Feature-specific attention allocation overrules the orienting response to emotional stimuli

Tom Everaert, Adriaan Spruyt, Valentina Rossi, Gilles Pourtois, and Jan De Houwer
Department of Psychology, Ghent University, Henri Dunantlaan 2, B-9000 Ghent, Belgium

Emotional stimuli are generally thought to be processed in an unconditional fashion. Recent behavioral studies suggest, however, that emotional stimulus processing is critically dependent on attention toward emotional stimulus features. We set out to test this hypothesis using EEG measurements and a modified oddball paradigm. Unexpected emotional stimuli evoked amplitude variations of the P3a (an ERP marker of attention orienting) when attention was directed to emotional stimulus properties but not when non-emotional stimulus properties were attended to. We conclude that emotional stimulus processing is not unconditional, but dependent on top-down attentional control.

Keywords: emotion; attention; P3a

In line with the assumption that emotional stimuli are processed in an unconditional, bottom-up fashion (e.g. Zajonc, 1984; Vuilleumier, 2005), a large number of studies have shown that the emotional tone of a stimulus can exert a profound impact on both behavior and neural activity (Pourtois et al., 2013). The amygdala, for instance, reacts more to emotional than to non-emotional stimuli (Morris et al., 1998; LeDoux, 2000; Phelps and LeDoux, 2005). Furthermore, the emotional tone of a stimulus affects several ERP components (Oloffson et al., 2008) such as the P1 component, related to early visual processing (Smith et al., 2003), and the P3a component, related to attention orienting (Campanella et al., 2002a). Moreover, such effects can occur even when the emotional stimulus is presented outside of conscious awareness (e.g. Kemp–Wheeler and Hill, 1992; Öhmann and Soares, 1998; Gaillard et al., 2006). Nevertheless, there is also evidence showing that emotional stimulus processing can be disrupted under certain conditions. For example, several researchers found no effects of emotional stimulus processing when a large attentional load is present (e.g. Pessoa et al., 2002; Lange et al., 2003; Doallo et al., 2006).

Building further on this discrepancy, a recent account proposed that emotional stimulus processing is not unconditional, but depends critically on feature-specific attention allocation instead (FSAA). In several studies, evidence for emotional stimulus processing was found only under conditions that promoted selective attention to emotional stimulus information. Similarly, evidence for enhanced processing of non-emotional semantic stimuli was found under conditions that promoted selective attention to relevant semantic stimulus information (Spruyt et al., 2007, 2009, 2012; Everaert et al., 2013). Such effects could have taken place through means of attentional sensitization, a process by which the pathways responsible for affective or semantic stimulus processing are enhanced or attenuated depending on current task demands (Kiefer and Martens, 2010; Kiefer, 2012). In the studies corroborating this account, however, emotional stimulus processing was measured at the behavioral level only. It thus remains to be seen whether these effects reflect a genuine modulation of emotional stimulus processing or merely reflect a performance effect instead. To resolve this issue, we examined the impact of FSAA on both emotional and non-emotional stimulus processing using EEG measurements.

Emotional stimuli can modulate the amplitude of the ERP signal in a variety of ways, one of which is related to the orienting of attention to unexpected stimuli in the environment. Unpredictable stimuli generally grab attention, which is reflected in the EEG signal by the P3a potential, a positive going deflection characterized by a fronto-central maximum peaking 250–350 ms post-stimulus onset (Knight, 1996; Hermann and Knight, 2001; Polich, 2007). Furthermore, when these unexpected stimuli are task-relevant, this component is accompanied by a P3b potential, which has a more centro-parietal maximum and generally peaks after the P3a component (400–800 ms). The P3a component (Campanella et al., 2002a; Delplanque et al., 2006) as well as the P3b component (Campanella et al., 2002b; Delplanque et al., 2004) seem to be sensitive to emotional variations in stimuli, especially in anxious populations (Rossignol et al., 2008). We therefore decided to perform an oddball study in which deviant, unexpected task-relevant and task-irrelevant stimuli were embedded in a sequence of expected (standard) stimuli.

We hypothesized that the orienting response toward emotional stimuli would be conditional on FSAA. Furthermore, we expected orienting responses toward non-emotional deviant stimuli to be dependent on FSAA as well. To test this hypothesis, participants were presented with a series of standard stimuli that were faces of middle-aged persons with a neutral facial expression. Occasionally, one of four types of deviant stimuli were presented: middle-aged happy, middle-aged sad, young neutral and old neutral faces. To manipulate attention, participants were asked to respond to one of the four types of deviant faces. In the emotion group, the go-stimuli were faces with a happy or sad expression. Hence, participants in this group directed their attention to the emotional content of the face. In the age group, the go-stimuli were young or old faces with a neutral expression. Attention allocation to the age of the faces was therefore required in this group. In each condition, there was one task-relevant deviant and two task-irrelevant deviants. A deviant is said to be task-relevant if it deviates from the standard stimuli on the same dimension (emotion or age) as the go-stimulus. For instance, if the go-stimuli were happy faces, sad faces were task-relevant deviants whereas young and old faces were task-irrelevant deviants.

We predicted that the P3a for task-relevant emotional deviants would be larger than the P3a for task-irrelevant emotional deviants.
For instance, the P3a to a deviant sad face should be smaller when participants were asked to detect young or old faces than when their task was to detect happy faces. Similarly, based on our existing behavioral data, we predicted the processing of non-emotional features to depend on attention allocation as well. That is, we expected the P3a for young and old deviant stimuli to be larger when they were task-relevant than when they were task-irrelevant.

**METHOD**

**Participants**

Thirty-three volunteers with normal or corrected-to-normal vision were paid € 20 to participate in this study. Six subjects were excluded from the analyses because their error percentages exceeded 20% in at least one cell of the design. The final sample thus consisted of 27 participants (M<sub>age</sub> = 21.8 years, 5 males, 2 left-handed), which is comparable to the sample size of previous studies focusing on the effects of emotion oddball on the genesis and systematic amplitude variations of the P3a (Campanella et al., 2002a; Delplanque et al., 2006; Rossignol et al., 2008).

**Stimuli and materials**

Facegen software (http://www.facegen.com) was used to create artificial faces and carefully parameterized variations of these faces along the emotion and age dimensions. To obtain a sufficiently large stimulus set, we first generated 32 random, distinct faces. In a next step we used the program’s ability to change the age and emotion of these faces to create 5 versions of each of the 32 faces: a neutral, 43-year-old face; a sad, 43-year-old face; a happy, 43-year-old face; a neutral, 15-year-old face; and a neutral, 65 year-old-face (for an illustration, see Figure 1). Consequently, 160 (32 × 5) different face pictures were used as stimuli, representing either standard, happy, sad, young or old faces. The settings used to generate the five different versions of the faces were piloted to ensure that the differences between the standard faces and the other faces were as comparable as possible. The pictures of the face stimuli measured 235 (width) × 215 (height) pixels and were presented in the center of a 19-inch CRT monitor with a refresh rate of 100 Hz and a resolution of 800 × 600 pixels.

**Procedure**

Participants were seated in a dimly lit room and were randomly assigned to one of two between-subjects conditions. Participants in the emotion group (n = 13) read instructions stating that the experiment aimed at investigating emotion perception. Participants in the age group (n = 14) read instructions stating that the experiment concerned age perception. They were asked to press the space bar with their dominant hand whenever a predefined face appeared in sequence of trials. Within each block, only one of the two emotions in the emotion group and one of the two ages in the age group required a response. The relevant emotional face type in the emotion group (happy or sad) and the relevant age face type in the age group (young or old) were alternated between blocks. Participants in the emotion group thus alternated between detecting happy faces and sad faces, whereas participants in the age group alternated between detecting young faces and old faces.

After reading the instructions, participants performed 2 training blocks of 20 trials each and 12 experimental blocks of 100 trials each. The stimuli presented in each block consisted of 80% standard faces and 20% deviant faces. Each type of deviant occurred equally often (5% of all trials).

The stimuli were assigned to the different blocks according to a specific procedure. For each of the 2 training blocks, 1 face and its variations were drawn from the basic set of 32 faces. For the 12 experimental blocks, the remaining set of 30 faces was divided in 6 subsets of 5 faces and their variations. The stimuli that were used in a block comprised of one subset. Since there were 12 blocks and 6 subsets, each subset was used twice throughout the experimental session. Therefore, 5 variations of 5 faces were used in each block. These 6 subsets were the same for each participant.

A trial consisted of the central presentation of a face that remained on screen until a response was given or 1500 ms elapsed. Afterwards, an inter-trial interval was initiated that varied randomly between 300 ms and 600 ms.

**EEG acquisition and statistical analysis**

An elastic cap was used to allow for the recording of the EEG through 128 Ag/AgCl electrodes that were distributed according to the ABC positioning system, with all electrode positions being radially equidistant from Cz (unlike an extended traditional 10/20 system). The signal was recorded with a Biosemi Active Two System (http://www.biosemi.com) and was referenced online to a CMS-DRL ground which drives the subject’s average potential as close as possible to the reference voltage of the amplifier (i.e. the amplifier zero). Additionally, two electrodes linking the mastoids were used to reference the data off line and four electrodes served to monitor vertical and horizontal eye movements. EEGs were digitized at 512 Hz and were band-pass filtered offline from 0.016 Hz and 70 Hz. An additional notch filter centered around 50 Hz reduced AC interference.

Off-line computations were performed with Brain Vision Analyzer 2.0 (Brain Products, GmbH, Munich, Germany). Segmentation was performed relative to stimulus onset with an interval ranging from 100 ms before to 1500 ms after stimulus onset. We corrected for eyeblink artifacts using the standard algorithm of Gratton et al. (1983). Each segment was baseline corrected to the 100 ms pre-stimulus onset interval. Trials contaminated by residual artifacts were semi-automatically detected and rejected with ±75 μV criterion relative to the baseline. Grand average waveforms were calculated separately for each Stimulus Type (standard face vs emotionally deviant face vs age deviant face) of each group (emotion vs age).

The identification of the P3a and P3b components was based on previous research (a.o. Polich, 2007) and visual inspection of the ERPs evoked by the deviants. The P3b component was identified as a slow component with a large, positive peak occurring between 400 ms and 800 ms after stimulus onset that was maximal over centro-parietal sites. The P3a component, however, emerged in the data as a smaller, positive peak that occurred earlier (between 220 ms and 400 ms after stimulus onset) and was maximal on more anterior, centro-prefrontal sites. Further analyses were based on the mean amplitudes in the aforementioned time intervals.

To minimize the impact of variance unrelated to oddball effects, we subtracted the mean amplitudes of the ERPs evoked by the standard faces from the mean amplitudes of the deviant faces. These difference scores (deviant – standard) where then entered as dependent variables in repeated measures ANOVA and post-hoc t-tests. A difference score that is significantly different from zero thus indicates a significant difference between the mean amplitudes evoked by deviant faces and the mean amplitudes evoked by standard faces (i.e. a significant P3a effect).
RESULTS

Behavioral results

Reaction-times for correct responses were analysed after exclusion of outlying latencies (3.3%). Cut-off boundaries were defined as being 2.5 s.d. above and below a participants’ mean latency in a particular condition (Ratcliff, 1993). No effects reached significance (Table 1).

An analysis of the number of correctly identified target faces (Table 2) revealed that participants made more correct identifications for sad target faces than for happy target faces, t(13) = 2.38, P < 0.05, d = 0.66. No other differences with regard to the number of correct hits reached significance, all t’s <1.65.

A 2 (group: emotion vs age) × 2 (dimension: emotion vs age) × 2 (face type: young or sad vs old or happy) repeated measures ANOVA on the false alarm rates (Table 3) revealed a significant main effect of dimension, F(1,25) = 5.76, P < 0.05, MSE = 0.08, f = 0.48, indicating more false alarms were made to emotional deviants. Also, a significant interaction between group and dimension showed that more false alarms were made toward task-relevant deviants than to task-irrelevant deviants, F(1,25) = 12.76, P < 0.01, MSE = 0.08, f = 0.71.

ERP results

A positive peak that occurred roughly between 220 ms and 400 ms post-stimulus and was maximal on prefrontal sites was clearly visible in the grand average data. These electrophysiological properties were compatible with the generation of a P3a component (Figure 2). Further analyses were restricted to the difference scores for the electrode that corresponded to Fpz/C17 and its surrounding five electrodes. A 2 (group: emotion vs age) × 2 (deviant type: emotion vs age) repeated measures ANOVA on the mean amplitude differences yielded a significant intercept, F(1,25) = 4.64, P = 0.041, MSE = 45.58, d = 0.36, and a significant interaction, F(1,25) = 6.61, P = 0.017, MSE = 2.48, f = 0.51. The significant intercept suggests that, overall, the deviants evoked a P3a. The interaction between group and deviant type, however, indicated that task-relevant deviant faces produced a significant P3a only, F(1,25) = 12.62, P = 0.002, MSE = 4.62, d = 0.28, whereas task-irrelevant deviant faces did not, F <1. Specifically, emotional deviants evoked a significant P3a when they were task-relevant, F(1,12) = 21.94, P = 0.0005, MSE = 1.88, d = 1.30, but not when they were task-irrelevant, F <1. Conversely, there was a tendency for age deviants to evoke a P3a when they were task-relevant, F(1,13) = 2.63, P = 0.129, MSE = 7.15, d = 0.43, that was not present when they were task-irrelevant, F(1,13) = 1.16, P = 0.303, MSE = 5.20, d = 0.30.

Similar effects emerged when the amplitude of the P3b was analysed (Figure 3). These analyses were restricted to the mean difference scores of six electrodes, that is Pz/A19 and its five surrounding, more posterior, electrodes. A 2 (group: emotion vs age) × 2 (deviant type: emotion vs age) repeated measures ANOVA also revealed a significant intercept term, F(1,25) = 79.90, P < 0.001, MSE = 11.07, d = 1.76, and a significant interaction between the two factors, F(1,25) = 48.49, P < 0.0001, MSE = 7.12, f = 1.39. The significance of the intercept

![Fig. 1](image-url) Selection of two faces used in this study, with their corresponding variations in emotion and age.

<table>
<thead>
<tr>
<th>Deviant type</th>
<th>Happy</th>
<th>Sad</th>
<th>Young</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean RT</td>
<td>674</td>
<td>689</td>
<td>677</td>
<td>671</td>
</tr>
<tr>
<td>SD</td>
<td>69</td>
<td>68</td>
<td>74</td>
<td>68</td>
</tr>
</tbody>
</table>

Notes: The columns relating to the happy and sad faces apply to the emotion group only. The columns relating to the young and old faces apply to the age group only.

<table>
<thead>
<tr>
<th>Deviant type</th>
<th>Happy</th>
<th>Sad</th>
<th>Young</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>92.4</td>
<td>97.4</td>
<td>95.0</td>
<td>95.0</td>
</tr>
<tr>
<td>SD</td>
<td>95.2</td>
<td>95.7</td>
<td>96.4</td>
<td>95.2</td>
</tr>
</tbody>
</table>

Notes: The percentages relating to the happy and sad faces apply to the emotion group only. The percentages relating to the young and old faces apply to the age group only.
indicates that, in general, a significant P3b was evoked by the deviants. Furthermore, every deviant type evoked a significant P3b, all $F$s > 4.69. However, the significant interaction indicated that the P3b amplitude was higher for task-relevant deviants than for task-irrelevant deviants, both for emotional deviants and age deviants, $F(1,25) = 28.21$, $P < 0.0001$, $MSE = 6.42$, $d = 1.42$, and $F(1,25) = 13.95$, $P < 0.001$, $MSE = 11.77$, $d = 2.07$, respectively. Furthermore, the P3b components elicited by the task-irrelevant emotional deviants did not differ
significantly from the P3b elicited by the task-irrelevant age deviants, \( F(1,25) < 0 \).

In addition, we also analysed the participants’ P3b mean amplitudes in response to the target emotional faces (emotion group) or the target age faces (age group). To that end, we performed a 2 (group: emotion vs age) \( \times \) 3 (stimulus type: target vs task-relevant deviant vs task-irrelevant deviant) repeated measures ANOVA. Only the main effect of stimulus type reached significance, \( F(2,50) = 61.53, \)
The absence of a significant interaction between group and stimulus type suggests that ‘targetness’ (reflected by an enhanced P3b component) was actually balanced between the two groups (age vs emotion group), $F(1,25) = 1.32$, $P = 0.26$, MSE = 44.12, $d = 0.44$.

To further validate the results obtained with traditional mean amplitude analyses, we performed an ERP topographical mapping analysis using the Cartool program (http://brainmapping.unige.ch/cartool). With this analysis, we assessed whether the abovementioned FSAA effects could also be evidenced when considering the global distribution of the electric field, rather than the mean amplitudes at a few electrode positions. Following standard practice, the grand average ERP waveforms were segmented into a restricted number of dominant topographical maps (i.e. microstates) by means of the K-means clustering algorithm (Pourtois et al., 2008). When the clustering algorithm was limited to the temporal interval in which the P3a occurred, a 3-map-solution (Figures 4 and 5) emerged that explained 95.80% of the total variance and was considered the best possible trade-off between data reduction and variance accounted for.

Map 3 emerged in this solution as the map that was related to the P3a due to its topography, marked by relatively more frontal positivity than the two other maps. Next, the dominant maps were fitted to the individual data sets to obtain quantitative values that would allow for statistical analyses. The dependent variable of these analyses was Global Field Power (GFP), which is a measure of the strength of the underlying field potentials of a given map. A 2 (group: emotion vs age) x 2 (map: map 2 vs map 3) repeated measures ANOVA on these GFPs revealed a significant three-way interaction between group, map and deviant, $F(1,25) = 5.14$, $P = 0.032$, MSE = 0.01, $f = 0.61$. When looking at each dominant map separately, a significant two-way interaction between group and deviant was observed for map 3 only, $F(1,25) = 15.90$, $P < 0.001$, MSE = 0.73, $f = 0.78$. This interaction revealed that the mean GFP was higher for task-relevant deviants than for task-irrelevant deviants. When broken down across deviant type (emotion vs age), the difference between task-relevant and task-irrelevant deviants remained significant (albeit marginally). Task-relevant emotional deviants yielded higher mean GFPs than task-irrelevant emotional deviants, $F(1,25) = 2.91$, $P = 0.101$, MSE = 1.82, $d = 0.66$, and task-relevant age deviants yielded higher mean GFPs than task-irrelevant age deviants, $F(1,25) = 3.03$, $P = 0.094$, MSE = 2.10, $d = 0.67$. No significant two-way interaction was found upon inspection of map 2, $F < 1$.

**Fig. 4** The maps that were extracted using Cartool (http://brainmapping.unige.ch/cartool).

**Fig. 5** The temporal distribution of the extracted maps for the emotion group (A) and the age group (B).

---

1. Emotional stimuli can influence ERP components generated earlier than the P3a following stimulus onset (e.g. Valldevera and Pouthos, 2007). An analysis of the mean amplitude around the peak corresponding to the N1/170 (160 – 190 ms post-stimulus onset, 6 lateral occipital electrodes) showed a trend significant two-way interaction between group and deviant type, $F(1,25) = 2.60$, $P = 0.119$, MSE = 4.91, $d = 0.32$. In line with our prediction, the difference in mean amplitude between the deviants and the standards reached marginal significance in the emotion group for the emotional deviants, $F(1,12) = 3.28$, $P = 0.095$, MSE = 1.10, $d = 0.50$, but not for age deviants, $F(1,12) < 1$. In the age group, this difference reached marginal significance for the age deviants, $F(1,13) = 3.26$, $P = 0.094$, MSE = 0.97, $d = 0.47$, but not for the emotional deviants, $F(1,13) < 1$. Although we first set out to perform a similar analysis for the face-specific vertex positivity (VPP, see Jeffreys and Tukmachi, 1992), no reliable VPP was elicited in our study and accordingly this component was not further considered. Further analyses on the EPN (280 – 320 ms post-stimulus onset, 6 lateral occipital electrodes) revealed similar effects, showing a significant two-way interaction between group and deviant type, $F(1,25) = 13.86$, $P = 0.013$, MSE = 1.93, $f = 0.54$. Although a marginally significant main effect suggested a greater EPN for emotional deviants irrespective of group, $F(1,25) = 3.37$, $P = 0.08$, MSE = 1.93, $f = 0.36$, the EPN evoked by emotional deviants in the emotion group was significantly larger than the EPN evoked by emotional deviants in the age group, $F(1,25) = 4.26$, $P = 0.049$, MSE = 2.99, $d = 0.46$. The difference between the EPN evoked by the age deviants in the emotion group and the age group did not reach significance, however, $F(1,25) = 1.58$, $P = 0.22$, MSE = 1.81. It may be noted, though, that the oddball paradigm used in the present study might not be optimal to study potential emotional modulations of these earlier sensory-related visual ERP components (Valldevera and Pouthos, 2007; Pouthos et al., 2013).

---
DISCUSSION

Emotional stimuli are generally thought to be processed in a fairly unconditional manner (e.g. Zajonc, 1984; Vuilleumier, 2005). This preferential processing can be reflected by an enhanced P3a component, which is usually evoked by unexpected stimuli and seems especially sensitive to emotional deviance (Campanella et al. 2002a; Olofsson et al., 2008; but see Pessoa, 2005). However, recent studies suggested that emotional stimulus processing occurs only when attention is directed to emotional stimulus information. Likewise, enhanced processing of non-emotional semantic stimuli is expected to occur when attention is directed to relevant non-emotional stimulus information (Spruyt et al., 2007, 2009, 2012; also see Kiefer and Martens, 2010; Kiefer, 2012).

We put this prediction to the test using EEG measurements and a standard oddball experiment. We found an enhanced P3a for unexpected emotional faces only when participants were encouraged to attend selectively to this specific face dimension. In contrast, a trend toward an enhanced P3a for unexpected young and old faces was found when participants were encouraged to attend selectively to age-related stimulus information. This modulation by FSAA was found using standard mean amplitude measures as well as alternative topographical mapping analyses that minimize the number of priors regarding the position and latency of the effects of interest. Our results therefore provide strong neurophysiological evidence for a dependence of emotional stimulus processing by FSAA (Spruyt et al., 2007, 2009, 2012; Everaert et al., 2013).

Although the results clearly show evidence for emotional stimulus processing only when attention was directed toward emotional stimulus features, it might be noted that further research is needed to establish the generality of this finding. For instance, the emotional expressions employed in this study were limited to sadness and happiness, which might be considered among the least potent of facial expressions. Accordingly, it remains to be established whether stimuli that are considered as more potent, such as fearful and threatening faces or emotional scenes, might be processed truly unconditionally, because of their more direct relevance to survival. Previous studies already showed that such stimuli may have the propensity to modulate early electrophysiological activities independently of specific attention or task demands (Vuilleumier, 2001; Pourtois et al., 2004; Schupp et al., 2007; Ferrari et al., 2008 Weinberg et al., 2012). Furthermore, similar effects have been found for other, non-emotional types of stimuli, such as faces in general (Finkbeiner and Palermo, 2009).

The account of FSAA, however, predicts that feature-specific attention is a necessary precondition for the processing of all emotional stimuli, including the extremely potent ones. Consequently, it can be presumed that FSAA might have been involved in earlier studies that corroborated unconditional emotional stimulus processing. Although participants were not explicitly asked to direct attention to emotional stimulus information in these studies, several characteristics of the experimental procedure, such as the blatant use of extreme, emotional stimuli, might have encouraged participants to do so (e.g. Everaert et al., 2011). Furthermore, recent behavioral studies have shown that emotional processing of extreme, affective stimuli (e.g. IAPS pictures; Lang et al., 1999) is not unaffected by manipulations of FSAA (Everaert et al, 2013). Future research should point out whether these effects translate to the neural level as well.

Our results go beyond earlier studies which suggest that emotional stimulus processing depends on attentional capacity and awareness (Pessoa, 2005). For instance, neural effects of emotional stimulus processing have been successfully abolished by presenting emotional stimuli under suboptimal conditions. Such conditions include presenting stimuli at unattended locations under a sufficiently high cognitive load (e.g. Pessoa et al., 2002; Erthal et al., 2005), or presenting stimuli below awareness thresholds (e.g. Phillips et al., 2004). The FSAA framework of Spruyt et al. (2007, 2009, 2012) predicts, however, that unconscious emotional stimulus processing can nevertheless occur under conditions that promote selective attention for emotional stimulus properties (Spruyt et al., 2012). Given the necessary condition that attention is directed toward emotional stimulus features, emotional stimulus processing will occur, even when stimuli are presented below awareness thresholds, at unattended locations, or when a high cognitive load taxes the available processing capacities. These predictions also fit Kiefer’s (2012; Kiefer and Martens, 2010) attentional sensitization model, which proposes that attentional enhancements of task-relevant processing pathways can even boost the processing of subliminally presented stimuli. Spruyt et al. (2012) provided data supporting this hypothesis, showing that subliminal affective priming depends critically on whether or not affective stimulus information is attended to. Hence, although both accounts are intrinsically related, the major difference between the account of FSAA and the account put forward by Pessoa (2005) pertains to the former proposing that emotional stimulus processing depends on attention toward a stimulus feature whereas the latter proposes that emotional stimulus processing depends on attention toward the specific stimulus as a whole.

In sum, we reported evidence for emotional stimulus processing to be conditional on FSAA. An enhanced P3a orienting response for emotional, unexpected stimuli was found only when emotional stimulus information was rendered task-relevant. This finding corroborates earlier behavioral studies and extends current theories on the attentional dependence of emotional stimulus processing.

REFERENCES


