COGNITIVE AND CULTURAL INFLUENCES ON EYE MOVEMENTS

认知与文化的眼动研究

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Chapter 9

Do emotional scenes catch the eye?

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To cope with the information processing limitations of the cognitive system, the attentional system ensures that the brain prioritizes the processing of highly salient and unexpected stimuli at the expense of other ongoing neural activity and behavior (Corbetta & Shulman, 2002). Emotional processes assess the importance of sensory events to our well-being and adjust our physiological, behavioral and cognitive responses to cope with encountered challenges by governing approach-avoidance behavior (Frijda, 1986; Lazarus, 1991; Scherer, 1999). Thus, emotion and attention are related as they both manage information processing priorities in the human brain (Oatley & Johnson-Laird, 1987) based on the perceived visual and phylogenetic salience of events occurring in the environment.

Both neuropsychological and behavioral studies suggest that affective stimuli are highly salient and consequently are especially likely to capture attention (for reviews, see Compton, 2003; Vuilleumier, 2005). Effective visual perception relies on the visual system's ability to acquire detailed information from the environment. Visual acuity is highest around the fovea. As the diameter of the foveal field of vision is small (2.5 degrees, see Wandell, 1995), the attentional system must be complemented by a perceptual mechanism that governs where the fovea is positioned from moment to moment (i.e., where to position the center of an eye fixation).

There has been some debate about what factors guide the eyes during scene perception. Although it is widely agreed that overall the eyes spend more time fixating informative regions of a visual scene than less informative regions (see Castelhano & Rayner, this volume; also Buswell, 1935; Henderson, Weeks, & Hollingworth, 1999; Loftus & Mackworth, 1978; Mackworth & Morandi, 1967; Yarbus, 1967; for a review, see Henderson & Hollingworth, 1999), there is some disagreement about the features of the scene that drive the eyes initially. In other words, the debated question is what determines where the eyes land initially on a scene. A seminal study of Loftus and Mackworth (1978) provided evidence supporting semantic guidance (for a review, see Henderson & Hollingworth, 1999). Surprising objects that did not fit in the scene (e.g., a lawnmower in the kitchen) were more likely to be fixated following the first saccade within the scene than scene-consistent objects (e.g., a toaster on the kitchen table). However, more recent studies of Henderson et al. (1999) and De Graef, Christiaens and d'Ydewalle (1990) could not replicate this early inconsistency effect. According to these studies, observers were not more likely to launch the initial saccade to an inconsistent than to a consistent object. Yet, the most recent studies of Underwood (2005) and de Graef (2005) have obtained evidence consistent with the early study of Loftus and Mackworth (see also Gordon, 2004, who showed, using a probe recognition paradigm, that attention is very rapidly and automatically drawn toward an inconsistent object). In sum, based on the available evidence it is not clear whether the initial eye fixation on a visual scene is primarily guided by low-level visual factors or by knowledge-based (semantic) guidance.

In the present chapter, we review studies that investigate whether the affective content of visual scenes is capable of automatically engaging the oculomotor system. More specifically, we examine whether participants are more likely to make an initial fixation on an emotional than neutral picture when an emotional and a neutral picture are presented simultaneously. We also examine whether saccadic trajectory is affected by parafoveally presented emotional pictures. In the final section we discuss the implications of our findings to the models of eye movement guidance during scene perception.

Prioritized processing of emotional content in the human brain

Four lines of evidence suggest that the brain prioritizes the processing of emotional information. Firstly, event-related-potentials (ERPs) recorded from the visual cortices demonstrate differences between schematic emotional and neutral faces as early as 80-90 ms from stimulus onset (Eger, Jedynak, Iwaki, & Skrandies, 2003) and around 250 ms from stimulus onset of complex emotional scenes (Junghöfer, Bradley, Elbert, & Lang, 2001). This suggests that discrimination between emotional and neutral visual information occurs early during visual processing. Secondly, even unattended emotional facial expressions produce enhanced responses in the fusiform face area when compared to unattended neutral facial expressions (Vuilleumier, Armony, Driver, & Dolan, 2001; see also Vuilleumier, Armony, & Dolan, 2003, for a recent review), though allocation of attention to another, resource-consuming task can interfere with the processing of task-irrelevant emotional information (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Pessoa, 2005). Thus, the high saliency of emotional stimuli could result from an enhanced sensory response to them, rendering them more—but not completely—resistant to suppressive interference (Vuilleumier, 2005). Thirdly, although visual acuity decreases rapidly outside foveal vision, both brain imaging and behavioral studies show that at least gross emotional information can readily be extracted even from the parafovea. Vuilleumier et al. (2001) demonstrated that fearful faces presented outside participants' foveal vision and visual attention can increase amygdala activity—a response traditionally attributed to processing of fear (see Adolphs, 2002). Similarly, when emotional visual scenes exceeding the area of foveal vision were presented 1.3° away from the fixation point, Keil, Moratti, Sabatinelli, Bradley, and Lang (2005) found enhanced cortical activation in the occipito-temporal and parietal regions in comparison with neutral scenes. These results suggest that the perceptual span may be wider for emotional than neutral scenes. This finding is corroborated by Calvo and Lang (2005). Employing a recognition priming paradigm, they presented two prime pictures (one neutral, one emotional) simultaneously to the left / right parafoveal visual field for 150 ms, followed first by a mask and then by a probe picture. Emotional probes were more likely to be recognized than neutral probes when primed by a picture of identical semantic content but different in size, orientation, and color, thus suggesting a parafoveal processing advantage for emotional over neutral content. The prioritized processing of emotional information is likely to be related to the amygdalar processing of emotional information and the amplified processing of emotional information in the visual cortex (VC) resulting from the thalamo-amygdalar projections to the visual cortex (see LeDoux, 1995; Vuilleumier, 2005, for reviews). Fourthly, as processing of emotional information is prioritized in the visual system, it logically follows from this that perception of emotional content brings about a reflexive shift of visual attention and an accompanying saccade to the emotional picture. Below we review in more detail our studies bearing on this final point.

Attentional capture by emotional pictures

Although a strong behavioral (Henderson, 2003) and neuropsychological (Awh, Armstrong, & Moore, 2006) relationship has been established between covert and overt orienting, only recently have the eye movement recording techniques been applied to the study of attentional capture by emotional content. Studies employing manual response latency paradigms have provided support for an attentional bias at different phases of attention orienting described by Posner's (1980) three-stage cycle of attention orienting: (1) disengagement of attentional resources from the currently attended objects, (2) shift of attention towards a new object, and (3) engagement of attention on the new object.

Studies using a modified version of Posner's cueing task with emotional pictures as cues have mainly demonstrated a bias in attentional engagement for emotional content, such as angry faces (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002), or complex pictures of threat-related scenes (Yiend & Mathews, 2001). The dot probe variant of the cuing task involves simultaneous presentation of two pictures, one emotional and one neutral, prior to the target dot probe that appears at the location of either of the pictures. The underlying assumption in this paradigm is that if an emotional picture captures attention, the dot probe that replaces this picture will be responded to faster than a dot probe that replaces a neutral picture. Anxious individuals have been found to react particularly quickly when the dot replaces an angry face (Bradley, Mogg, Falla, & Hamilton, 1998; Mogg & Bradley, 1999). Armony and Dolan (2002) found with aversively conditioned angry faces that all participants were faster to respond to the probe that replaced an angry face in comparison with a neutral face. Similarly, when the stimuli depict highly threatening scenes rather than emotional faces, all individuals tend to show a bias towards them (Mogg, McNamara et al., 2000).

Studies employing variants of the visual search task have provided corroborative evidence. In such tasks participants are required to search for a pre-specified target stimulus or for a non-prespecified discrepant object, for example, a spider, embedded in an array of non-target stimuli such as flowers. Studies have consistently demonstrated that a discrepant schematic angry face is detected faster among other faces than a friendly or sad face (Calvo, Avero, & Lundqvist, 2006; Fox et al., 2000; Öhman, Lundqvist, & Esteves, 2001; Tipples, Atkinson, & Young, 2002). Studies employing more complex stimuli such as pictures of animals have demonstrated search time advantages for fear-relevant animals amongst fear-irrelevant stimuli (Öhman, Flykt, & Esteves (2001). Moreover, a search advantage has also been observed for pictures of both threatening and pleasant animals (Tipples, Young, Quinlan, Broks, & Ellis, 2002), phylogenetically non-significant but nevertheless unpleasant stimuli such as guns and syringes (Blanchette, 2006), and for any animal irrespective of its fear relevance (Lipp, Derakshan, Waters, & Logies, 2004).

Eye movement studies on attentional capture by emotional pictures

The experimental paradigms reviewed above are limited in the sense that they only enable the assessment of one or two attentional components at a time. The visual search and dot probe tasks do not allow us to distinguish between the biases in orienting versus engagement of attention. In theory, a modified Posner's cueing task could enable this, but demonstrating attentional bias in orienting as a function of the emotional meaning of the cue is probably very difficult, as the mere onset of the cue singleton consists of a highly visually salient event which might override the more subtle effects arising from the picture content. However, by employing eye movement recordings in a variety of experimental paradigms we feel that we have successfully avoided these limitations.

General methodology of the studies

In all the studies reviewed below, the participants were university students; the majority of them were females. The basic setup in most studies (Calvo & Nummenmaa, 2007, is the exception) was one where emotional-neutral picture pairs were simultaneously presented, one in the right and another in the left visual field. The possibility for an overt attentional bias toward emotional content was studied by recording the viewers' eye movements when they were examining the scenes. Depending on the experiment, the pictures were presented either parafoveally or peripherally. Different task instructions were used (see the respective experiments for details) in order to study both automatic and controlled orienting of attention. The stimuli were selected from the International Affective Picture System (IAPS; see Lang, Bradley & Cuthbert, 2005). Stimulus displays consisted of two scenes. On each trial, an unpleasant, neutral, or pleasant target scene depicting people was presented with a neutral control scene (Nummenmaa, Hyönä & Calvo, 2006), which all depicted inanimate objects (see Figure 9.1 for stimulus examples). The unpleasant target scenes depicted people exposed to threat or suffering from a serious harm, the neutral target scenes involved people in daily non-emotional activities, and the pleasant target scenes involved people enjoying themselves or showing positive affect. Unpleasant and pleasant target pictures were matched for their perceived arousal level; moreover, unpleasant, neutral, and pleasant target pictures as well as control pictures were matched for low-level visual features such as luminosity, contrast density, color channel saturation and complexity.

Stimuli were presented on a 20-inch 200 Hz ViewSonic monitor with a 2 GHz Pentium III computer. Participants' eye movements were recorded with an EyeLink II eye tracker connected to a 2 GHz Pentium III computer. The sampling rate was 500 Hz, and the spatial resolution was better than 0.5 degrees.

Emotional content influences saccade target selection

In Experiment 1 of Nummenmaa et al. (2006) participants were presented with emotional and neutral pictures (involving humans) paired with neutral control pictures (involving objects). The pictures were lo-

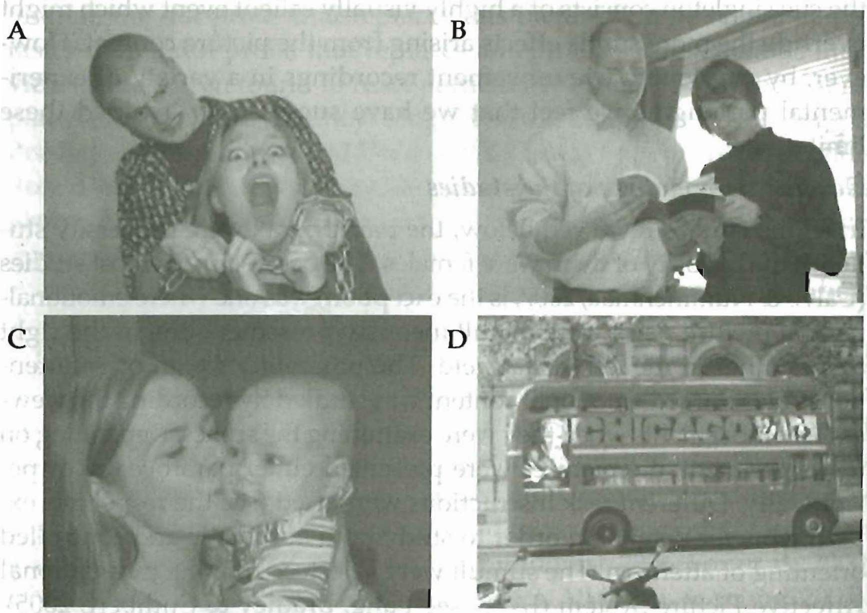

Figure 9.1 Illustration of unpleasant (A), neutral (B), pleasant (C), and control (D) stimuli used in the studies. Note that these example pictures were not among the experimental stimuli. (*See Plate 6.*)

cated at opposing corners of the screen, and the distance between the initial fixation and the innermost edge of the pictures was 4 degrees of visual angle. Pictures were presented for 3 s with the instruction to compare whether they are equally pleasant (neutral-neutral trials) or not (emotional-neutral trials). This bogus task ensured that participants had to look at both pictures. However, the task did not constrain the order in which the two pictures were looked at. The picture pairs were shown twice in two separate blocks to assess potential effects of the novelty of the emotional scenes. The probability of the first fixation landing on different types of target scenes was used as an index of bias in overt orienting of attention, and the number of first pass fixations was used to index the bias in attentional engagement.

The probability of first fixation was influenced by emotional valence (see Figure 9.2(A)). More specifically, both unpleasant and pleasant pictures received the first fixation with a greater likelihood than neutral pictures, suggesting a bias in attentional orienting towards emotional

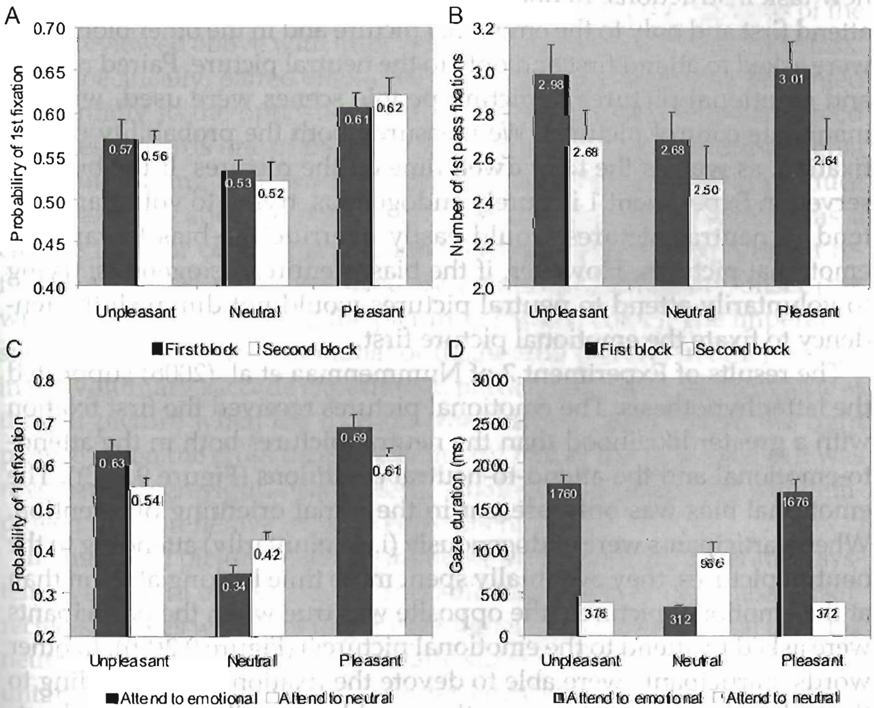

Figure 9.2 Probability of first fixation (A) and number of first pass fixations (B) as a function picture valence and block in Experiment 1, and probability of first fixation (C) and gaze duration (D) as a function of picture valence and attentional condition in Experiment 2.

content. The number of first pass fixations was influenced both by emotional valence and block, with both unpleasant and pleasant pictures receiving more first pass fixations than neutral ones, and with less overall first pass fixations in the second than in the first block. However, valence and block did not interact with each other. The main effect of valence implies here that emotional content biases engagement of attention, and the main effect of block reflects the fact that participants pay less attention to the familiar pictures.

In sum, the above results suggest that both initial saccade target selection and subsequent engagement of attention are biased towards emotional content present in complex visual scenes. However, the results do not necessarily reflect the fact that the bias is purely exogenous (stimulus-driven, automatic) in nature. It may as well be the case that the participants were deliberately paying more attention to the emotional than neutral pictures. Experiment 2 was conducted to test this possibility. It was a replication of Experiment 1 with an addition of two new task instructions. In one block the participants were instructed to attend first and only to the emotional picture and in the other block they were asked to attend first and only to the neutral picture. Paired neutral and emotional pictures depicting people scenes were used, with no inanimate control pictures. We measured both the probability of first fixation, as well as the total dwell time on the pictures. If the bias observed in Experiment 1 is purely endogenous, trying to voluntarily attend to neutral pictures would easily override the bias toward the emotional pictures. However, if the bias is entirely exogenous, trying to voluntarily attend to neutral pictures would not diminish the tendency to fixate the emotional picture first.

The results of Experiment 2 of Nummenmaa et al. (2006) supported the latter hypothesis. The emotional pictures received the first fixation with a greater likelihood than the neutral pictures both in the attend-to-emotional and the attend-to-neutral conditions (Figure 9.2(C)). The emotional bias was only present in the initial orienting of attention. When participants were endogenously (i.e. voluntarily) attending to the neutral pictures, they eventually spent more time looking at them than at the emotional pictures (the opposite was true when the participants were asked to attend to the emotional pictures) (Figure 9.2(D)). In other words, participants were able to devote the fixation time according to the task instructions. However, they could not inhibit first overtly attending to an emotional picture when the instruction was to attend to the neutral picture. All in all, Experiment 2 confirmed that the bias towards emotional pictorial content is at least partly exogenous. However, the bias was not purely exogenous in nature as it was slightly diminished in the attend-to-neutral condition.

Emotional content biases saccade initiation

The above results lend support to the view that the content of parafoveally or peripherally presented visual scenes can exert a relatively automatic influence on saccade target selection. Even though the emotional pictures were completely comparable to the neutral pictures in their low-level visual features in both Experiment 1 and 2 of Nummenmaa et al. (2006), they still attracted initial saccades with a greater likelihood. However, these studies are limited in the sense that they are only capable of demonstrating an emotional bias in attentional selection. The question arises whether a similar bias is also observed, when the task does not require the participants to deliberately attend to the picture contents. Thus, our current work is aimed at determining whether the bias extends to saccade programming when the triggering of saccades is not based on the picture contents. We have recently run variants of the study reviewed above with important modifications in the saccade task. More specifically, paired emotional and neutral pictures were presented horizontally to the opposite visual fields, and participants performed saccades towards one of the pictures according to an imperative signal that had nothing to do with the picture contents. In order to produce voluntary saccades, in one experiment the imperative signal was a change in color of the initial fixation cross; in another experiment reflexive saccades were produced by an abrupt luminosity onset (the white border surrounding the pictures changed color). The imperative signal cued either the emotional or the neutral picture. In other words, in the voluntary saccade experiment, participants were asked to look at the left picture when the fixation cross turned green and to the right picture when the cross turned orange (for half of the participants it was reversed: green-right, orange-left). Analogous instructions were employed in the reflexive saccade experiment.

If emotional pictures exert an influence on the saccade generation system, we should expect shorter saccadic reaction times and less misdirected saccades when the imperative signal cued the emotional than the neutral picture. Our results generally support this hypothesis. For voluntary saccades, significantly shorter latencies were observed for saccades made towards unpleasant or pleasant pictures than toward neutral pictures, when the imperative signal was presented 150 ms before (RTs 345, 347, and 353 ms) or 150 ms after (RTs 316, 319, and 325 ms) the onset of the target pictures. For reflexive saccades, similar results were observed when the imperative signal was presented simultaneously (RTs 258, 259, and 268 ms) or 150 ms after (RTs 249, 239, and 253 ms) the onset of the target pictures. The fact that we found a significant emotional effect also for the exogenous (i.e. reflexive) saccades suggests that the effect does not need voluntary control to be materialized, and it is in that sense automatic.

Another follow-up experiment implementing the oculomotor inhibition paradigm provided even more convincing evidence for the view that emotional content is capable of affecting automatic saccade programming. In this experiment, the emotional-neutral picture pairs were presented as in the previous experiments (i.e., one to the left and one to the right of the center fixation point), but now participants did not initiate a saccade to one of the pictures but to a cross that was presented orthogonally (up or down) to the picture locations. A cross appearing at the visual periphery aligned with the central vertical axis served as the imperative signal and the saccade target. In other words, participants made vertical saccades in the presence of horizontally and parafoveally presented visual scenes that now served as distracters. Thus, the emotional and neural pictures did not share a spatial or response compatibility with the demanded saccade response. The participants were told to ignore the pictures and perform vertical saccades according to the imperative signal (i.e. to the cross appearing up or down).

The premotor theory of attention (Rizzolatti, Riggio, Dascola, & Umilta, 1987) posits that shifts of covert attention involve programming (but not executing) an eye movement. This theory has been supported by data showing that saccades deviate away from a location that has recently been attended to (for a review, see Van der Stigchel, Meeter, & Theeuwes, 2006). This is explained by the notion that competition takes place between the stimuli in the neural map that specifies the saccade goal (e.g. Godjin & Theeuwes, 2004). Competing stimuli that can potentially serve as a saccade target activate separate populations of neurons. If a distracter is presented simultaneously with or before the task-relevant saccade target, and this distracter competes for a candidacy for a saccadic target, the inhibition of the saccadic response to the spatial location of the distracter will reduce the activity of neurons responsible for programming a saccadic response to the distracter below the baseline level. This causes the task-relevant saccade to curve away from the distracter. Thus, a measure of saccadic curvature and saccadic error (i.e. deviation of the saccade endpoint from the designated target) can be used to study whether a saccade has been initially programmed (and soon inhibited) towards the location of the distracter. Figure 9.3 illustrates how to compute these two measures, saccadic curvature and endpoint deviation. Saccadic curvature is the maximum curvature away from a distracter that is observed in the saccadic trajectory. Endpoint deviation refers to the size of the saccadic error: how much the observed landing position deviates from the intended location.

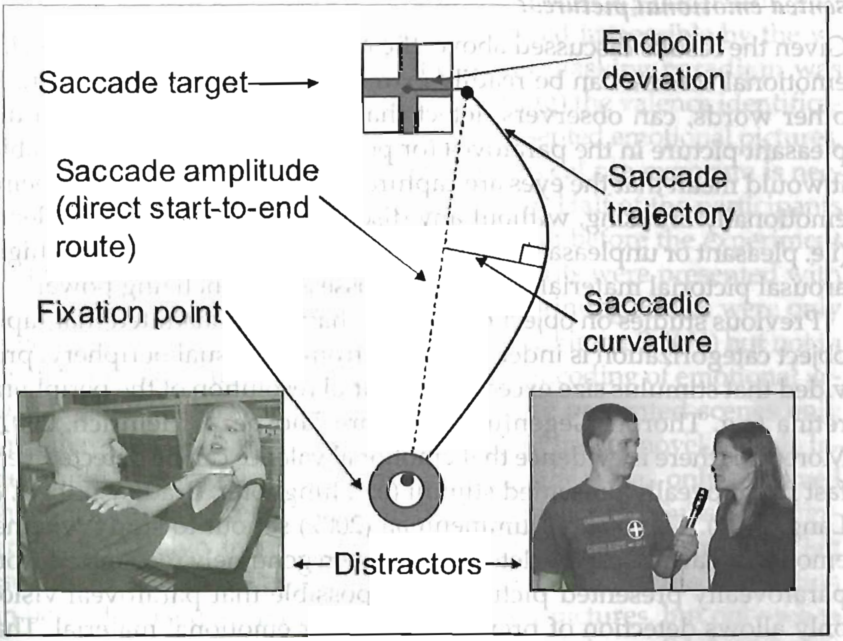

Figure 9.3 An illustration of the measure of saccadic curvature and saccade endpoint deviation. An emotional distracter appears on the left and a neutral distracter on the right. (*See Plate 7.*)

Based on the findings reviewed above, we predicted emotional pictures to automatically attract an eye movement. In the present task, such an eye movement would be inappropriate and thus be inhibited. If so, the actually performed saccade should deviate away from the emotional picture that is now a distracter. This in turn would give us reason to argue that the emotionality of an unattended stimulus is encoded and subsequently influences saccade programming. This was exactly what we observed in our experiment. The saccades deviated away from the location occupied by the emotional pictures. In other words, when an emotional picture was located to the left of the center fixation point, the endpoint of the vertical saccade (up or down) was shifted away from the visual field where the emotional picture was presented. Similarly, the saccadic trajectory curved away from the emotional picture. These findings provide strong support for the notion that (1) emotional content can be readily detected from the parafovea and (2) that perception of emotional content brings with it an automatic saccade towards the location occupied by the emotional scene.

What information is extracted from parafoveally or peripherally presented emotional pictures?

Given the results discussed above, the question arises whether specific emotional content can be readily extracted from peripheral vision. In other words, can observers detect that there is a pleasant or an unpleasant picture in the parafovea (or periphery)? If this is not possible, it would mean that the eyes are captured by the stimulus merely being emotionally arousing, without any discrimination of affective valence (i.e. pleasant or unpleasant content). If so, this would suggest that high-arousal pictorial materials in general possess "magnetizing power".

Previous studies on object recognition have demonstrated that rapid object categorization is indeed possible from the visual periphery, provided that stimulus size exceeds the spatial resolution of the peripheral retina (e.g. Thorpe, Gegenfurtner, Fabre-Thorpe, & Heinrich, 2001). Moreover, there is evidence that emotional valence can be detected very fast from foveally presented stimuli (e.g. Junghöfer, Bradley, Elbert, & Lang, 2001). Calvo and Nummenmaa (2007) set out to study whether emotional valence can be detected and even genuinely recognized from parafoveally presented pictures. It is possible that parafoveal vision only allows detection of previously familiar emotional material. That is, pictures that have previously been perceived under foveal vision might be quickly detected from the parafovea, but the emotional valence of totally novel pictures might not be encoded parafoveally. Such an argument has recently been put forth by Cave and Batty (2006) and Storbeck, Robinson and McCourt (2006). The idea is that emotional valence cannot be encoded pre-attentively, but object or scene features need to be first attentively identified before genuine affective analysis of the scene as a whole is possible.

In order to test whether encoding of emotional valence is possible for novel stimuli, Calvo and Nummenmaa (2007) conducted a set of experiments by using the affective priming paradigm. Also the gaze-contingent masking paradigm was implemented in a subset of the experiments. In the affective priming experiments a pleasant or unpleasant prime picture was presented parafoveally for 150 ms, followed by a 150 ms blank screen and a centrally presented probe picture that was either congruent (e.g. pleasant-pleasant) or incongruent (e.g. pleasant-unpleasant) with respect to the affective valence of the prime. By pressing a designated key in the computer keyboard, participants were asked to respond as fast as possible whether the probe picture was pleasant or unpleasant. In the gaze-contingent masking paradigm, a visual mask covering the foveal area moves along with the participant's eyes. Thus, even if the participant makes an eye movement to a parafoveally presented picture, its foveal inspection is rendered impossible by the visual mask. In their Experiment 5, the foveal masking paradigm was employed to directly study (i.e. not via priming) the valence identification (via subjective report) of parafoveally presented emotional pictures.

The initial experiment assessed whether foveal pre-exposure is necessary for the affective priming effect to occur. Half of the participants were presented foveally with the prime stimuli before the experiment proper, whereas the other half of the participants were presented with a set of unrelated pictures. As expected, the priming effects were only observed in the foveal pre-exposure group (see Figure 9.4(A)) but not in the no-preview group. This suggests that the encoding of emotional valence is possible for unattended, parafoveally presented scenes only when they have been previously processed, but not for novel stimuli. Interestingly, the significant affective priming effect was only observed when the primes were presented in the left visual field. Subsequent experiments of Calvo and Nummenmaa (2007) further confirmed this left visual field advantage and demonstrated that valence discrimination can be undertaken for parafoveally presented pictures, but only when they are presented repeatedly to the parafovea. A crucial demonstration of this effect was Experiment 4 in which the parafoveal primes were presented four times, once in each block under gaze-contingent foveal masking that strictly prevented the foveal inspection of the primes. In this experiment (see Figure 9.4(B)) the priming effects emerged only in the fourth block (i.e. when the prime was presented to the parafovea for the fourth time). Importantly, the priming effect was again observed only when the primes were presented to the left visual field.

Experiment 5 of Calvo and Nummenmaa (2007) tested directly the processing of parafoveally presented pictures. Participants' task was to evaluate the affective valence of the pictures. They responded whether the single picture presented for 150 ms to the parafovea was pleasant or unpleasant. To make sure that foveal inspection of the pictures was not

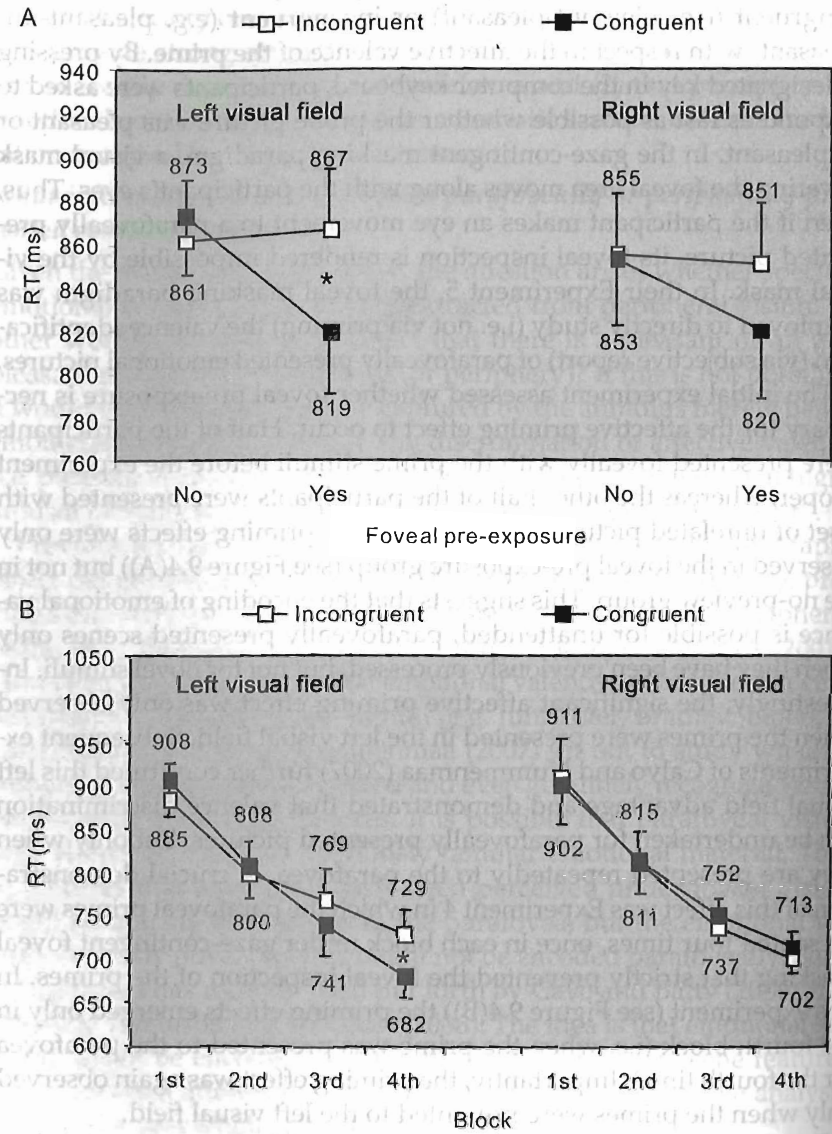

Figure 9.4 Reaction times as a function of prime-probe congruency, the visual field of the prime and foveal preview in Experiment 1 (A), and as a function of prime-probe congruency, the visual field of the prime, and block in Experiment 4 (B) of Calvo and Nummenmaa (2007).

possible a gaze-contingent foveal mask was used. The presentation of the picture set was repeated three times. Experiment 5 confirmed the results of the priming studies by demonstrating that the recognition of affective valence improved with repeated exposure to the same pictures and was better for the pictures presented to the left visual field. Interestingly, the recognition was above chance even during the first exposure to the pictures, which suggests that observers are able to pick up from the parafovea affectively relevant information.

The general conclusion derived from the priming experiments of Calvo and Nummenmaa (2007) is that emotional valence may be detected parafoveally, but only when they have pre-exposed to the picture either foveally or parafoveally. In other words, no affective priming was observed when the prime picture was presented for the first time; the effect only appeared when the observers had a chance to see the picture a few times. This is consistent with the view (Cave & Batty, 2006) that a repeated parafoveal exposure leads to a sufficient recognition of the scene to render possible its affective evaluation. Experiment 5 provided evidence in support of the view that emotional valence may be recognized even for novel stimuli. This suggests that, although affective valence of overtly unattended scenes is quickly detected and encoded, affective priming requires stronger activation that is accrued through repeated exposure. In any case, the effects only emerged or were greater, both for affective encoding and priming, when the pictures were presented in the left than right visual field. This supports a right hemispheric specialization in visual emotional processing.

General discussion

Reflexive attentional capture by emotional pictures

Dual-process theories of attention (see Barrett, Tugade, & Engle, 2004; Corbetta & Shulman, 2002; Egeth & Yantis, 1997) distinguish between a reflexive and a voluntary mechanism of attention orienting. In the former case attention is captured exogenously, preattentively, by the stimulus properties, whereas in the latter case the allocation of attention is controlled endogenously by the individual's goals and interests. The findings presented in this chapter consistently suggest that there is a genuinely exogenous attentional capture by emotional stimuli. Further, the results lend support to the notion that not only covert attention but reviewed above. It is generally consistent with the findings of Calvo and Nummenmaa (2007) who found no affective priming for novel pictures. However, that study contains evidence (their Experiment 5) suggesting that even the recognition of emotional valence may be possible in the parafoveal vision.

This conclusion bears some similarity to findings demonstrating that the gist of a visual scene (e.g. that the picture depicts a traffic situation or a football game) can be perceived very rapidly (in about 100 ms; e.g. Biederman, 1972; Boyce & Pollatsek, 1992; for a review, see Underwood, 2005). However, these two findings differ in that the "gist effect" implies that global, non-specific semantic information is readily perceived of a scene, whereas our emotional effect suggests that stimulus features that give rise to emotional arousal (regardless of their specific emotional content) can be readily picked up from the periphery.

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