

Orienting to exogenous cues and attentional bias to affective pictures reflect separate processes

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On the basis of psychophysiological research it has been argued that pleasant and unpleasant pictures inhibit orienting to abrupt startle stimuli. Converging psychophysical evidence was sought for this finding using a modified version of the spatial precueing paradigm (Posner, 1980). Specifically, exogenous cues were presented to the left and right of neutral, pleasant and unpleasant picture stimuli. In contrast to the experimental hypothesis, pleasant and unpleasant pictures failed to affect attention to exogenous cues despite slowing overall reaction times in comparison to neutral pictures. This null finding was replicated in a further experiment where rate arousal was varied within the pleasant and unpleasant picture groups. However, unpleasant pictures produced more task interference than pleasant pictures and highly arousing pictures produced more interference than pictures rated low in arousal.

A good deal of evidence suggests that the analysis of spatial information is automatic under certain circumstances. This assumption is based on research using exogenous cues or ‘abrupt-onsets’ (Posner, 1980). Exogenous cues are typically represented by a rapid flash of light across a potential target location. Early findings showed that these cues produce both benefits and costs in subsequent target-processing reaction times, irrespective of the perceiver’s intention to ignore such stimuli (Jonides, 1981). Such effects appear to continue despite dual task capacity limitations (Jonides, 1981) and short stimulus onset asynchronies (McCormick, 1997). From these findings it can be argued that exogenous cues reflect the activity of an automatic attentional orienting system that is mainly driven by stimulus properties in a bottom-up fashion. According to LaBerge (1995, p. 64), ‘an exogenous cue is typically similar to a reflex, and for this reason it resembles the older notion of orienting described by Pavlov (1927) and Sokolov (1960)’.

Startle stimuli lead to a series of rapid flexor movements, such as the eyeblink response. Such a response is known as defence orienting which functions to protect vital organs (e.g. the eye) and also interrupt ongoing behaviour (Lang, 1995). In a similar vein to experiments describing orienting to exogenous cues, early explanations for defence orienting to startle stimuli highlighted the automatic nature of this effect (Yantis, 1995). However, more recent evidence, from research with pre-pulse

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inhibition, has noted that the startle reflex can be affected by attentional mechanisms. Pre-pulse inhibition occurs when a weak non-startle stimulus presented shortly (30–500 ms) before a startle probe, dampens or lessens the effects of the probe. Such an effect is claimed to ‘protect’ the initial processing of the pre-pulse (Graham, 1980). Further evidence has shown that affective stimuli can also act as a pre-pulse to startle stimuli (Lang, Bradley, & Cuthbert, 1997). When unpleasant and pleasant pictures are presented shortly before startle stimuli, the magnitude of the eyeblink response is reduced compared to neutral pictures (Bradley, Cuthbert, & Lang, 1993).

Lang *et al.* (1997) have also argued that pre-pulse inhibition due to affective pictures reflects the operation of pre-attentive processes which serve to increase vigilance, literally within the blink of an eye (under 500 ms; Bradley *et al.*, 1993). The notion of the pre-attentive processing of affect sits well with other evidence. For example, Ohman and Soares (1994) found that animal phobic participants but not controls exhibited elevated skin conductance to phobic content (snakes and spiders) even when the pictures were presented at a level below conscious recognition. Taken together such findings are claimed to support the notion of an evolved mechanism for automatically detecting emotional meaning (Ohman, 1996).

EXPERIMENT 1

In the present paper we seek converging psychophysical evidence for these findings, by testing whether affective pictures are capable of reducing the impact of exogenous cues. Following research described by Lang (1995), modification of the effects of exogenous cues is expected when such cues appear in the context of affective pictures. Specifically, in line with the findings of Bradley *et al.* (1993), both unpleasant and pleasant pictures are expected to lessen the effects of spatial cues at a short picture-to-cue interval. If affective pictures act as a pre-pulse by automatically inhibiting subsequent processing, then the automatic encoding of spatial location should be disrupted by such activity. To examine this hypothesis we adopted a widely used cueing paradigm (Posner, 1980). In this paradigm, exogenous cues, displayed for under 150 ms, are placed in either the same location as an ensuing target on valid trials, or in the opposite location to a target on invalid trials. A cue validity effect is said to occur when valid cues facilitate reaction times in comparison to invalid cues. A reduction in the magnitude of the cue validity effect is expected if affective pictures disrupt the orienting of attention.

Method

Participants

Twenty-eight undergraduate students at the University of Kent took part in partial fulfilment for a course credit.

Apparatus and materials

Seventy-two pictures were selected from the International Affective Picture System (Center for the Study of Emotion and Attention, 1995). The pictures were split into three equal groups depending on their normatively rated valence, producing pictures of pleasant, neutral and unpleasant content. The

Table 1. Arousal and valence scores as a function of picture type (pleasant, unpleasant, neutral)

	Picture type			<i>F</i> (2,21)	<i>p</i> <	MSE =
	Pleasant	Unpleasant	Neutral			
Arousal	5.80 (.84)	6.20 (.96)	3.33 (.96)	67.607	.001	.860
Valence	7.16 (.52)	2.63 (.90)	5.02 (.77)	218.348	.001	.562

Note. All ratings are originally from Lang, Bradley, and Cuthbert (1995).

unpleasant and pleasant pictures were rated as significantly more arousing than the neutral pictures (see Table 1). The experiment was carried out on a Viglen P200 computer, using Superlab (version 1.04).

Design

The main block consisted of 144 trials. Within these trials there was a total of four within-participants variables: target position (left, right), target type (T, L), picture type (pleasant, unpleasant, neutral) and cue validity (valid, invalid). Each picture type appeared once in the valid and once in the invalid cueing conditions. With respect to the remaining conditions pictures were randomly assigned to the four balanced factorial combinations of target location (left, right) and target type (T, L). Superlab randomly selected trial presentation order.

Procedure

After obtaining consent to present the pictures, participants viewed the instructions on the computer screen. To further familiarize themselves with the task, participants undertook 32 practice trials in which a neutral stimulus was presented. Participants were seated approximately 70 cm from the screen. In the main experiment, each trial began with the presentation of a centred, grey, filled rectangle measuring 134 mm in height and 180 mm in width. After 720 ms the grey rectangle was replaced by a same-sized picture. Participants were told to fixate on the grey rectangle and then look at the picture. They were told to keep fixated on the picture throughout each trial. After 170 ms an uninformative cue measuring 10 mm in height and 5 mm in width was presented 20 mm from the nearest edge of the picture. The cue was presented for 150 ms before being replaced by the letter target on the same side (on valid trials) or on the opposite side (on invalid trials) of the picture. Participants made a forced-choice target discrimination by pressing the U and N keys on the keyboard for the L and T targets, respectively ('L' and 'T' labels were placed on the appropriate keys). The target letters were presented 15 mm from the nearest edge of the picture and did not overlap spatially with the cues. Responses were made with the index and middle finger from the participant's dominant hand. If an incorrect response was made or participants took longer than 3000 ms to respond, the target was replaced by the word 'error!' The error message was displayed for 400 ms. Participants were instructed to respond as quickly and accurately as possible. After a correct response or an error message the screen was cleared and remained blank for 1000 ms before a new trial began.

Results

The mean reaction times for correct responses as a function of picture type and cue type are shown in Fig. 1. The data were analysed in a picture type (pleasant, unpleasant, neutral) \times cue type (valid, invalid) repeated measures ANOVA. The analysis revealed main effects for picture type $F(2,54) = 13.32$, $p < .001$, MSE = 1679.42 and cue type $F(1,27) = 72.977$, $p < .001$, MSE = 9150.97. The picture

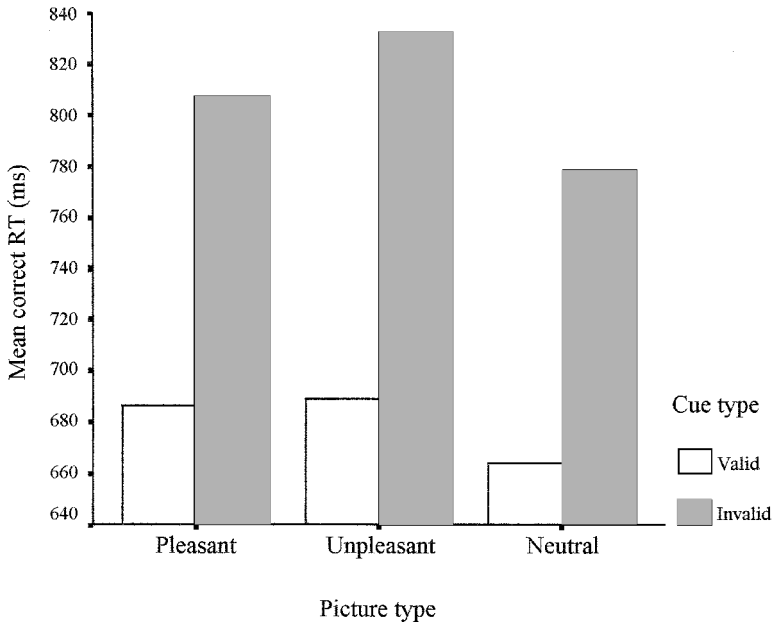


Figure 1. Mean correct reaction times as a function of picture type (pleasant, unpleasant, neutral) and cue type (valid, invalid).

type \times cue type interaction was not significant $F(2,54) = 2.053$, $p = .138$, $MSE = 1672.62$. The main effect of cue type reflected substantially faster reaction times for valid trials in comparison to invalid trials. To examine the main effect of picture type, *post hoc* analyses were carried out using Tukey's HSD. Reaction times to targets were slower when accompanied by both unpleasant (760.97 ms) and pleasant (746.57 ms) pictures, in comparison to neutral fixation pictures (721.47 ms) ($p < .01$).

Analysis of errors

The picture type \times cue type ANOVA was repeated on the mean number of target errors. Following the reaction time there was a higher proportion of errors in the unpleasant (.024) and pleasant (.021) picture conditions, picture type $F(2,54) = 3.043$, $p = .056$, $MSE = .0008$. All other differences failed to reach significance (cue type $F(1,27) = .693$, $p = .413$, $MSE = .0003$; picture \times cue type $F(2,54) = .544$, $p = .584$, $MSE = .0004$).

Discussion

Experiment 1 failed to demonstrate an interaction between cueing and picture type. There was no appreciable evidence of affective pictures leading to a reduction in the cue validity effect. However, both unpleasant and pleasant arousing pictures produced task interference in the form of slowed reaction times. This finding converges with other evidence using a modified version of the Stroop task, in which

subjects are asked to colour name words differing in valence. A typical finding in this research is that clinically anxious participants take longer to colour name threat-related words in comparison to non-threat words (e.g. MacLeod, Mathews, & Tata, 1986; Mathews & MacLeod, 1985). Interference effects have also been recorded in picture versions of the emotional Stroop task (Kindt & Brosschot, 1997). However, in contrast to the findings reported here, such effects seem less reliable (Lavy, Van den Hout, & Arntz, 1993).

EXPERIMENT 2

It is difficult to argue that the null results of Expt 1 reflect measurement error, as the task *was* sensitive to both the cueing effect and the affective nature of the pictures. However, in keeping with the 'good effort' criterion put forward by Frick (1995), an attempt was made to replicate the null findings of Expt 1. In addition, Expt 2 examined a further possible reason for the lack of an interaction in Expt 1. Recent evidence from Cuthbert, Bradley, and Lang (1996) shows that only affective pictures judged as having high arousal value produce startle inhibition. The effect of arousal occurs irrespective of valence, with both highly arousing unpleasant and pleasant pictures producing startle inhibition. Arousal has also been found to impact reaction times selectively. For example, Bradley, Greenwald, Petry, and Lang (1992) found that subjects were slower making recognition memory judgments of pictures rated high in arousal compared to pictures rated low in arousal. Experiment 2 was designed to look at the possible effects of arousal on cueing, by systematically varying arousal within the pleasant and unpleasant picture categories. In addition, the effects of arousal were also expected to be apparent in the reaction time data, with highly arousing images producing most task interference.

Method

Participants

Twenty-six undergraduate students at the University of Kent took part in partial fulfilment for a course credit.

Apparatus and materials

Eight pictures were selected from the International Affective Picture System (Center for the Study of Emotion and Attention, 1995). The pictures were split into five groups depending on their normatively rated valence and arousal (see Table 2). In addition to neutral pictures (low arousal and low valence), high and low arousal subsets were created within the pleasant and unpleasant picture categories. Neutral pictures all belonged to the category of household objects (e.g. dustpan, iron, rolling pin, etc.). The experiment was carried out on a Viglen P200 computer, using Superlab (version 1.04).

Design and procedure

The main block consisted of 160 trials. The design and procedure was the same as Expt 1 except that five picture categories were used (pleasant high, pleasant low, unpleasant high, unpleasant low, neutral) with each picture appearing once in the valid and once in the invalid cueing conditions.

Table 2. Arousal and valence scores as a function of picture type (pleasant high, pleasant low, unpleasant high, unpleasant low, neutral)

	Picture type				
	Pleasant high ^a	Pleasant low ^b	Unpleasant high ^c	Unpleasant low ^d	Neutral
Arousal	6.73 (.23)	5.58 (.08)	6.86 (.24)	5.49 (.17)	2.50 (.39)
Valence	7.02 (.36)	6.89 (.27)	2.26 (.27)	2.37 (.18)	4.88 (.22)

Note. All ratings are originally from Lang, Bradley, and Cuthbert (1995).

^aPleasant high arousal.

^bPleasant low arousal.

^cUnpleasant high arousal.

^dUnpleasant low arousal.

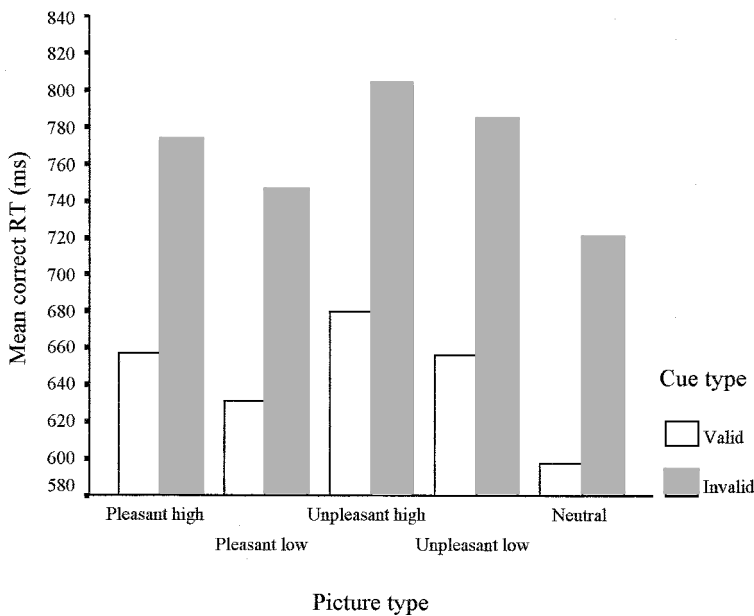


Figure 2. Mean correct reaction times as a function of picture type (pleasant high, pleasant low, unpleasant high, unpleasant low, neutral) and cue type (valid, invalid).

Results

The mean reaction times for correct responses as a function of picture type and cue type are shown in Fig. 2. The data were analysed in a picture type (pleasant high, pleasant low, unpleasant high, unpleasant low and neutral) \times cue type (valid, invalid) repeated measures ANOVA. The analysis revealed main effects for picture type $F(4,100) = 17.185, p < .001, \text{MSE} = 3083.39$ and cue type $F(1,25) = 109.340, p < .001, \text{MSE} = 8577.97$. The picture type \times cue type interaction was not significant

$F(4,100) = .181, p = .948, \text{MSE} = 2331.377$. In line with Expt 1, the main effect of cue type reflected faster reaction times for valid trials (644.34 ms) compared to invalid trials (764.46 ms).

To focus on the effects of picture type, further analysis concentrated on task interference due to arousal and valence. F tests comparing the neutral picture condition with each of the other picture type conditions showed that all pleasant and unpleasant conditions produced significant task interference (all F s $> 10.40, p < .005$). To analyse the contribution of arousal and valence, separate interference indices were created by subtracting the neutral picture condition from all other picture conditions. The indices were analysed in a picture valence (pleasant, unpleasant) \times picture arousal (high arousal, low arousal) repeated measures ANOVA (see Fig. 3). Interference was greater for unpleasant compared to pleasant pictures

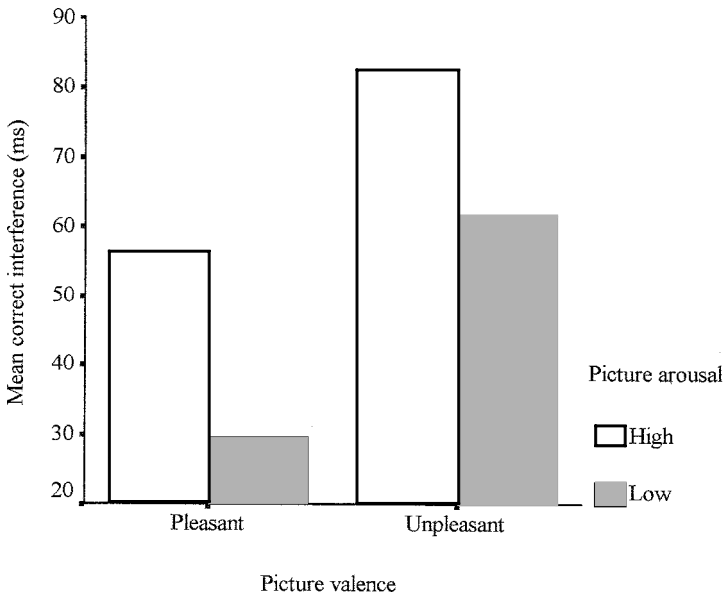


Figure 3. Mean correct interference effects (ms) as a function of picture valence (pleasant, unpleasant) and picture arousal (high, low).

$F(1,25) = 17.713, p < .001, \text{MSE} = 1239.07$. In addition, interference was greater for high arousal pictures compared to low arousal pictures $F(1,25) = 9.522, p < .006, \text{MSE} = 1576.54$. There was no hint of an interaction between arousal and valence $F(1,25) = .141, p > .7, \text{MSE} = 1336.73$.

Analysis of errors

The picture type \times cue type ANOVA was repeated on the mean number of target errors. The later analysis failed to reveal any significant differences for picture type, $F(4,100) = 2.186, p = .076, \text{MSE} = .001$ or cue type, $F(1,25) = .406, p = .530, \text{MSE}$

= .003. However, there was a marginally significant two-way interaction between picture \times cue type $F(4,100) = 2.404$, $p = .055$, $MSE = .001$. For highly arousing pleasant picture more errors were made on invalid trials (.05) in comparison to valid trials (.02). In contrast, for unpleasant pictures this pattern was reversed, with more errors made on valid trials (.05) compared to invalid trials (.03).

Discussion

The results of Expt 2 replicate the findings of Expt 1, and show that the task was sensitive to the effects of exogenous cues and the affective identity of the stimuli. However, affective pictures once again failed to modify the covert orienting of attention. In line with the hypotheses of Expt 2, specific patterns of task interference occurred as a function of picture arousal and valence. Unpleasant pictures created more interference than pleasant pictures and interference increased with the rated arousal value of the pictures, independent of their valence. These findings support the earlier work of Bradley *et al.* (1992) and show that stimulus activation property (arousal value) is an important factor in sustaining visual attention. Clearly, it is beneficial to attend to arousing information that is linked to possible negative or positive outcomes. In addition, the greater interference for unpleasant pictures also supports earlier findings where unpleasant words have been found to produce more interference than pleasant words (e.g. McKenna & Sharma, 1995; Pratto & John, 1991). Indeed, such a bias may be linked to a mechanism designed to scan the environment for potential threat (Eysenck, 1997).

GENERAL DISCUSSION

In Expts 1 and 2, unpleasant and pleasant pictures failed to modify the covert orienting of spatial attention. The replication of this null effect and the ruling out of arousal as a possible influential variable strengthens the case for the null hypothesis. Therefore, in contrast to the work of Bradley *et al.* (1993), the current research highlights a context in which affective picture stimuli do not seem to affect spatial orienting. These results therefore support the view that the early analysis of spatial processing operates independently from the analysis of affect.

Why did affective pictures fail to affect orienting to exogenous cues? Further research might seek to examine the differences between the current study and the work of Bradley *et al.* (1993). In the work of Bradley *et al.* (1993) the high-intensity probe stimulus is clearly an aversive stimulus which elicits a specific reflex response (eyeblink). In contrast, in the current experiments the cue was not aversive and the ensuing response was a voluntary button press rather than a reflexive response. These differences may hold the key to understanding the lack of an interaction between orienting and picture affect. Furthermore, it should also be noted that there are other ways to examine the hypothesis raised in the current research. For example, Mogg and Bradley (1998) have argued that covert orienting mechanisms operate as attention shifts toward affective pictures.

Even with these considerations in mind there are neuroscientific grounds for *not* expecting an interaction between the processing of picture identity and the orienting

of spatial information. Converging evidence has shown that object recognition (e.g. picture identification) and orienting visual attention, involve separate pathways and brain structures. Orienting to exogenous spatial cues depends upon a dorsal pathways from the primary visual cortex to the posterior parietal cortex and further connections to the pulvinar nucleus of the thalamus and superior colliculus (see Posner & Raichle, 1994, for a review). In contrast, object identification depends on a different, ventral pathway from the primary visual cortex to the inferior temporal cortex (Haxby *et al.*, 1994).

The neural structures involved in emotion can be further separated from both object recognition and visuospatial orienting. Specifically, the amygdala, prefrontal cortex, anterior cingulate, ventral striatum and insular cortex have all been implicated in emotion (Davidson & Irwin, 1999). Primate research by Rolls and colleagues (Rolls, Judge, & Sanghera, 1977) has shown that the representation of reinforcement value occurs separately from object recognition within the inferior temporal cortex (Rolls *et al.*, 1977; see Rolls, 1999). Moreover on the basis of fMRI data, Lang and colleagues (Lang *et al.*, 1998) argue that affective pictures enhance activation of the perceptual processing areas in the visual cortex as a result of *re-entrant* processing from anterior sections of the brain (the amygdala and anterior cingulate). Certain types of stimuli (e.g. aversively conditioned stimuli) may trigger an emotional response 'prior' to full object representation via direct links between the thalamus and amygdala (LeDoux, 1995). However, there is no direct evidence linking such processes to activation in the posterior parietal cortex. In summary, neuroscientific research suggests that emotion-related processes occur at separate processing stages and in separate neural loci to visual orienting and object recognition.

At a different level of analysis, the current data complement and extend those of the emotional Stroop task (e.g. McKenna & Sharma, 1995; Pratto & John, 1991). Both unpleasant and pleasant pictures produced task interference. However, unlike the emotional Stroop, participants were *not* told to ignore the critical stimulus. On this point, it should be noted that asking participants to ignore a relatively large photograph placed on the screen while responding to other elements on a screen, lacks rather obvious face value as an experimental procedure. In addition, it is not clear what the instruction 'ignore' entails. If ignoring pictures is intended to prevent object recognition *completely* then affective interference might be regarded as a mechanism that occurs at an early stage of stimulus processing (e.g. before the stimulus can be coherently represented and identified). A more likely explanation is that attention is not always perfect and participants sometimes fail to prevent attention to the critical stimulus (see Schmidt & Dark, 1998).

A more compelling reason for not requiring participants to ignore or focus attention away from the picture stimuli lies in the size of the interference effects recorded in the current experiments. Not only was the task sensitive to both the valence and arousal value of the pictures, but the size of the interference effect exceeded 80 ms for highly arousing unpleasant pictures. This contrasts with other affective picture studies employing Stroop-like procedures where subjects are told to ignore the picture stimuli. When presented on a computer, interference effects in specific subgroups are either not significant (e.g. Lavy *et al.*, 1993) or do not create more interference than phobia-related words (Kindt & Brosschot, 1997). Whatever the

nature of the mechanisms involved in such task interference, the sensitivity of the current task to arousal and valence effects needs to be noted and examined in further research.

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