

Be(a)ware of spider! An Attentional Blink study on fear detection

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ABSTRACT

We investigated whether detection of fearful stimuli is independent from attention by using an iconic version of the Attentional Blink Task in arachnophobic individuals. A colored animal icon (Target) and a black spider or butterfly icon (Probe) appeared in close temporal proximity within a stream of distractors, at one of 4 possible time lags. In one task, Probe detection was required; in another one, Target identification was also requested. In this case, competition for attentional resources produces the so-called AB effect, that is the decrease of Probe perception as a function of lag.

During spider-Probe detection, arachnophobics showed a reduced AB effect with respect to the butterfly-Probe session. Their spider detection scores were also greater than ratings obtained by non-phobic controls with both Probe types. Thus, fear appears to enhance the probability of consciously perceiving the stimulus even when attention is engaged by a previous demanding event.

One may assume that spider-Probe is scarcely attention demanding because detection of threat in arachnophobics is increased by rapid amygdala activation of visual areas and/or facilitated by a strong arousal-induced noradrenergic cortical input.

Alternatively, an attention capturing mechanism involuntary triggered by the phobic meaning of the stimulus could be hypothesized.

Key words

Fear • Attention • Perceptual Awareness • Animal Phobia Model • Attentional Blink Task • Humans

Introduction

An experimental model of Fear

Fear is the basic and most preserved emotion of the animal kingdom. In humans the fear/threat appraisal entails a more complex processing than simple detection of the predators features. Indeed, potentially aversive events are evaluated and filtered in humans by the high cognitive functions that take into account many different dimensions of the stimuli including the social and symbolic aspects (Leventhal and Scherer, 1987). Because of the context-sensitive control of human fear, most experimental conditions fail to evoke con-

sistent fear responses, distinct from responses to other aversive states (e.g. disgust, dismay). Stimulus-driven reactions of fear, however, can be effectively induced in the individuals affected by animal phobia, that is a syndrome characterized by intense and uncontrollable fear toward a specific animal (DSM-IV, American Psychiatric Association, 2000; Mayer et al., 2000). In phobic subjects, the picture of the feared animal is sufficient to trigger a typical defensive response marked by both visceral and brain modifications (Hare and Blevings, 1975; Fredrikson, 1981; Dilger et al., 2003; Kolassa et al., 2005; Straube et al., 2006; Wendt et al., 2008; Knopf and Possel, 2009).

Our psychophysiological study of the spider-phobia (arachnophobia) has shown that in arachnophobic subjects the presentation of even a spider-like shape does elicit autonomic defensive responses stronger than those evoked by conventional aversive stimuli, such as facial expressions or affective words with negative valence (D'Alessandro et al., 2005). Thus, the animal phobia may provide a simple and reliable model for the experimental studies of fear in humans.

Attention, Fear and Awareness

Research on fear and phobia point to "automatic" or "pre-attentive" detection of the threatening stimuli (LeDoux, 1998; Ohman and Mineka, 2001). Studies on the backward masking effect indicated that both pictures of the phobic object and related words could elicit autonomic responses without conscious perception of the stimulus (Ohman and Soares, 1993, 1994; Van den Hout et al., 2000; Ruiz-Padial et al., 2005). In line with the idea that threat is detected without attention are the results of visual search experiments showing that fear-relevant stimuli are easily detected from an array of neutral distractors, irrespective of their number (Ohman et al., 2001; Blanchette, 2006). Finally, the studies employing the Stroop paradigm claim that the aversive meaning of colored words can "automatically" interfere with the performance on color naming task (Mathews and MacLeod, 1985; Watts et al., 1986; McNally et al., 1990).

According to these studies amygdala would play a key role in the automatic detection of threatening stimuli by activating a behavioural module of response to the fearful stimulus independently from attention, awareness or task instructions. Although some neurophysiological findings support this view (Morris et al., 1998; Vuilleumier and Schwartz, 2001), there is no definitive evidence that the processing of emotional stimuli is entirely automatic (Compton, 2003; Pessoa, 2005). For instance, Pessoa et al. (2002) have shown that spatial attention modulates the emotional processing by enhancing the activity of several brain regions in addition to the amygdala. More recently, Straube et al. (2006) have suggested that the right amygdala is crucial for automatic reactions to the phobic stimuli whereas the evaluation of the threat depends on the anterior cingulate and insular cortex and requires an adequate amount of attentional resources.

Some authors (Varela and Depraz, 2000; Lambie and Marcel, 2002) claim that every emotional state implies selective and enhanced awareness rather than unconscious/automatic reactions to specific events. When we are frightened, the objects of the environment acquire differential priorities for perception and action, and this is achieved by a peculiar deployment of attention, both in space and in time domain. If attention is the process that assigns priorities to events, then a crucial issue is how emotion and attention interact to shape the subjective perceptual awareness.

The Attentional Blink

In order to examine to what extent emotion depends on attentional resources and whether emotion may influence attention, we used an experimental paradigm in which the conscious perception of a stimulus is impaired by attentional temporal load.

It is well known that even highly supraliminal stimuli can be neglected if the subject's attention is at that moment unavailable or differently engaged (Shapiro, 1994; Enns and Di Lollo, 2000; Kim and Blake, 2005). The Attentional Blink effect (AB) is one of the most robust evidence of such a temporary functional blindness. The AB effect refers to the failure to detect a second salient target (Probe or T2) presented after the first one (Target or T1) within a sequence of visual stimuli occurring in rapid succession at the same spatial location (Rapid Serial Visual Presentations, RSVP) (Raymond et al., 1992; Chun and Potter, 1995; Shapiro et al., 1997a). Typically, the Probe detection is reduced if it appears within 100-500 ms following the correct identification of the Target. Magnitude of the AB effect is measured as the decrease of Probe detections relative to the number of detections in the control condition in which the subjects are instructed to ignore any item of the array but the Probe (Raymond et al., 1992). It is assumed that detectability of the Probe depends mainly on the amount of attention that is available at particular time lags from the Target presentation. Probe stimuli are differentially resistant to the AB effect. The detection of affective probes, such as emotional words (Keil and Ihssen, 2004; Anderson, 2005), emotional faces (Mack et al., 2002; Fox et al., 2005) and the personal own name (Shapiro et al., 1997b) is found less impaired than detection of non emotional probes. The AB effect can be attenuated

also by perceptual factors that increase uniqueness of the probes (Chun and Potter, 1995; Raymond et al., 1995). All together these findings suggest that the arousal dimension (including emotional meaning) of the stimuli may reduce the threshold for perceptual awareness (Anderson, 2005).

Recent reports indicate that phobic stimuli may influence the AB effect. A slight shortening of AB occurs in the arachnophobic subjects required to identify spider-related words (Target) followed by neutral word Probes (Cisler et al., 2007). In a recent ERP study on arachnophobic subjects, Trippe et al. (2007) employing pictures of spiders and pictures with emotional content as probes, showed a phobia-related attenuation of AB and the enhancement of P300 concomitant to facilitation in spider detection. The main limitation of this study concerns the evaluation of the AB effect. In fact, AB was estimated on the basis of the detection scores obtained in the conditional task and no comparison with probe detection in the single task was done. Thus, this study fails to evaluate possible differences in the basal discriminability and/or attentional prerequisites of probes. Furthermore, probe was presented at a fixed lag, resulting in a poor description of the temporal aspects of the AB phenomenon.

The present study addresses again the question of phobic-fear relevance and perceptual salience of stimuli presented in the conditions of temporally limited attention that yield the AB phenomenon.

To this aim, we designed an experiment involving an iconic version of the Attentional Blink paradigm in which we compared the performance of arachnophobic subjects and non-phobic controls on an Attentional Blink paradigm, with spider and butterfly's icons as Probes to be detected within a stream of non-phobic animals (see Fig. 1).

Given previous evidence of facilitated perception of arousing stimuli (Anderson and Phelps, 2001; Anderson, 2005), we expected a smaller AB effect in arachnophobics than in controls, limited to the spider-Probe.

Methods

Subjects

Volunteers were recruited from a group of 190 students at the University of Pisa. The Italian version of the Spider Phobia Questionnaire (SPQ) (Klorman et al., 1974) was used to rate the aversion to spiders of each subject. In subjects with scores higher than 20, the presence of specific phobia for spiders was assessed by a psychiatrist, according to the DSM-IV, APA, 2000. Eighteen individuals (2 males, 16 females), with a mean SPQ score of 24.22 (range 21-28), corresponding to the 90° percentile of the sample's scores distribution (Fig. 1), were assigned to the group of Arachnophobics. Eighteen participants (2 males, 16 females) with a mean SPQ score of 2.5

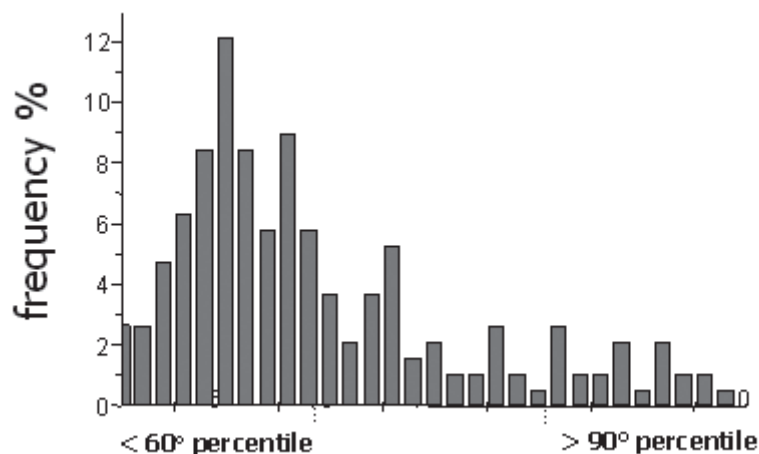


Fig. 1. - Frequency distribution of the Spider Phobia Questionnaire scores in the sample of 190 students participating to the study. The Arachnophobics group consists of individuals with scores higher than 20, corresponding to the 90° percentile of the sample's scores distribution; the Control group consists of individuals with scores lower than 10, corresponding to the 60° percentile of the sample's scores distribution.

(range 0-5) corresponding to the 60^o percentile of the sample's distribution (Fig. 1) served as controls.

The prevalence of women in our sample of phobic individuals reflects the gender differences in the prevalence of animal/spider phobia in the general population (Fredrikson et al., 1996).

All the subjects were drug free, had normal or corrected-to-normal vision and did not present medical, neurological or psychiatric disorders, apart from phobia.

All participants signed an informed consent approved by a local Ethical Committee.

Stimuli and procedure

Visual stimuli and experimental paradigm are shown in Figg. 2 and 3.

Experiment was run on a FreeBSD PC system (Imago program, feanor.sssup.it/~pv/). Stimuli were projected for 70 ms in the centre of a screen placed at 57 cm from the eyes of the subject so that each image (figure + background) covered an area of 4° x 4°. The inter-stimulus interval (ISI) was set at 30 ms to obtain a frequency of presentation of 10 image/sec. An acoustic warning cue and the simultaneous appearing of a fixation point in the centre of the screen signalled the start of the stimuli presentation. Each array of stimuli included the Distractors, the Target and the Probe.

Distractors were the black outlines of 24 innocuous animals; Target was the silhouette, coloured in blue, of an animal randomly chosen among the 24 distractors; Probe was the black outline of butterfly or spider, neither of them belonging to the group of the distractors.

In the sequence, Target was presented at a distance of 9-13 distractors from the beginning. Probe was presented 10 times in each of 4 different positions of the sequence, namely lag I, lag III, lag V, and lag VII, corresponding to the latencies of 100, 300, 500 and 700 ms from the Target presentation. Twenty catch trials in which the Probe was lacking were included, such that in total 60 sequences were presented in random order to each participant.

During the experimental sessions the subjects seated in front of the monitor in a darkened and sound attenuated room. They were instructed to fixate the central fixation point and refrain from moving the eyes throughout the task. In order to reduce head movements and keep fixed the distance from the screen, the subjects positioned their head on a suitable support.

The experiment was completed in two sessions, performed in different days, one having as probe the butterfly and the other having as probe the spider. The order of the two sessions was balanced among the subjects.

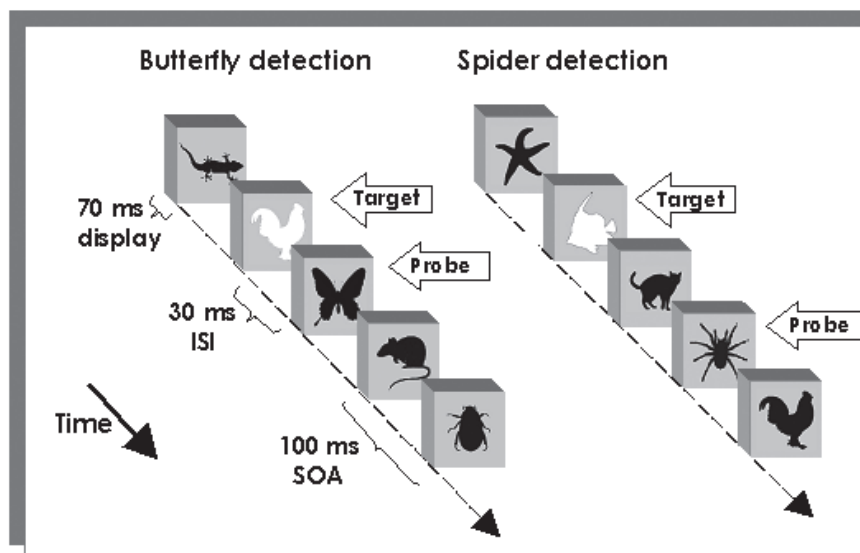


Fig. 2. - Schematic representation of Stimuli and Temporal Parameters.

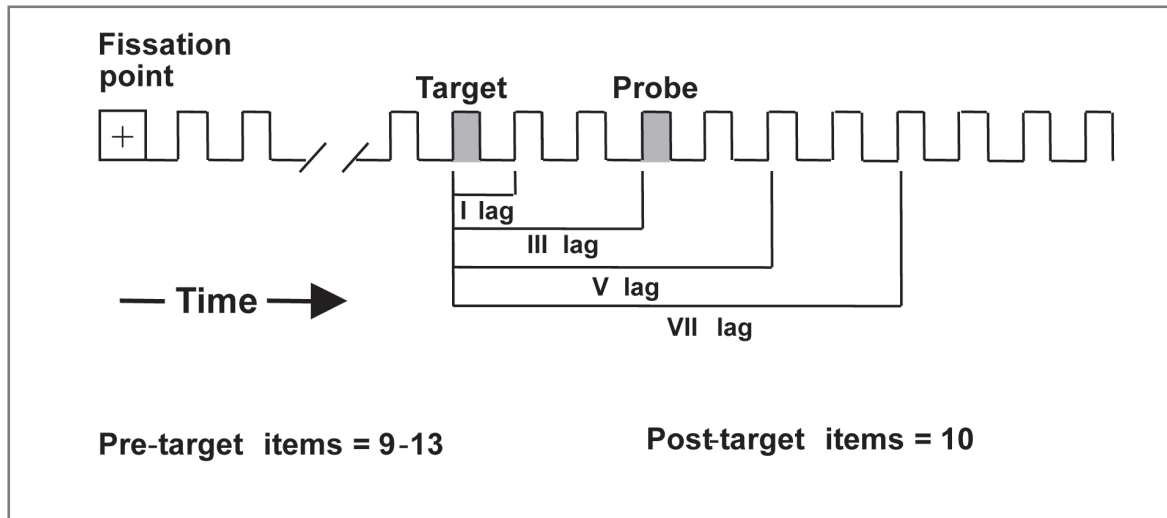


Fig. 3. - Flow Chart of the Attentional Blink paradigm.

Each session included 10 training trials followed by two blocks, each of 60 experimental trials. In the first block (Simple Task) the participants' task was to detect the Probe while ignoring all the other stimuli, included the blue Target. In the second block the subjects were asked to identify the colored Target and detect the Probe (Conditional Task). In both conditions the subjects were instructed to report at the end of each sequence their visual experience, as accurately as possible, and avoid guessing the occurrence of the Probe and/or the identity of the Target.

Data analysis

In the Simple Task the percentage of correct detection of each Probe in each of the 4 lag/position (I, III, V, VII) was calculated for each participant. In the Conditional Task, for each subject, the percentage of correct detection of each Probe was calculated for each lag with respect to the number of trials in which the Target was correctly identified. All the trials in which Target identification was incorrect were excluded. For analysis, percentage data were arcsine transformed according to the Anscombe formula (Anscombe, 1948). Butterfly and Spider Probe data were separately analyzed, through Repeated Measures ANOVA, with Lag (I, III, V, VII) and Task (Simple Detection, Conditional Detection) as Within Subjects factors, and Phobia (Arachnophobics, Controls) as Between Subjects

factor. In addition, for each group of subjects, AB effects for Butterfly and Spider were calculated as the difference between Simple Detection and Conditional Detection scores, and compared by means of Repeated Measures ANOVA, with Probe (Butterfly, Spider) and Lag (I, III, V, VII) as Within Subjects factors.

Results

Butterfly Probe detection

Fig. 4A shows the mean percentage of Butterfly Probe detections scored in the Simple and Conditional task by Arachnophobics and Controls.

On Simple detection the accuracy of all subjects is very high (> 80%), regardless of the probe lag. On Conditional detection, in both groups of subjects, the Probe detection falls below 75% within the interval of 500 ms after target, the lowest score being recorded at lag III. The different rate of detections in Simple and Conditional tasks indicates the occurrence of AB effect. ANOVA, in fact, shows significant Task ($F(1, 34) = 194.7, p < 0.001$) and Lag ($F(3, 102) = 36.5, p < 0.001$) effects, and Lag X Task interaction ($F(3, 102) = 33.9, p < 0.001$). The difference between simple and conditional detection scores is significant ($p < 0.05$) at lag I, III and V. No Phobia effect is present.

Spider Probe detection

Fig. 4B shows the mean percentage of Spider-Probe detections scored in the simple and conditional task by Arachnophobics and Controls.

On simple detection the accuracy is very high at all Probe lags (> 80%) for both groups.

The AB effect occurs in both groups. In fact, in the Conditional task, the rate of the spider detection decreases within an interval of 500 ms from Target, with a peak at lag III. However, the amplitude of the AB in Arachnophobics appears smaller than in Controls.

Anova confirmed these observations by yielding

significant Phobia ($F(1, 34) = 56.7, p < 0.001$), Task ($F(1, 34) = 130.7, p < 0.001$), Lag ($F(3, 102) = 17.4, p < 0.001$), and Lag X Task ($F(3, 102) = 24.7, p < 0.001$) effects. A significant Task x Phobia interaction was also found ($F(1, 34) = 13.2, p = 0.001$) with higher scores in Arachnophobics than in Controls on both simple ($F(1, 34) = 14.4, p < 0.001$) and conditional tasks ($F(1, 34) = 45, p < 0.001$). More specifically, conditional detection scores of Arachnophobics were significantly greater than those of Controls at lag I ($F(1, 34) = 10.3, p < 0.03$) and V ($F(1, 34) = 10.7, p < 0.02$). No significant differences between groups were found at lag III.

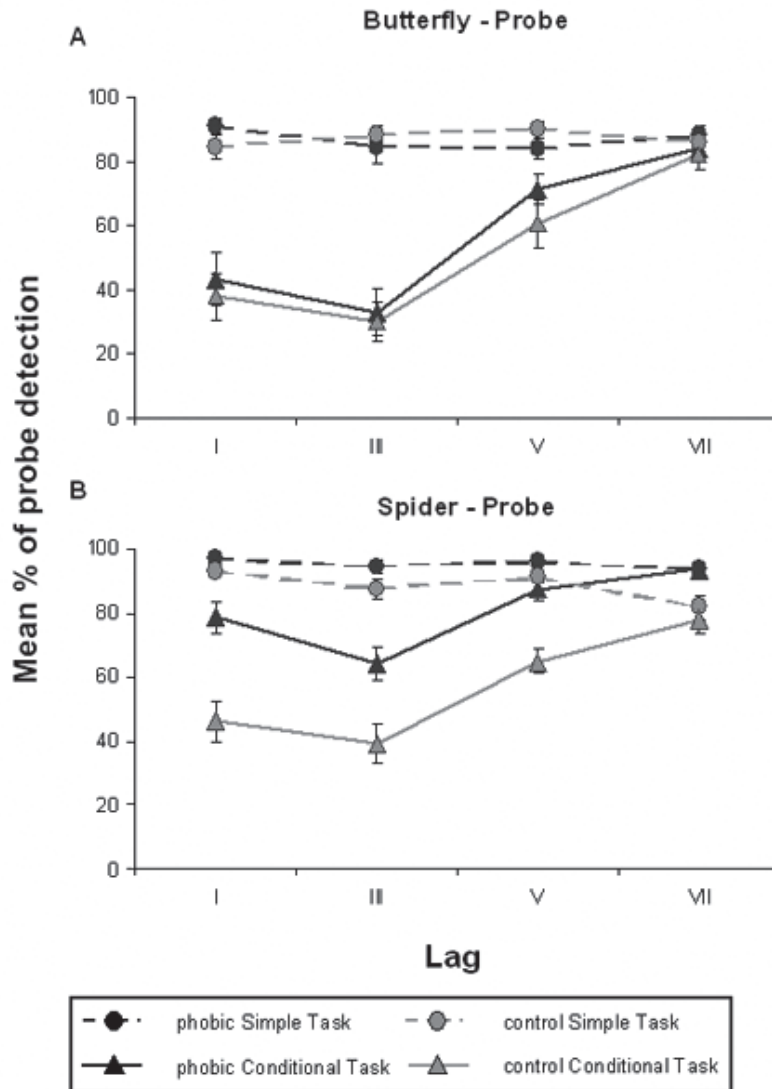


Fig. 4. - Mean percentage (\pm SEM) of butterfly-Probe (A) and spider-Probe (B) detections scored by Arachnophobics and Controls during Simple and Conditional Tasks.

Butterfly vs. Spider AB effect

In the Control group Butterfly and Spider AB effects were similar. In fact, ANOVA did not yield any significant Probe or Probe x Lag effects.

In the Arachnophobic group, Spider-Probe detection scores were higher than Butterfly ones. Indeed, ANOVA revealed significant Probe ($F(1,17) 9.21$, $p < 0.007$) and Probe x Lag effects ($F(1,51) 2.98$, $p < 0.04$) with Butterfly significantly different from Spider at lag I and lag III (lag I: $F(1,17) 7.31$, $p < 0.015$; lag III: $F(1,17) 6.42$, $p < 0.021$).

Probe detection errors

For each task and for each probe we calculated the false positive errors as the percentage of probe detections on catch-trials. In both groups the mean percentage of errors never exceeded 20%. ANOVA performed separately on arcsine-transformed data relative to spider and butterfly probe detection errors did not reveal any significant group difference.

Target identification task

Both groups performed the Target identification task with high accuracy. There were a small proportion of intrusion errors, i.e. the wrong reporting of an icon preceding (negative intrusion) or following (positive intrusion) the actual target. No significant difference was found between the two groups on either spider or butterfly detections.

Discussion

Results have shown that Arachnophobics detected spider Probes better than Controls, both in simple and conditional detection tasks. This yielded a significant reduction of the AB effect in Arachnophobics compared to non phobic subjects. This outcome cannot be accounted for by non-affective stimulus-related differences, as the same iconic stimuli have been presented to the two groups of subjects. As well, it cannot be ascribed to general differences in attentional capabilities of Arachnophobics and Controls, since the two groups perform at comparable level on both simple and conditional detection of the butterfly Probes.

In addition, on detection of spider probes, the phobic subjects committed the same number of false-pos-

itive errors as the controls. This rules out the possibility that the sparing of attentional blink reflects an anticipatory behaviour due to a “higher arousal state” of the phobics relative to non phobic controls. The main finding of this study is that in phobic subjects the conscious perception of their phobic object is largely preserved even when a previous identification task engages most of their attentional resources. Our results agree with previous studies on Attentional Blink in which it was found that subjects’ own name or a word with a strong emotional valence presented in a stream of verbal stimuli (Shapiro et al., 1997b; Anderson, 2005), as well as a happy face icon among shapes of familiar objects (Mack et al., 2002), produced analogue reductions of the AB effect.

In line with the automatic view of emotions, it may be conjectured that spider icon is less attention demanding for Arachnophobics than for Controls, because phobic objects evoke a noradrenergic-mediated arousal reaction that increases responsiveness of the cortical output (Castellani et al., 2007). Alternatively, enhanced capacity of visual identification of the threat might be accounted for by the amygdala rapid responses that modulate the activation of visual areas.

This hypothesis is in accord with recent findings showing a slight shortening of AB in Arachnophobics required to identify spider-related words (Target) followed by neutral word Probes (Cisler et al., 2007).

However, it cannot be excluded that the two groups could differ in the degree of familiarity with spider stimuli. A benefit of familiarity on the stimulus detection has been recently reported by Jackson and Raymond (2006) who found a reduced AB for familiar faces.

On the other hand, it can be hypothesized that the conscious perception of feared object may be facilitated by the involuntary, stimulus-driven recruitment of attentive resources referred to as Attentional Capture (Simons, 2000; Yantis and Egeth, 1999). Indeed, there is evidence that meaningful objects, such as a smiling face or the subject’s own name, are able to draw the attention even when they are unattended and task-irrelevant (Mack et al., 2002). In order to clarify this issue, the effects of the spider as either a Distractor to be ignored or a Target to be identified, deserves further investigation.

Conclusions

Altogether these results suggested that:

- The fear salience of a stimulus enhances its probability to be consciously perceived even when attention is temporally engaged by a previous demanding event.
- Such enhancement of probe visibility was not associated to a trade-off effect that is a reduced accuracy in the identification of critical target.
- The possibility that the enhanced perception of fear stimuli was due to an involuntary capture mechanism rather than to a reduction in attention demands needs to be further investigated.

Acknowledgements

This work was funded by the Italian Ministry of University and Research. We gratefully acknowledge Prof. M. Di Stefano for her helpful comments.

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