Distinct Temporal Processing of Task-Irrelevant Emotional Facial Expressions

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Abstract:

There is an ongoing debate on the extent to which emotional faces automatically attract attention. Using a single-target Rapid Serial Visual Presentation (RSVP) methodology, it has been found that presentation of task-irrelevant positive or negative emotionally salient stimuli (e.g., negative scenes or erotic pictures) results in a temporary inability to process target stimuli (*emotion-induced blindness*). In the present study we sought to examine emotion-induced blindness effects for negative (angry) and positive (happy) facial expressions. Interestingly, task-irrelevant emotional facial expressions *facilitated* rather than impaired target detection when presented in close temporal proximity of the target. Similar facilitation effects were absent for neutral faces or rotated neutral faces that were both included as control stimuli. These results indicate a distinct temporal processing of emotional facial expressions, which accords well with the signal value of emotional expressions in interpersonal situations.

Keywords: attentional bias; temporal attention; facial expressions; attentional blink; emotion-induced blindness; social anxiety

Distinct Temporal Processing of Task-Irrelevant Emotional Facial Expressions

Emotional facial expressions provide crucial information in the context of social interactions (e.g., Goffman, 1967). Accordingly, theorists have assigned a special status to the cognitive processing of emotional facial expressions (e.g., Öhman, 2002). In support of this, a wealth of studies has shown that briefly presented emotional faces attract attention and are associated with heightened activation of neural structures involved in emotion processing and attention (e.g., Pourtois et al., 2004; Schupp et al., 2004).

Originally, research on selective processing of emotional faces has concentrated on the spatial domain (e.g., Bradley et al., 1998). Yet, prioritized processing of emotional faces may not only facilitate detection of relevant interpersonal signals but may also interfere with ongoing task performance (e.g., Bögels & Mansell, 2004). If, for example, signs of (dis)approval are granted prioritized access to limited cognitive resources (e.g., in the context of an ongoing social interaction), detection of (dis)approval may hamper the processing of task relevant information that appears within a certain time interval following the detection of the emotional signal (cf. de Jong et al., 2010).

An approach that seems particularly helpful for examining the temporal characteristics of visual attention towards facial displays is the Rapid Serial Visual Presentation (RSVP) paradigm (e.g., Raymond, Shapiro, & Arnell, 1992). In the RSVP-paradigm multiple slides, including particular targets (e.g., emotional expressions), are presented in rapid succession. Following each trial, participants are asked to identify the target(s). It is a robust finding that target identification rates drop when this target is preceded by another target in close temporal proximity. This deficit in the identification of a second target (T2) has been called the *attentional blink* (AB; Shapiro et al., 1992; Martens & Wyble, 2010). If, indeed, emotional expressions receive preferential processing, such facial stimuli should survive the

AB effect. In line with this, dual-target RSVP studies demonstrated that AB effects are smaller when happy, angry or fearful faces are presented as T2 (e.g., de Jong et al., 2009; Milders et al., 2006). In further support of the view that facial expressions have privileged access to limited cognitive resources, subsequent research showed that the AB for neutral T2 stimuli is enhanced when angry or fearful faces are presented as T1 (Stein et al., 2009; de Jong et al., 2010). Thus, these dual-target RSVP-studies indicate that when engaging in a controlled, top-down search for faces, people readily detect emotional expressions. However, especially threat-related facial expressions elicit elaborate processing that is associated with temporal attention costs.

The present study focused on the effects of spontaneous, bottom-up processing of emotional expressions when people search for a non-facial target. Predictions are less clear for the effects of task-irrelevant faces on subsequent target processing. Previous RSVP-studies showed that task-irrelevant positive and negative arousing stimuli spontaneously capture attention and hamper subsequent detection of non-emotional targets (e.g., Arnell, Killman, & Fijavz, 2007; Ihssen & Keil, 2009; Most et al., 2005; Most et al., 2007). These findings lead to the prediction that emotional faces will similarly attract attention at the cost of current task goals. Yet, the extraction of emotional information from facial expressions often requires monitoring of sequences of facial displays (e.g., Keltner, 1995). Thus, from a functional view on attention, it would be maladaptive if task-irrelevant emotional faces hamper subsequent information-processing that may be necessary for rapid and adaptive responding. Accordingly, this would lead to the contrasting prediction that facial distractors would *not* impede or perhaps even facilitate target identification (e.g., Phelps, Ling & Carrasco, 2006).

Consistent with the latter prediction, an earlier single-target RSVP-study showed that presenting fearful faces as distractors did not impede the identification of neutral targets

(Stein et al., 2009). However, this failure to find an influence of facial distractors on task performance might have been due to particular features of the RSVP-task that was used. The target in this earlier study was presented on a fixed position in the stream. In addition, the neutral targets (indoor/outdoor scenes) as well as the facial distractors clearly stood out in the stream of scrambled-face-filler stimuli. These task features might have helped participants to discard the processing of the facial distractors in a way to optimally comply with their task set (Stein et al., 2009). The very short presentation time of each stimulus within the RSVP-streams (64 ms) might have contributed further to participants' success in conforming to their task and ignoring the facial distractors. Thus, it remains to be established whether the failure of task-irrelevant emotional faces to elicit an AB represents a robust phenomenon that also holds in more ambiguous contexts in which it is more difficult to inhibit the bottom-up processing of task-irrelevant stimuli. Moreover, it would be important to see whether the apparently distinct processing of emotional faces would be restricted to negative expressions or would also be evident for positive (happy) facial expressions.

Following this, the present RSVP-study included both angry and happy face distractors, and was designed to minimize the opportunity for participants to strategically inhibit the processing of (facial) distractors. We therefore (i) presented the targets on variable positions in the RSVP-stream, (ii) used filler stimuli that shared many features with faces to reduce the perceptual differences between distractor and filler stimuli, (iii) used target stimuli that shared many features with both filler and distractor stimuli, and (iv) used longer presentation times. As an additional issue, we tested whether the impact of emotional faces is modulated by social anxiety.

Method

Participants

Participants were 83 undergraduate students (45 women). Scores on the social phobia subscale of the Fear Questionnaire (FQ; Marks & Mathews, 1979) ranged from 0 to 27 (M = 14.75; SD = 5.53). Scores on the Brief Fear of Negative Evaluation Scale (BFNE; Leary, 1983) ranged from 0 - 45 (M = 17.50; SD = 10.24).

Materials and Procedure

We used a single-target RSVP that contained 512 trials, consisting of a variable number of gray scale photographs (118 ms/item). There were four categories of distractor stimuli: angry faces, happy faces, neutral faces, and rotated neutral faces as control stimuli. The latter category was included to examine the specificity of the effect of facial distractors on task performance. We selected rotated faces as control category because these stimuli have identical low level physical features as common facial stimuli but do not readily impress as facial expressions (because of their composition). Facial stimuli were selected from the Karolinska Directed Emotional Faces (KDEF, Lundqvist, Flykt, & Öhman, 1998) database. We selected 6 male and 6 female faces and included all three facial expressions of each of these persons. Previous studies have shown that similarity between targets and distractors enhances the attentional blink (Raymond, Shapiro & Arnell, 1995). Thus to enhance the sensitivity of our task to detect the potential influence of face distractors on target identification, we used photographs (24) of fronts/rears of cars as targets (12 rotated 90 degrees to the left and 12 to the right) because they share many visual features with faces and have a holistic face-like composition. We used 88 different photographs of car fronts/rears as filler stimuli (see Appendix 1) to enhance the perceptual similarity between fillers and targets/distractors.

Distractors were presented on position 3, 4, or 5, and targets two or eight items after the distractor (lag 2 and lag 8). Each target was followed by 6 fillers. At the end of each RSVP-trial, participants pressed either a left-arrow or a right-arrow key to indicate which way the

target had been rotated. Participants were instructed to be as accurately as possible, without speed pressure. Each of the 4 Type of Distractor (happy, angry, neutral, rotated neutral control) x 2 Gender (male, female model) x 2 Lags (2, 8) type of trials was presented 16 times. To test the influence of these distractors, for half of the trials another filler was placed on the same position in the stream as the distractors during the other half of the trials. The experiment consisted of four blocks of 128 trials, with a 30 s break between each block to reduce fatigue. Following the test, participants completed the FQ and BFNE.

Results

To simplify analyses, we first subtracted the percentage correct target identifications on filler trials from those on distractor trials. Percentages of correct identifications are presented in Table 1. The accuracy rates relative to filler trials are depicted in Figure 1.

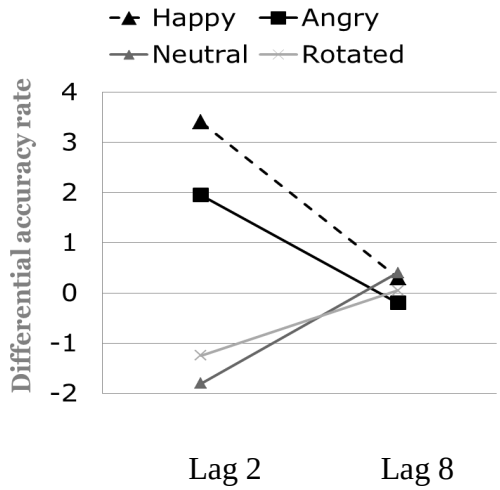

Figure 1. Accuracy relative to filler trials as a function of Lag (2, 8) and Type of Distractor (happy, angry, neutral, rotated neutral control).

A 4 (Type) x 2 (Lag) analysis of variance showed a significant main effect of Type [$F(3,225) = 7.12$, $p<.001$, $\eta^2 = 0.09$], which was qualified by a Type x Lag interaction [$F(3,225) = 7.95$, $p<.001$, $\eta^2 = 0.09$]. There was no main effect of Lag [$F(1,75) = 0.20$]. To analyse the source of the Type x Lag interaction we carried out two separate analyses for each Lag. For

Lag 8, there was no main effect of Type [$F(3,225) = 0.26$, $p = .84$]. For Lag 2, the Type main effect was significant [$F(3,225) = 12.41$, $p<.001$, $\eta^2 = 0.14$]. Tests of within subjects contrasts indicated that relative to control trials showing rotated neutral faces, the percentages correct target identifications were larger for trials showing happy [$F(1, 75) = 19.17$, $p < .01$, $\eta^2 = 0.20$] or angry [$F(1,75) = 9.27$, $p<.01$, $\eta^2 = 0.11$] face distractors. The difference between angry and happy face distractor trials did not reach significance [$F(1,75) = 3.31$, $p = .07$, $\eta^2 = 0.04$]. Also compared to trials showing neutral faces, performance on trials showing happy [$F(1,75) = 24.00$, $p<.01$, $\eta^2 = 0.24$] or angry [$F(1,75) = 14.22$, $p<.01$, $\eta^2 = 0.15$] facial distractors was better. Performance on trials showing neutral face distractors did not differ from performance on control trials displaying rotated neutral faces [$F(1,75) = 0.13$, $\eta^2 < 0.01$].

To evaluate the impact of presenting a particular distractor per se on participants' task performance, we also evaluated the contrasts between distractor and filler trials (as reflected in the intercept). These contrasts indicated that performance significantly improved when happy [$F(1,75) = 19.36$, $p<.01$, $\eta^2 = 0.20$] or angry [$F(1,75) = 6.90$, $p<.05$, $\eta^2 = 0.08$] faces were added to the stream. In contrast, the inclusion of neutral faces [$F(1,75) = 2.70$, $p = .10$, $\eta^2 = 0.03$] or rotated neutral faces that were included as control stimuli [$F(1,75) = 1.52$, $p = .22$, $\eta^2 = 0.02$] did not affect task performance.

Pearson's p-m correlations between the indices of social anxiety (FQ, FNE) and the facial distractor-induced change in error rates (for each type of distractor) did not reach significance.

Discussion

This study examined attentional processing of task-irrelevant emotional faces in a single-target RSVP-task. The presentation of happy and angry facial distractors resulted in

improved task performance rather than in distractor-induced blindness. A similar pattern was absent for neutral or rotated neutral faces that were included as control stimuli. Thus, the results suggest a distinct attentional facilitation following task-irrelevant emotional faces. This effect was found to be independent of social anxiety.

A series of studies have demonstrated that presenting task-irrelevant threatening scenes or erotic pictures in a single-target RSVP impairs task performance (Most et al., 2007). Yet, a previous study testing the impact of task-irrelevant emotional faces failed to find a similar *emotion-induced blindness* effect for fearful faces (Stein et al., 2009). The present study underlined the apparent distinctness of facial processing by showing that task-irrelevant angry or happy faces not only failed to elicit emotion-induced blindness but even resulted in a boosting of task performance. This emotional boosting effect was only observed when the distractor was presented in close proximity to the target. These findings are consistent with the view that emotional expressions may elicit a temporary increase of resources for processing incoming information to promote rapid and adaptive responding (cf. Oatley & Johnson-Laird, 1987). This seems especially relevant for facial expressions as decoding the (implicit) information transmitted via facial displays is often dependent on the analysis of *temporal sequences* of facial gestures. It should be acknowledged, however, that it can not be ruled out that low level physical features associated with happy/angry faces rather than the emotional value per se has driven the current facilitation effect. One way to test this would be to include rotated angry/happy faces in future research.

The failure to find a similar beneficial effect for fearful faces in the RSVP-study of Stein et al. (2009) might be explained by task differences. The fixed position of the target, the shorter presentation of the distractor faces, and the distinctness of the targets may all have helped participants to conform to their task set and to discard the facial distractors. Future

studies are necessary to test whether emotional facilitation is indeed restricted to contexts with only few opportunities for controlling one's attention.

It seems also important to consider an alternative account of the superior performance on angry/happy face distractor trials. Because the occurrence of facial distractors has some predictive value for target onset (distractors always precede the appearance of the target by 2 or 8 items), it could be that these distractors might have helped participants to prepare for the processing of upcoming targets. Thus this alternative account would explain the beneficial effect of emotional face distractors by virtue of their predictive value instead of their virtue to heighten attention. However, if indeed participants would generally profit from the predictive value of distractors, a similar beneficial effect would have emerged for the rotated neutral face control stimuli. Yet, neither these control nor the neutral face distractor stimuli gave rise to enhanced task performance which casts doubt on the relevance of the distractor's predictive value for participants' task performance.

The previous finding that angry (and fearful) faces can also hamper subsequent target processing when presented as T1 (de Jong et al., 2010; Stein et al., 2009) may be explained in terms of two-stage models of temporal attention. These models differentiate between an initial high-capacity sensory processing stage (Stage 1) that may give rise to emotion-induced facilitation effects, and a subsequent limited-capacity attentional processing stage (Stage 2) in which stimulus representations are maintained to enable conscious report (Potter et al., 2002; Wierda, van Rijn, Taatgen, & Martens, 2012). This latter process enhances the processing of emotional stimuli at the expense of neutral stimuli (Bocanegra & Zeelenberg, 2009). This may explain why angry faces hamper subsequent task performance when presented as T1, because under that condition the angry faces need to be overtly identified and thus require access to Stage 2 processing.

All in all, the present results indicate that people are generally prone to spontaneously attend to emotional facial expressions. This is in line with views proposing that emotional facial expressions receive high priority, even under conditions of competition and limited cognitive resources (e.g., Öhman & Mineka, 2001). Yet, the present finding that the influence of facial distractors on target detection was similar for angry and happy faces provides no further evidence for the idea that the automatic capture of visual attention would be specific for threatening faces. To conclude, this study is the first to show that angry and happy faces are processed in a temporally distinct fashion, causing a momentary enhancement of attention for stimuli presented within close temporal proximity.

Authorship

All authors contributed to the development of the study concept and the study design. Testing and data collection were performed by SQN and AvL under supervision of LB and PdJ. AvL and PdJ performed the data analysis. PdJ drafted the paper, and all authors provided critical revisions. All authors approved the final version of the paper for submission.

Author Note.

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Figure Legend

Figure 1. Accuracy relative to filler trials as a function of Lag (2, 8) and Type of Distractor (happy, angry, neutral, or rotated neutral faces).

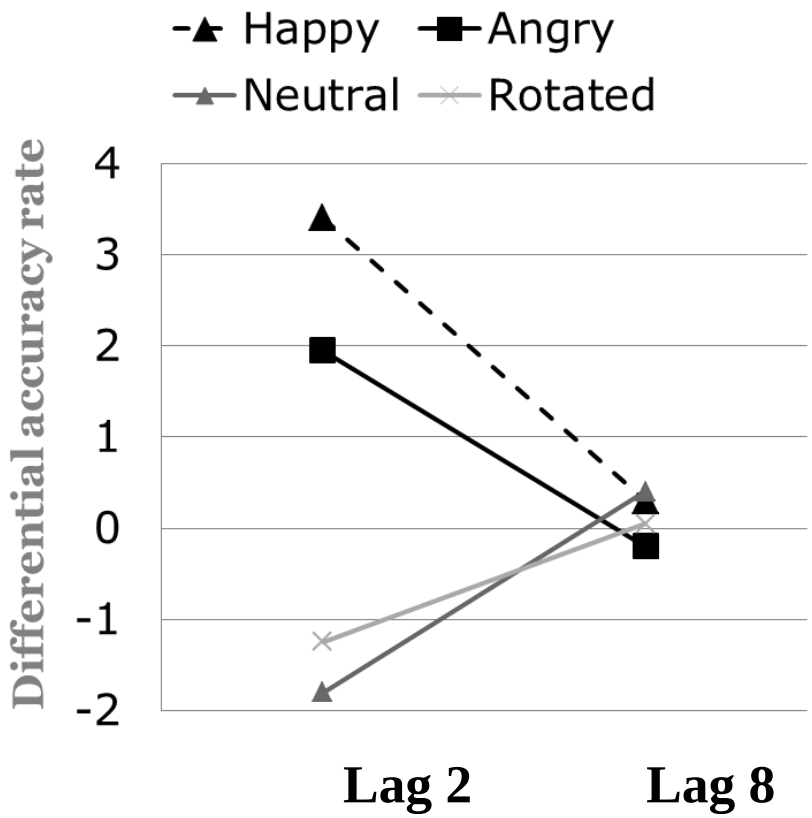
Happy
Angry
Neutral
Rotated
Differential accuracy rate
4
3
2
1
0
-1
-2
Lag 2
Lag 8

Table 1. Mean (SE) Percentage of Correct Target Identification as a Function of Type of Distractor and Lag (2 vs. 8).

	Angry		Happy		Neutral		Rotated		Filler	
Lag	2	8	2	8	2	8	2	8	2	8
Measures										
% Correct	87.34	87.62	88.81	88.18	83.82	88.28	84.18	88.09	85.44	87.77
	(11.59)	(12.19)	(9.94)	(10.69)	(12.48)	(11.40)	(12.61)	(11.41)	(10.44)	(10.52)

Appendix 1: Illustration of the Critical Part of a Typical Trial. The Rotated Target (Car) and the Distractor (Face) are Presented in a Stream of Cars.