strategy for participants might be to focus their attention on one potential target location (i.e. always the left location) and press the corresponding button if a target appears at that location, and the other button if it does not (see already Mogg & Bradley, 1999b, for this argument). This strategy should lead to null effects. Second, any cueing effects found with the location task cannot solely be attributed to attentional processes. More specifically, the cueing effects in the location task might be confounded with response-priming processes. To elaborate on this argument more deeply, we must trace the dot-probe paradigm back to its roots, that is, to the exogenous spatial cueing paradigm of basic attention research (Posner et al., 1980). In exogenous cueing, a cue flashes briefly on one side of the screen. Subsequently a target appears either in the same location as the cue or in a different location. when the target appears on the same side as the cue, it is processed faster than when the target appears on the opposite side, presumably because attention switches to the cue. However, this interpretation is undermined if the task asks participants to indicate the location of the target since it can be argued that the cue acts like a response prime: The cue is as easily categorized in terms of location as the target. Therefore, it could be the case that the cue's location, which is irrelevant to the task, already triggers a response tendency that facilitates responding to a target in the valid location and impairs responding to a target in the invalid location.

This alternative interpretation of cueing effects might be less plausible for the dot-probe paradigm where the cueing display contains two stimuli (e.g., a happy face and a neutral face), since we have to assume that the position of one of the two face cues is non-intentionally processed in the context of the target location task. But if we assume – just for the sake of the argument – that the position of the neutral face is processed, the negative cueing effect that seemingly indicated attentional avoidance of happy faces might be in fact a response priming effect as explained above. This might be seen as a far-fetched idea. But the main point is that the results found with the location task remain open to criticism. Thus, we believe that the inconsistent results between Gronchi et al. (2018) and Wirth and Wentura (2020) warrant a further investigation of the issue of using a discrimination task versus a location task in the dot-probe paradigm.

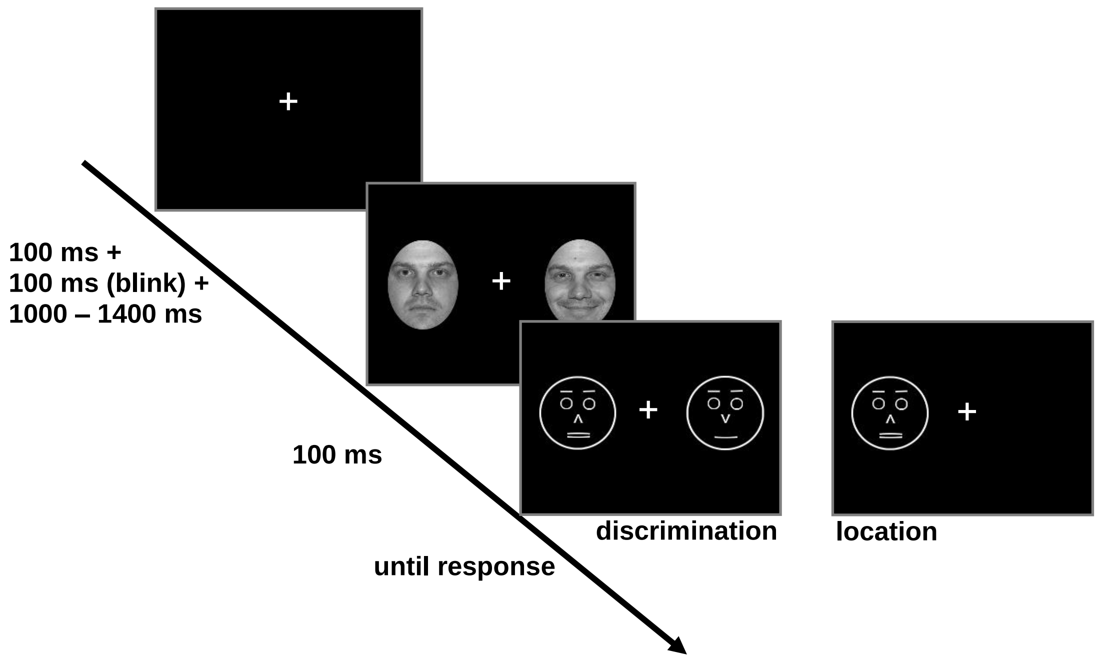
In an early study, Mogg and Bradley (1999b) already tested for differences between the use of a discrimination and a location task in the dot-probe paradigm. They found comparable results for both tasks and concluded that the use of the location task might pragmatically be preferred because it is the easier task. However, the cue-target asynchrony in this experiment was 500 ms. The study is therefore not relevant for the comparison of Wirth and Wentura (2020) and Gronchi et al. (2018). Moreover, obtaining cueing effects of similar size does not necessarily mean that the same underlying processes are at work for these different tasks. For example, for the emotional spatial cueing paradigm (Fox et al., 2001) – a close relative of the dot-probe paradigm – Imhoff et al. (2019) showed that cueing effects obtained by different tasks measure indeed different processes (we will return to this study in the *General Discussion*).

With the present study we aim to replicate both Wirth and Wentura (2020) as well as Gronchi et al. (2018; young sample) in a single experiment with *task* (discrimination versus location) as a between-participants factor. We decided for a *direct/exact* replication of Experiment 4 of Wirth and Wentura and therefore for a *conceptual* replication of Gronchi et al. In each trial, either a happy-neutral or angry-neutral cue pair was presented. As in the two original studies, this allowed us to observe the bias towards happy faces cues when happy/neutral trials were randomly intermixed with trials containing a different emotion (i.e., angry/neutral trials). The result of Experiment 4 by Wirth and Wentura was inconclusive: the happy bias was significant, the angry bias was not; however, the test of the difference between the two biases was not significant. Gronchi et al. (2108) also used a mixture of emotional cues; they presented happy/neutral, fearful/neutral, disgusting/neutral, and neutral/neutral pairs.

In the *discrimination* task, the target screen always contained two schematic faces, that is, a target face and a distractor face (see Figure 1). The participants' task was to categorize the direction of the target's "nose" (up vs. down). The distractor was added to establish a social processing mode – "Categorize the 'nose' of the *face* with the open mouth (i.e., the double line mouth)!" –, which had been shown to be a necessary condition to find the *angry* face bias (Wirth & Wentura, 2019).

In the *location* task, the target display contained only the target face (i.e., no distractor was presented) and participants were asked to indicate the location (left or right) of the target. This design is similar (but not identical) to Gronchi et al. (2018) who presented a single dot as the target.

Figure 1. Schematic illustration of a typical trial of Experiment 1. In the discrimination task, participants had to find the stimulus with the horizontal double line (here: the left one) and report the direction of its nose (up/down). In the location task, participants had to categorize the location of the target (left/right). An invalid trial is depicted here as the target is not in the same position as the happy face. In Experiment 2, the neutral photographic face is not presented. For the sake of visibility, proportions are not true to scale.



For the sake of transparency, we should note that we asked participants to complete the trait scale of the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) at the end of the experimental session. We did this to stay in line with our earlier studies (Wirth & Wentura, 2018a, 2019, 2020) and because previous studies have shown an anxiety-linked bias towards emotional, especially negative, stimuli (e.g., Bar-Haim et al., 2007), albeit mostly with larger CTAs. However, we did not find meaningful correlations of attention biases with the STAI in the earlier studies. Thus, we did not expect them in the previous study either (see our pre-registration).

To anticipate, Experiment 1 yielded a replication of Wirth and Wentura (2020), but failed to replicate Gronchi et al. (2018). This analysis leads to Experiment 2 that shows the potential contamination of attentional processes with response-related processes if the location task is used.

Experiment 1

We pre-registered our main experiment on aspredicted.org. The preregistration can be accessed via the following link: https://aspredicted.org/kj8qk.pdf

Method

Participants

The final sample consisted of 176 participants (*n* = 84 for location and *n* = 92 for discrimination; 131 males, 40 females, 5 persons of undisclosed gender). Age ranged from 18 to 35 years (Md = 24 years). Participants were recruited via the online recruitment platform Prolific (prolific.co, Prolific Academic Ltd. London, England). In order to be included in the study, participants had to be of age 18 to 35, to be fluent in English (to be able to understand the instructions), and to have a prolific approval rate of 95 % or higher. The sample completing the discrimination task contained n_{Disc} = 92 participants, the sample completing the location task had n_{loc} = 84 participants. Participants were paid 4.55 £ as compensation. The experiment lasted approximately 35 minutes.

Our power considerations aimed at having enough power to replicate (a) the attentional bias toward positive faces found by Wirth and Wentura (2020), (b) the attentional bias away from happy faces found by Gronchi et al. (2018), and (c) to detect a significant difference between the two groups with regard to this bias. With regard to (a), in previous experiments using the same experimental design (i.e., Wirth & Wentura, 2020), the size of the attentional bias towards happy faces ranged from d_Z = 0.33 to d_Z = 0.37. In order to detect an effect of d_Z = 0.33 with a power of 1-β = .80 (α set to .05), *N* = 75 participants are required. Regarding (b), Gronchi et al. (2018) found an inverted effect for happy faces of d_Z = 0.68. With *N* = 75 an effect of d_Z = 0.68 can be detected almost with certainty (i.e., 1- β = .9999, given α = .05). (c) The differences between the location task (i.e., the replication of Gronchi et al.) and the discrimination task (i.e., the replication of Wirth & Wentura) could be conservatively estimated at d_S = (0.33 – [-0.33] =) 0.66 (i.e., by assuming that the reversed effect found with the location task is not larger than the positive effect found with the discrimination task). With $n_1 = n_2$ = 75, the power to detect an effect of d_S = 0.66 is 1- β = .98 (α = .05). All power calculations were done using G*Power; Faul, et al., 2007. With regard to potential exclusions, we aimed for $n_1 = n_2$ = 85, i.e., a total of N=170.

A first recruitment phase in Prolific ended with n_{Disc} = 89 and n_{loc} = 86. Unexpectedly, according to our preregistered outlier criteria (see below), the initial discrimination task sample reduced to n_{disc} = 65, whereas the location task sample reduced only to n_{loc} = 84. Therefore, we recruited an additional n=34 for the discrimination task to finally have approximately comparable samples for the two tasks.

Our first preregistered outlier criterion was that “participants showing accuracy rates more than three interquartile ranges below the first quartile of the distribution of all participants will be excluded from further analysis” (far-out values according to Tukey, 1977). This criterion resulted in a loss of $n = 31$ for the discrimination task and $n = 1$ for the location task. Our second preregistered outlier criterion was that “participants whose average response times are more than three interquartile ranges above the third quartile of the distribution of all participants” will be discarded. In order to be meaningful, this criterion must be applied on a sample-specific basis, as there were large differences in the general level of speed in the two tasks (see *Results*). This criterion resulted in an additional loss of $n = 1$ for the location task.

Design

We employed 2 (*cue emotion*: happy vs. angry) × 2 (*cue validity*: invalid vs. valid cue) × 2 (*task*: location vs. discrimination) design with emotion and validity as within-participants factors and task as a between-participants factor.

Materials

The cues were photos of eight females and eight males[2] showing happy, angry, and neutral facial expressions taken from the NimStim set of facial expressions (Tottenham et al., 2009). Because exposed teeth are a strong perceptual confound of happy expressions, potentially biasing the dot-probe effects (Wirth & Wentura, 2018b), we used only happy and angry faces with closed mouths in the present study; the intensity of the emotional expression is thus rather moderate in these faces. Using Adobe Photoshop (Adobe Systems Inc., San Jose, CA), all stimuli were cropped to a standard oval shape, masking hair and external features, and were converted to grayscale.

Procedure

The study was conducted online. The experimental routine was created using PsychoJS, the JavaScript counterpart to PsychoPy (Peirce et al., 2022) and hosted on Pavlovia (pavlovia.org, Open Science Tools Ltd., Nottingham, England). After agreeing to participate

[2] Images from the following individuals were used: 01, 02, 03, 05, 07, 08, 09, 10, 20, 22, 23, 25, 32, 34, 36, 37.

in the study on Prolific, participants were automatically transferred to Pavlovia and the experiment started in their Browser (participation was only allowed on a desktop computer or laptop). To adjust presentation parameters to the actual screen size, participants were asked to resize a credit card image (presented on the screen) to the size of a real credit card (or equivalent) by using the arrow buttons on their keyboard (Morys-Carter, 2021, May 18). After completing the informed consent form, they were shown a screen with instructions on the experimental procedure. The temporal parameters were identical to our previous dot-probe studies (Wirth & Wentura, 2018a, 2019, 2020). Figure 1 shows the progression of an exemplary trial. Throughout the experiment, a gray fixation cross was displayed on a black background to direct participants' attention to the center of the screen. To indicate the start of a trial, the fixation cross blinked for 100 ms. The fixation cross then remained on the screen for a variable interval (randomly selected from the set 1000, 1100, 1200, 1300, or 1400 ms) to avoid any anticipatory effects. Two photographic face cues were then presented to the left and right of the fixation cross for 100 ms, either one happy and one neutral or one angry and one neutral. The two faces in a given trial were always of different identities (but of the same gender). Each face was 4.5 × 6.2 cm (4.0 × 5.5°); the distance between faces (center to center) was 11.1 cm (9.8°). Immediately after the offset of the cues, the target display was presented until a response was given.

In the discrimination task, two schematic faces (with neutral expression) were presented during the target display, a target face with open mouth (symbolized by a horizontal double line) and a schematic distractor face with closed mouth (symbolized by a single horizontal line). Participants had to indicate the direction of the nose of the target face while ignoring the distractor face. The schematic faces were 2.8 × 2.8 cm (2.5 × 2.5°) and the center-to-center distance was 11.1 cm (9.8°). The nose/arrow directions of the target and distractor stimuli were uncorrelated, that is, the nose/arrow of the target stimulus pointed in the same direction as the nose/arrow of the distractor stimulus on 50% of the trials and in the opposite direction on the remaining trials. (This was varied orthogonally to the other experimental factors). Participants were asked to respond as quickly as possible by pressing the "t" key for "up" or the "v" key for "down." On half of the trials, the target stimulus appeared at the location of the emotional (i.e., happy or angry) face cue (valid cue), and on the remaining trials, at the location of the neutral face cue (invalid cue). Each response was followed by a 500 ms intertrial interval. If participants made a mistake or took longer than 1,500 ms to make a response, they received a 1,000 Hz warning tone of 500 ms duration.

In the location task, everything was the same as in the discrimination task except that (a) the target face was the only stimulus presented during the target display (i.e., no distractor face was presented) and (b) the position (right or left) of the target face had to be categorized using the "c" (left) and "n" (right) keys.

The experiment comprised 448 trials and lasted about 35 minutes. A self-paced break was taken every 112 trials. At the beginning of each block, participants were presented with 32 training trials that were not included in the data analysis. These training trials used faces of individuals that were not shown on the main trials.

To stay in line with dot-probe research in general as well as with our own earlier research, participants of Experiment 1 completed the trait-anxiety scale of the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) at the end of the procedure. However, we expected no correlations with attentional bias (see the pre-registration), given the results of our previous studies (Wirth & Wentura, 2018a, 2019, 2020, but see Wirth & Wentura, 2018b).

Results

Average classification accuracy was M = 98.5 % (SD = 1.7 %) and M = 96.4 % (SD = 2.8 %) for the location task and the discrimination task, respectively. For the response time (RT) analysis, RTs below 150 ms were excluded, as were RTs more than 1.5 interquartile ranges above the third quartile of the individual participant’s distribution (Tukey, 1977). This led to the exclusion of 5.15 % and 2.44 % of all trials with correct responses for location task and discrimination task, respectively. Table 1 shows average RTs as a function of the experimental factors. As can be easily seen, descriptively the results pattern found by Wirth and Wentura (2020; Exp. 4) with the discrimination task was replicated, whereas a null result was found with the location task.

Pre-registered analyses

Our pre-registration stated with regard to the main analyses: “Data will be analyzed using a 2 (cue emotion: happy vs. angry) × 2 (cue validity: invalid vs. valid cue) × 2 (task: localization vs. classification) mixed ANOVA and mean reaction times on correct trials as the dependent variable. Even if the task factor does not significantly interact with the other factors, separate ANOVAs for the two tasks will be conducted to see whether the results of both previous studies (Gronchi et al., 2018; Wirth& Wentura, 2020) can be replicated with the respective versions of the dot-probe task.” Thus, we present first an overall analysis, followed by analyses of the two sub-samples.

Moreover, in the power planning part of our pre-registration, we wrote: “Our power considerations aim at having enough power to replicate (a) the attentional bias towards positive faces found by Wirth and Wentura (2020), (b) the attentional bias away from happy faces found by Gronchi et al. (2018), and (c) to find a significant difference between the two.” Thus, though not explicitly noted in the “main analyses” section of the pre-registration, a comparison of the happy bias of the two samples is implied with this plan.

Overall analysis. We conducted a 2 × 2 × 2 mixed ANOVA with the factors cue *emotion* (happy vs. angry) and *cue validity* (valid cue vs. invalid cue) as within-participants factors and *task* (location vs. discrimination) as between-participants factor as well as mean (correct) RTs as the dependent variable. Complete results are presented in Table A1 in the *Appendix A*. The analysis revealed a significant main effect of *task*, which reflects faster RTs in the location group (*M* = 410 ms, *SD* = 46) than in the discrimination group (*M* = 817 ms, *SD* = 112). This result is not surprising because in the discrimination group, participants had to select the target stimulus before they could categorize it. In contrast, in the location group they only had to categorize the location of a single stimulus. All other effects were not significant. The three-way interaction is associated with $F(1,174) = 2.87$, $p = .092$, $\eta_p^2 = .016$. As noted above, we compared the mean happy cueing effects (i.e., $RT_{invalid} – RT_{valid}$) of the two samples. A Welch's t-test (due to unequal variances) yielded a significant result, $t(119.45) = 2.06$, $p = .042$, $d_S = 0.30$. That is, the happy bias is significantly larger in the discrimination-task sample compared to the location-task sample.

Table 1. Mean RTs and Cueing Scores (in ms) as a Function of Cue Validity, Cue Emotion, and Task

Task	Cue validity		
Cue emotion	Valid	Invalid	Cueing-Score
Discrimination			
Happy	813 (96.6 %)	818 (96.3 %)	5 [2]
Angry	819 (96.3 %)	818 (96.4 %)	-1 [2]
Location			
Happy	410 (98.5 %)	410 (98.5 %)	0 [1]
Angry	410 (98.6 %)	410 (98.4 %)	0 [1]

Note. Accuracy rates are given in parentheses, SEs are given in brackets, cueing score = $RT_{invalid} – RT_{valid}$. The equality of the four RT averages referring to the location task (when rounded up to whole milliseconds) is purely incidental (and not a typo).

Discrimination task. We conducted a 2 (*emotion:* happy vs. angry) × 2 (*cue validity:* valid vs. invalid) ANOVA for repeated measures with mean (correct) RTs as the dependent variable. The analysis revealed no significant main effects, $F(1, 91) = 3.77$, $p = .055$, $\eta_p^2 = .040$ and $F(1, 91) = 1.25$, $p = .267$, $\eta_p^2 = .014$ for emotion and cue validity, respectively, but a significant interaction, $F(1, 91) = 4.00$, $p = .048$, $\eta_p^2 = .042$. The cueing effect for happy faces was significantly larger than zero, $t(91) = 2.28$, $p = .025$, $d_Z = 0.24$. The cueing effect for angry faces was not significant, $|t| < 1$.

Location task. A 2 (*emotion:* happy vs. angry) × 2 (*cue validity:* valid vs. invalid) ANOVA for repeated measures with mean (correct) RTs as the dependent variable yielded no significant effects, all Fs < 1. The cueing effects for happy and angry faces were not significant, both $|t|$s < 1.

Exploratory analyses

Error rates. Not explicitly mentioned in our pre-registration, but in accordance with usual practice for response time paradigms, we conducted for all analyses reported above corresponding analyses of error rates to check for possible speed-accuracy tradeoffs. There were no significant effects (see *Appendix A*, Table A1), except the main effect of task, $F(1,174) = 34.79$, $p < .001$, $\eta_p^2 = .167$; accuracy was slightly higher in the location group than in the discrimination group.

Individual differences. As pre-registered, we checked for individual differences. As expected, participants' trait anxiety as assessed with the STAI did neither significantly correlate with cueing scores in the location sample, $r(82) = .01$, $p = .947$ for the angry bias score, $r(82) = .179$, $p = .103$ for the happy bias score, nor in the discrimination sample, $r(90) = .073$, $p = .486$ for the angry bias score, $r(90) = .138$, $p = .191$ for the happy bias score.[3]

[3] Actually, we noted in the pre-registration (section on "secondary analyses"): "Participants' individual trait-anxiety will be used as a covariate. However, we do not expect interactions between trait-anxiety scores and the attentional bias towards happy faces." Indeed, using STAI as a (centered) covariate in the ANOVAs reported above yielded no significant effects involving STAI; all effects reported above (i.e., effects not involving STAI) were essentially

Discussion

The *discrimination* task yielded a replication of the attentional bias for happy faces as found in several experiments by Wirth and Wentura (2020). Moreover, as in Experiment 4 of the previous study, there was no significant bias toward angry faces when angry/neutral trials were randomly intermixed with happy/neutral trials. Here, however, the result was even clearer since the difference between the bias towards happy faces and the bias towards angry faces was significant.

The *location* task yielded neither an effect in line with Gronchi et al. (2018) – who found a reversed effect – nor an effect in line with Wirth and Wentura (2020). We found clear null results for both happy and angry faces. The difference between the two task versions with regard to the happy face bias was significant.

Why did we obtain different results in our conceptual replication compared to the original study by Gronchi et al. (2018)? Their result was quite clear – *M* = -12 ms, *SE* = 3 ms (see Fig. 2 in Gronchi et al.) which corresponds to a Bayes factor of BF_{10} = 79 – and the power in our conceptual replication was extremely large (see *Participants* section). Thus, the probabilities of a false positive or a false negative result, respectively, are rather low. Speculations about the difference should therefore focus on differences in the design between the original study and our conceptual replication. There were three. One is rather minor: We presented a more complex target stimulus than Gronchi et al., that is, a schematic face instead of a dot. However, since only the location of the target mattered in both cases, it is rather implausible to assume an influence of this difference. The two other differences seem to be better candidates to focus on in potential follow-up research: (1) The happy/neutral trials in the Gronchi et al. study were intermixed with disgust/neutral, fearful/neutral, and neutral/neutral trials and not with angry/neutral trials as in our conceptual replication. (2)

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the same. While writing this manuscript, it appeared to us that reporting simple correlations is more convenient for the reader.

Gronchi et al. always presented pictures of the same stimulus person in a given trial whereas we always presented pictures of different stimulus persons in a given trial. However, we will hold back on speculation here, as any test of this speculation will be a test using the location task again, which we consider problematic from the start on.

In the introduction, we mentioned two possible problems of the location task. First, a simple strategy could be for participants to focus their attention on one potential target location and press the appropriate key if the target appears at that location and the other key if not. This strategy is expected to produce a null result. Thus, to explain the present null result in the location task, it is sufficient to assume that this strategy was used by participants.

However, given that we are faced with diverging results – our null result, the reversed effect by Gronchi et al. (2018), and positive effects by others (e.g., Orgeta, 2011)[4] – it might be worthwhile to further investigate the other criticism. As discussed before, the dot-probe paradigm can be considered a variant of the exogenous cueing paradigm of basic attention research (Jonides, 1981; Posner, 1980; Posner & Cohen, 1984). In a prototypical version of the exogeneous cueing task, a small rectangle is briefly flashed either on the left or right of the fixation cross. After a short cue-target asynchrony (CTA), a target is briefly presented either on the same side as the rectangle (valid condition) or on the other side (invalid condition). Participants either have to quickly affirm the presence of the target (detection task; in this variant the inclusion of catch trials secures attentive performance) or to quickly categorize the target in a binary decision (e.g., whether the target is an "L" or "R"; discrimination task). In case of short CTAs (e.g., 100 ms) responses are typically faster in valid compared to invalid conditions. This effect is attributed to attentional capture by the abrupt onset cue.

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[4] Orgeta (2011) found a positive effect of M = 18 ms (see Table 2) with a cue-target asynchrony of 85 ms (17 ms cue presentation plus 68 mask), which was not tested independently. Even a conservative calculation of the standard error, however, indicates significance.

It is immediately apparent why using the location task (i.e., whether the target is presented to the left or right of fixation) would not be a good choice in this classical paradigm: In this case, the cue feature “location” is either response-congruent (in the valid condition) or incongruent (in the invalid condition). Thus, using the location task turns the exogeneous cueing paradigm into a hybrid of cueing and response priming. It is a defining characteristic of response priming designs that the target stimulus is categorized in a binary decision task (e.g., arrow direction left vs. right, Vorberg et al., 2003, or valence evaluation positive vs. negative, Fazio et al., 1986) and a preceding prime stimulus (which is briefly presented with short prime-target asynchrony) carries a feature that either matches the correct response to the target or mismatches it (i.e., the prime is itself an arrow pointing to the left or right or is a positive/negative stimulus, respectively). Typically, response priming results in a congruence effect (i.e., responses are faster if the prime feature matches the correct response in comparison to a mismatch; for more general discussions, see Schmidt et al., 2011; Wentura & Degner, 2010). However, negative effects were observed as well (e.g., Eimer & Schlaghecken, 1998). Most important in the present context is the conclusion that by using the location task, a cueing effect cannot be unambiguously interpreted as an attentional effect (see also Ansorge & Heumann, 2004, for a discussion of this issue).

Given the structural similarities of exogenous cueing and the dot-probe paradigm, we can surmise that the same ambiguity of interpretation applies to the dot-probe paradigm: In the *exogenous cueing* paradigm, we can describe the stimulus situation at the time of cueing in the following way: There are two relevant locations on the screen. In each trial, the only difference between the two locations is the feature “abrupt onset (of a stimulus)”, which is present at one location but not at the other. This parallels the situation in the *dot-probe paradigm*: There are two relevant locations on the screen; in each trial, the difference between the two locations is the feature “facial expression: happy”, which is present at one location but not at the other (i.e., “facial expression: neutral”). Of course, although the confound of the validity variation with the response congruence variation is not as evident in the dot-probe paradigm as it is in exogeneous cueing, it is present and it should be tested whether it biases results.

To demonstrate this hybrid character of cueing using the location task, we replicated Experiment 1 with one critical change: On each trial, the cue display only contained one emotional face (i.e., the neutral face was not presented). Thus, the experiment can now be considered to be a version of cueing with an abrupt onset cue (i.e., the emotional face) and the location task. The most plausible expectation for this kind of experiment is to find a positive cueing effect caused by either attentional capture of the abrupt onset cue and/or response priming.[5]

Moreover, if response priming occurs in the experiment, we can expect a typical signature of response interference experiments: the congruence sequence effect (CSE). This effect describes the phenomenon that congruence effects are significantly reduced when the preceding trial was an incongruent trial (Gratton et al., 1992; for reviews, see Duthoo et al., 2014; Egner, 2007). Standard paradigms where a CSE usually occurs are variants of the Stroop task (e.g., Notebaert & Verguts, 2007), the flanker task (e.g., Gratton et al., 1992), or the Simon Task (Hommel et al., 2004), that is, paradigms in which task-relevant and task-irrelevant information are presented simultaneously (e.g., the word “red” presented in green font color). However, a CSE was found for response priming tasks (i.e., tasks with sequential presentation of task-relevant and task-irrelevant features) as well (e.g., Frings & Wentura, 2008). Thus, if a cueing task with a single cue and the location task is governed by response interference processes a CSE should be likely found.

[5] As an aside, since we only had to make minor adjustments to the program code from Experiment 1 for Experiment 2, we can use Experiment 2 to demonstrate that the absolute null results of the location task in Experiment 1 were not due to erroneous code.

The CSE can be explained by several theories, for example, by adaptive control processes (Botvinick et al., 2001). According to this theory, the experience of response conflict (as in incongruent trials) triggers conflict regulation, which results in increased attention to the task-relevant dimension (here: the location of the target) and decreased attention to the task-irrelevant dimension (here: the location of the cue) in the subsequent trial. Note that other theories can explain the effect as well (e.g., feature integration, Hommel et al., 2004); it is beyond the present article to contribute to this debate (see Duthoo et al., 2014, for a discussion).

To summarize, if a cueing effect found with the location task in Experiment 2 is based on response priming processes, potentially a CSE can be expected. That is, in this case the cueing effect should be significantly smaller if the preceding trial was an invalid one. This pattern should not be observable with the discrimination task.

Experiment 2

Experiment 2 is an exact replication of Experiment 1 with one critical exception: During the cue display, only one face cue was presented. Thus, this face cue was an abrupt-onset cue which should yield a clear cueing effect.[6]

Method

Participants

For Experiment 2, we recruited *n* = 29 participants for the location task and *n* = 35 participants for the discrimination task (again via Prolific). A further participant of the location group showed average RTs that were more than three interquartile ranges above the third quartile of the distribution of all participants in that group. Their data were therefore

[6] For the sake of transparency it should be noted that we first collected the data of the location group (because the location task was the target of our theoretical considerations). With some months delay, we recruited the discrimination task sample for control reasons (i.e., to show that no CSE occurs for this task). For the sake of convenience, we nevertheless treat task as an experimental factor in the following sections although recruitment did not follow a strict randomization protocol. It was of course checked that samples did not overlap.

discarded. Data of five further participants of the discrimination group were discarded because their accuracy was more than three interquartile ranges below the third quartile of the distribution of all participants in that group (i.e., below 75 %).

A sample size of N=29 allows to detect an effect of $d_Z = 0.69$ with power $1-\beta = .95$ ($\alpha = .05$). For onset-cue / onset-target experiments, this effect size is a plausible expectation (see, e.g., Ansorge & Heumann, 2004).[7]

Design, Materials, and Procedure

Design, materials, and procedure were identical to Experiment 1 except for the cue display which only contained a single (emotional) face cue.

Results

Average classification accuracy was M = 98.2 % (SD = 1.7 %) and M = 95.6 % (SD = 4.3 %) for the location task and the discrimination task, respectively. For the response time (RT) analysis, RTs below 150 ms were excluded, as were RTs more than 1.5 interquartile ranges above the third quartile of the individual participant's distribution (Tukey, 1977). This led to the exclusion of 3.00 % and 2.25 % of all trials with correct responses for location task and discrimination task, respectively. Table 2 shows average RTs as a function of the factors cue validity, previous cue validity, and task. (Appendix B reports descriptive statistics and analyses that additionally included the factor cue emotion, which yielded – as expected – no significant moderations.)

Response Times

A 2 (*cue validity:* valid vs. invalid) × 2 (*previous cue validity:* valid vs. invalid) × 2 (*task*: location vs. discrimination) mixed ANOVA with task as a between-participants factor

[7] Ansorge and Heumann (2004) conducted onset-cue / onset-target experiments using the location task. In their Experiment 1b (which is most comparable to our location task control experiment), the overall validity effect had a size of $d_Z = 2.31$. Admittedly, the effect was clearly moderated by a further binary factor. Nevertheless, $d_Z = 0.69$ seems to be a conservative assumption.

with mean (correct) RTs as the dependent variable yielded a significant three-way interaction, $F(1,62) = 9.44$, $p = .003$, $\eta_p^2 = .132$. (All other tests are presented in Table A2 in the Appendix A.) For the location task, a 2 (*cue validity:* valid vs. invalid) × 2 (*previous cue validity:* valid vs. invalid) ANOVA for repeated measures yielded two significant main effects, $F(1,28) = 10.37$, $p = .003$, $\eta_p^2 = .270$ and $F(1,28) = 42.37$, $p < .001$, $\eta_p^2 = .602$ for validity and previous validity, respectively, which were qualified by a significant interaction, $F(1,28) = 87.09$, $p < .001$, $\eta_p^2 = .757$. The cueing effect was positive and significant, $t(28) = 5.80$, $p < .001$, $d_Z = 1.08$, if the previous trial was valid; the cueing effect was not different from zero, $t(28) = 0.01$, $p = .989$, $d_Z = 0.003$, if the previous trial was invalid. Thus, the typical CSE emerged. For the discrimination task, a 2 (*cue validity:* valid vs. invalid) × 2 (*previous cue validity:* valid vs. invalid) ANOVA for repeated measures yielded only a significant main effect for validity, $F(1,34) = 37.03$, $p < .001$, $\eta_p^2 = .521$ ($M = 48$, $SE = 8$ ms, $d_Z = 1.01$; both $Fs < 1$ for previous validity and the interaction term).

Table 2. Mean RTs and Cueing Scores (in ms) as a Function of Cue Validity, Cue Validity of the Preceding Trial, and Task (Experiment 2)

Task	Cue validity		
Previous Validity	Valid	Invalid	Cueing-Score
Discrimination			
N-1 Valid	823 (96.0 %)	874 (95.3 %)	51 [9]
N-1 Invalid	827 (95.7 %)	873 (95.5 %)	46 [8]
Location			
N-1 Valid	370 (99.5 %)	393 (95.6 %)	23 [4]
N-1 Invalid	390 (99.0 %)	390 (98.7 %)	0 [4]

Note. Accuracy rates are given in parentheses. SEs are given in brackets, cueing score = $RT_{invalid} – RT_{valid}$.

Accuracy

A 2 (*cue validity:* valid vs. invalid) × 2 (*previous cue validity:* valid vs. invalid) × 2 (*task*: location vs. discrimination) mixed ANOVA with task as a between-participants factor with accuracy as the dependent variable yielded a significant three-way interaction, $F(1,62) = 10.56$, $p = .002$, $\eta_p^2 = .146$. (All other tests are presented in Table A1 in the Appendix A.) For the location task, a 2 (*cue validity:* valid vs. invalid) × 2 (*previous cue validity:* valid vs. invalid) ANOVA for repeated measures yielded two significant main effects, $F(1,28) = 25.65$, $p < .001$, $\eta_p^2 = .478$ and $F(1,28) = 13.31$, $p = .001$, $\eta_p^2 = .322$ for validity and previous validity, respectively, which were qualified by a significant interaction, $F(1,28) = 20.75$, $p < .001$, $\eta_p^2 = .426$. The cueing effect was positive and significant, $t(28) = 5.30$, $p < .001$, $d_Z = 0.98$, if the previous trial was valid; the cueing effect was non-existent, $t(28) = 0.83$, $p = .415$, $d_Z = 0.15$, if the previous trial was invalid. Thus, the typical CSE emerged. For the discrimination task, a 2 (*cue validity:* valid vs. invalid) × 2 (*previous cue validity:* valid vs. invalid) ANOVA for repeated measures yielded no significant effects (all *Fs* < 1).

Discussion

First of all, the control experiment for the location task yielded a clear cueing effect. Thus, our procedure proves to be a valid operationalization of the cueing paradigm (which readers might have doubted by seeing exactly the same mean RTs of all conditions in Experiment 1; see Table 1 and Footnote 4). Similarly, a large cueing effect was found for the discrimination task.

However, results show an important difference between the two tasks. In the location task, we found a clear CSE, that is, the cueing effect was only present if the preceding trial was a valid/congruent one. It was, however, completely absent if the preceding trial was an invalid/incongruent one. As already discussed, this result is consistent with the interpretation of the RT difference between valid and invalid trials in terms of response interferences. Thus, it is not clear whether attentional processes are additionally at play in the location task. In the discrimination task, however, there was no evidence for a CSE effect suggesting that the RT difference between valid and invalid trials was caused by attentional processes.

Note that the effect in Experiment 2 should not be interpreted in terms of the emotional value of the cue. To explain the result, it is enough to assume that an abrupt onset cue (irrespective of meaning, valence, etc.) attracts attention and/or triggers a response due to its location (since location is the response-relevant feature of the targets). Following Fox et al. (2001), one might have expected the cueing effect to be somewhat larger for angry faces than for happy faces because it might be more difficult to disengage attention from an angry face in the event of an invalid trial than from a happy face. However, this should only be an ordinal moderation of a clear cueing effect that is caused by abrupt onset (if at all).

General Discussion

In the present study, we investigated whether attentional bias towards happy faces is contingent on the task that participants have to perform, thereby trying to reconcile two results that were recently reported in the dot-probe paradigm: Wirth and Wentura (2020) found positive cueing effects for happy faces (with a cue-target asynchrony of 100 ms). In contrast, Gronchi et al. (2018) found a negative cueing effect for happy faces (in the 100 ms cue-target asynchrony block) for their sample of younger participants. That is, they found a bias that must be interpreted either as a bias *away* from happy faces (an assumption not easily reconcilable with the 100 ms asynchrony) or a bias towards faces with neutral expressions.

The most obvious difference between the two studies was the task that participants had to perform. Gronchi et al. simply asked for a categorization of the target location (left vs. right; location task), which entails that the location of a valid (invalid) cue is congruent (incongruent) with the correct response. Wirth and Wentura (2020), instead, asked for a categorization of a binary target feature that was varied orthogonally to cue validity (discrimination task).

By using the discrimination task, we were able to replicate Wirth and Wentura's (2020) result of a positive cueing effect for happy faces. The effect was a bit smaller than in the published study; this might be due to the fact that the present experiment was conducted online (with more noisy data). Several other details are consistent with Wirth and Wentura's previous results: In Experiment 4 of their 2020 study, the angry face bias was not significant as was the case in the present study. This is remarkable because an angry face bias was reliably found in earlier studies (Wirth & Wentura, 2018a, 2019) if it was tested in isolation (i.e., if all trials contained angry and neutral face cues and no other emotion was used). Thus, further research should clarify whether the angry face bias is contingent on the absence versus presence of other emotions in the trial sequence.

By using the location task, we were unable to replicate the negative cueing effect reported by Gronchi and colleagues (2018, younger sample, 100 ms cue-target asynchrony). Instead, we found a clear null effect. Of note, Gronchi and colleagues used the dot-probe paradigm in their study to contribute to research on the positivity effect in the elderly, that is, a hypothesized general age-related trend favoring positive over negative stimuli in cognitive processing (see Reed et al., 2014, for a review and meta-analysis on this cross-paradigms research). Consistent with their hypothesis, they indeed found a significant difference in attentional bias towards happy faces between their older and younger samples: Whereas their younger sample showed the reverse bias for happy faces – the subject of the present article – their older participants showed a positive attentional bias for happy faces. Thus, the result pattern that is used to support the age-related hypothesis is based, at least in part, on the a priori implausible and – as we can see in our experiment – not easily replicable negative effect in the younger sample.

Null effects found with the location task can be easily explained with a strategy potentially used by participants that was already suspected by Mogg and Bradley (1999b). A high level of overall performance can be achieved even if participants do not comply with the instruction to focus on the center of the screen throughout the trials. If a participant instead focuses on one side of the screen, appearance of the target on that side can be quickly affirmed by pressing the corresponding key; non-appearance of the target on that side (in the expected time frame) can be quickly affirmed by pressing the other response key. This strategy is particularly feasible if – as is frequently the case in dot-probe studies – there is a fixed cue-target asynchrony throughout a given block of trials.

However, since across published studies a variety of cueing effects for the location task were found (i.e., our null results, the negative effect by Gronchi et al., 2018, and positive effects by others, e.g., Orgeta, 2011), we draw attention to a further confound with the present Experiment 2: That is, the location task confounds attentional processes with response interference processes. A cue presented in the left location carries the feature “left” which might in turn facilitate the response “left” if the target is presented on the left as well and might be in conflict with the response “right” if the target is presented on the right.

In order to demonstrate that such processes can in principle occur in this paradigm, we conducted Experiment 2 where only one face cue was presented during the cue display. It was highly expectable, given the basic literature on cueing effects, that an abrupt onset cue (i.e., here: the single emotional cue) will cause cueing effects. First of all, especially for the location task, this control experiment showed that our experimental procedure (including the online realization) allowed to find robust cueing effects (which seemed necessary after the complete absence of mean RT differences in Experiment 1; see Footnote 2).

Crucially, we found a pronounced congruence sequence effect (CSE) with the location task, that is, a dependence of the cueing effect on the validity of the preceding trial. CSEs are known from response interference paradigms, but not from genuine cueing effects.

(correspondingly, we found no CSE with the discrimination task.) Thus, the cueing effect found with the location task (in Experiment 2) can be explained better in terms of a response interference effect.

What do these considerations tell us about the use of the location task in the dot-probe paradigm in general? Admittedly, the confound between spatial cueing and response priming is not very obvious in the dot-probe paradigm since two cues – one on the left, one on the right – are presented on each trial. Nevertheless, in principle, the confound could play a role. If we assume that participants process the cue screen not as a symmetrical arrangement of two approximately equivalent stimuli (i.e., two faces), but in an asymmetrical manner, that is, prioritizing one face type (either happy or neutral), the explanation of response interference becomes more plausible. Participants might notice the asymmetry of cue displays (i.e., that there is always a difference in emotional expression between the two cues) already during the first trials, which might cause them to prioritize one face type.

Based on these considerations, the range of possible explanations for the unexpected negative cueing effect for happy faces found by Gronchi et al. (2018) grows. We can not only explain it by attentional biases (either away from happy faces or towards neutral faces), but by a prioritized processing of neutral faces or even by a prioritized processing of happy faces, if we take into account that sometimes reverted response interference effects were found (e.g., Eimer & Schlaghecken, 1998).

Of course, our study had the limitation that the location task sample of Experiment 1 yielded a clear null result. Therefore, we were not able to directly show the contribution of response interference processes (e.g., by finding a congruence sequence effect) in the dot-probe paradigm itself. However, we believe that the demonstration of response interference processes in Experiment 2 make it plausible to the reader that in principle these processes might contribute to effects found with the location task in the dot-probe paradigm.

Finally, it should be noted that the dot-probe paradigm has a close neighbor, for which Imhoff et al. (2019) have already pointed out the problem of using the location task. This paradigm is referred to as "emotional spatial cueing task" (see, e.g., Bar-Haim et al., 2007) or "modified spatial cueing task" (see, e.g., Imhoff et al., 2019). In this paradigm (that was introduced by Stormark & Hugdahl, 1997, and popularized by Fox et al., 2001), an abrupt onset cue is presented that varies in valence (e.g., neutral, positive, threatening). Importantly, the cue is informative in regards to the target location, that is, 75 % of trials are valid. The basic idea is that exogenous attentional control (caused by the abrupt onset of the cues) as well as endogenous attentional control (i.e., participants direct their attention based on the information value of the cue) ensures that attention is directed to the indicated location, leading to fast responses in valid trials regardless of valence. In invalid trials, however, valence might matter insofar as, for example, a threatening cue might hold attention such that the switch to the opposite location is delayed. Thus, the paradigm is aimed more at the process of attentional disengagement. It should be noted that published studies using the emotional spatial cueing task also vary with respect to the task, that is, whether location or discrimination is used. It should be apparent from the preceding considerations that the confound with response interference is evident when the location task is used. Using diffusion model analyses, Imhoff et al. (2019) provided evidence that is compatible with this assumption.

In conclusion, we strongly recommend to not use the location task in paradigms aiming at the measurement of attentional biases for emotional stimuli, like the dot-probe paradigm or emotional spatial cueing. To obtain genuine attentional effects, a confound-free design is necessary, which is provided by using a target discrimination task.

Open practices statement

The data and the program code for all experiments are available on the Open Science Framework (OSF). These files can be accessed via the following link: https://osf.io/32v9d/?view_only=c772c8a8d9f04d20a220254d3559467b

Experiment 1 was preregistered at aspredicted.org. The documentation of this preregistration can be accessed via the following links: https://aspredicted.org/kj8qk.pdf

The stimulus materials of the present study were taken from the NimStim set of facial expressions (Tottenham et al., 2009). Therefore, due to copyright issues, the materials cannot be made publicly available.

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Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1

Results of the overall ANOVA for RTs and Accuracy (Experiment 1)

	RT			Accuracy		
	F(1,174)	p	η_p^2	F(1,174)	p	η_p^2
Emotion (Emo)	2.77	.098	.016	0.06	.808	.000
Cueing (Cue)	1.01	.316	.006	.92	.340	.005
Emo × Cue	3.50	.063	.020	.07	.796	.000
Task	967.32	< .001	.848	34.79	< .001	.167
Emo × Task	3.26	.073	.018	.14	.704	.001
Cue × Task	1.04	.309	.006	.04	.851	.000
Emo × Cue × Task	2.87	.092	.016	.89	.348	.005

Table A2

Results of the overall ANOVA for RTs and Accuracy (Experiment 2)

	RT			Accuracy		
	F(1,62)	p	η_p^2	F(1,62)	p	η_p^2
Cueing (Cue)	41.18	< .001	.399	12.13	< .001	.164
Previous Cueing (PCue)	7.24	.009	.105	5.77	.019	.085
Cue × PCue	21.55	.001	.258	18.76	< .001	.232
Task	313.00	< .001	.835	9.30	.003	.130
Cue × Task	15.68	< .001	.202	5.85	.019	.086
PCue × Task	3.69	.059	.056	6.75	.012	.098
Cue × PCue × Task	9.44	.003	.132	10.56	.002	.146

Appendix B

Table B1

Mean RTs and Cueing Scores (in ms) as a Function of Cue Validity, Emotion, Cue Validity of the Preceding Trial, and Task (Experiment 2)

Task / Cue emotion / Previous Validity	Cue validity		
	Valid	Invalid	Cueing-Score
Discrimination			
Onset (Happy)			
N-1 Valid	823 (95.8 %)	874 (95.6 %)	51 [9]
N-1 Invalid	823 (95.8 %)	870 (95.3 %)	47 [9]
Onset (Angry)			
N-1 Valid	823 (96.1 %)	873 (95.1 %)	50 [9]
N-1 Invalid	831 (95.5 %)	876 (95.8 %)	45 [10]
Location			
Onset (Happy)			
N-1 Valid	370 (99.2 %)	393 (95.9 %)	24 [4]
N-1 Invalid	390 (99.1 %)	391 (98.9 %)	1 [4]
Onset (Angry)			
N-1 Valid	371 (99.8 %)	393 (95.3 %)	22 [4]
N-1 Invalid	391 (98.9 %)	390 (98.6 %)	-1 [4]

Note. Accuracy rates are given in parentheses. SEs are given in brackets, cueing score = $RT_{invalid} - RT_{valid}$.

Table B2

Results of the overall ANOVA for RTs and Accuracy (only emotion-related effects; Experiment 2)

	RT			Accuracy		
	F(1,62)	p	η_p^2	F(1,62)	p	η_p^2
Emotion	1.47	.229	.023	0.08	.775	.001
Emotion × Cueing (Cue)	0.18	.671	.003	0.70	.407	.011
Emotion × Prev. Cueing (PCue)	2.00	.163	.031	0.00	.988	.000
Emotion × Task	0.95	.332	.015	0.04	.834	.001
Emotion × Cue × PCue	0.06	.804	.001	1.72	.195	.027
Emotion × Cue × Task	0.01	.925	.000	0.70	.405	.011
Emotion × PCue × Task	2.59	.113	.040	0.21	.646	.003
Emotion × Cue × PCuei × Task	0.01	.935	.000	0.06	.814	.001

Note: For effects without emotion see Table A2.