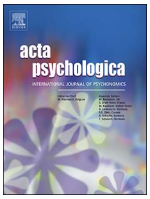
Acta Psychologica 185 (2018) 166–171

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy



Investigating evolutionary constraints on the detection of threatening stimuli in preschool children

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ARTICLE INFO

Keywords:
Visual search
Threat detection
Fear
Attention
Spider
Syringe

ABSTRACT

Numerous objects and animals could be threatening, and thus, children learn to avoid them early. Spiders and syringes are among the most common targets of fears and phobias of the modern word. However, they are of different origins: while the former is evolutionary relevant, the latter is not. We sought to investigate the underlying mechanisms that make the quick detection of such stimuli possible and enable the impulse to avoid them in the future. The respective categories of threatening and non-threatening targets were similar in shape, while low-level visual features were controlled. Our results showed that children found threatening cues faster, irrespective of the evolutionary age of the cues. However, they detected non-threatening evolutionary targets faster than non-evolutionary ones. We suggest that the underlying mechanism may be different: general feature detection can account for finding evolutionary threatening cues quickly, while specific features detection is more appropriate for modern threatening stimuli.

1. Introduction

Fear is one of the most common and the oldest of emotions, as it has a crucial role in survival. Human adults know that numerous objects and animals could mean a potential threat and, thus, are better avoided. A large body of research (Blanchette, 2006; Brosch & Sharma, 2005; Gomes, Silva, Silva, & Soares, 2017; Purkis & Lipp, 2007; Thrasher & LoBue, 2016; Waters & Lipp, 2008; Zsido, Deak, & Bernath, 2017; see also LoBue & Rakison, 2013 for review) showed that there are distinct cues that we quickly learn to fear, to detect automatically, and to respond to them quickly. These stimuli can be broken down into two main categories: ones that have an evolutionary history and those that are highlighted during the course of ontogenesis. It has been shown (see e.g., Öhman & Mineka, 2001; Seligman, 1971; Tooby & Cosmides, 1990) that stimuli with evolutionary relevance have an advantage, and therefore, fear acquisition occurs more rapidly and possibly after the very first exposure. For other stimuli, it seems that the three-way model of Rachman (1977) could describe the connection. The model suggests that fear can be acquired via three general pathways, where the first is direct learning through association, and there are two indirect, social learning pathways through observation and verbally transmitted information (see also Mobbs, Hagan, Dalgleish, Silston, & Prévost, 2015).

The advantage of evolutionary relevant cues has been supported by a vast body of literature (Öhman, Flykt, & Esteves, 2001, Purkis & Lipp, 2007, Shibasaki & Kawai, 2009, Soares, Esteves, & Flykt, 2009, Tipples, Young, Quinlan, Broks, & Ellis, 2002). Moreover, this bias was also demonstrated in different populations of children. One of first research studies to do so was conducted by Waters, Lipp, and Spence (2004). Using a dot-probe paradigm, they showed that children had a stronger attentional bias towards threatening than non-threatening cues. Later, LoBue and DeLoache (2008) introduced the classic visual search task (VST) designed by Öhman and colleagues (see. e.g., Öhman et al., 2001; Öhman & Mineka, 2001) in testing fear advantage in children. The adult version of the VST consists of a total of nine pictures arranged in a 3 × 3 array. For target present trials, eight pictures serve as distractors, or *background* en masse, and one image from a different category serves as the *target*. To avoid false responses, target absent trials are needed with nine pictures of the same category. However, this doubles the overall number of trials presented and is not efficient for use in testing smaller children. Hence, LoBue and DeLoache (2008) created and validated a touchscreen version of the VST, and showed that preschool children possess an attentional bias and visual search advantage for snakes, in spite of the fact that only a few children reportedly feared snakes. The same pattern was also demonstrated for spiders (LoBue, 2010a).

However, there are only a few previous research studies (Blanchette, 2006; LoBue, 2010b; Zsido, Bernath, Labadi, & Deak, 2018) exploring the rapid detection of modern threatening stimuli, in

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https://doi.org/10.1016/j.actpsy.2018.02.009
Received 21 June 2017; Received in revised form 14 February 2018; Accepted 19 February 2018

particular, whether as young as preschool children are capable of using a similar mechanism as proposed for evolutionary relevant threatening stimuli. It seems reasonable to claim that the rapid acquisition of modern threats could add to the probability of survival. Thus, an advantage similar to evolutionary threatening stimuli appears plausible for some modern stimuli that children previously encountered and had caused negative experiences. This idea is supported by the results of LoBue (2010b) who used the VST to show different modern threatening and non-threatening targets to children. LoBue also included consideration of previous negative experiences. LoBue found that children detected more quickly the targets with which they had previous negative experience (syringe), compared to neutral (pen) ones. However, they found threatening stimuli without a previous negative encounter (knife) equally as quickly as other neutral (spoon) cues.

Up to now, there has been no research using the classic visual search paradigm to directly compare evolutionary old and modern threatening stimuli that are equally familiar to children in the sense that they reportedly had previously encountered them. Therefore, the overarching goal of our research was to fill this gap. Our first hypothesis was that both types of threatening cues are found equally as quickly, and faster than non-threatening cues. Furthermore, we had a second, more exploratory hypothesis that the visual similarity between threatening and non-threatening targets may contribute to the understanding of the underlying mechanisms for detecting threatening cues such that different strategies might be used for evolutionary relevant and modern exemplars.

2. Method

The paradigm used in this paper is similar to what previous studies (LoBue, 2010a, 2010b; LoBue & DeLoache, 2008) developed to test the attentional bias towards threatening stimuli in children. Here, participants see nine pictures at a time in a 3 × 3 block arrangement. One of the pictures, the *target*, is different from the others. Henceforth, pictures other than the target that were included in the visual search task will be referred to as *background* images.

However, our paradigm includes some changes and novelties compared to those used in previous studies. We directly compared modern and evolutionary relevant threatening and non-threatening targets among neutral distractor images (both modern and ancient) that never served as targets, to avoid any confusion. Thus, a 2 × 2 × 2 design was used with type of background (i.e., evolutionary and modern), origin of target (i.e., evolutionary and modern), and threat level of target (i.e., threatening vs. neutral) as fixed factors.

Images within respective target categories (evolutionary relevant, modern) were similar in shape and pose; and all pictures used were averaged for low-level visual features. This allows us to test the threat advantage hypothesis in a population of children, and rules out variables that were previously proven to be confusing (Quinlan, 2013; Quinlan, Yue, & Cohen, 2017); for instance, distracter picture only serving as a background, and not a target.

2.1. Participants

Sixty-eight (33 girls, 35 boys) preschool children participated in our experiment in exchange for small gifts (i.e., stickers or erasers). Their mean age was 5.5 years ($SD = 0.6$). All of them were right-handed with normal or corrected-to-normal vision, as reported by their parents. We also asked some control questions about their handedness (i.e., "Which hand do you use to hold your spoon when eating?"). Testing was carried out during a previously set one-week interval with the contribution of an institute that oversees several kindergartens in the region. Data from six children were excluded because of failure to follow the instructions, and one child did not want to proceed with the trial phase. Our research was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). Informed written consent was obtained from parents, and oral consent was obtained from the children.

2.2. Stimuli

The stimuli consisted of targets and background images. All of the pictures were taken from the internet. There were four types of targets based on the level of threat (fearful and neutral) and the evolutionary age (modern and old). We sourced nine exemplars of each target category. Spiders were used as evolutionary threats, and ladybirds as a neutral control; the modern threatening cues were pictures of syringes, and pens were used as a neutral control. When sourcing the images, steps were taken to attempt to control and match the pose of the respective threatening cues with their neutral counterparts. Ratings of the threat of images were assessed using a visual analogue scale (transformed to scores 0–100, higher scores mean higher perceived threat level) by our participants after completing the visual search task. The threatening targets (evolutionary relevant $M = 69.12$, $SD = 46.54$; modern $M = 66.18$, $SD = 47.66$) were rated as more threatening than the non-threatening ones (evolutionary relevant $M = 11.77$, $SD = 32.46$; modern $M = 10.29$, $SD = 30.61$; $F(1,67) = 133.35$, $p < 0.01$), the modern and ancient threatening and non-threatening groups did not differ from each other, and there was no interaction between type and origin of the stimulus ($Fs < 1$, $ps > 0.1$). All participants reported that they are familiar with the targets, i.e., they have previously encountered them on more than one occasion. In each case this was also confirmed by one of their parents.

Different targets and backgrounds were used to avoid possible confusion between the tasks. We used two types of background, pictures of bushes serving as evolutionary relevant and pictures of mugs as having modern relevance. There were 16 exemplars of both categories.

After collecting the images, we used the Spectrum, Histogram, and Intensity Normalization and Equalization (SHINE) toolbox (Willenbockel et al., 2010) written using Matlab to control the low-level visual features (luminance, contrast, spatial frequency). The matching steps were applied to the whole images. All the images (threatening and non-threatening targets, backgrounds) were loaded in the program and converted to grayscale. Then, the low-level properties of all of the images were equalised.

First, the luminance and contrast values were matched using exact histogram matching across images. An image histogram is a graphical representation of the tonal distribution in a digital image that plots the number of pixels for each tonal value. For each image, a histogram is extracted. Then, the average histogram is calculated and applied to the original images. The sfMatch function equates the rotational average of the Fourier amplitude spectrum (i.e., the average energy at each spatial frequency) of the histogram matched images. The structural similarity (SSIM) indexes between the images were also optimised, to maximise the perceptual image quality (using three iterations). Therefore, after passing through this process, every image had the same luminance, contrast, and spatial frequency levels.

The 3 × 3 sets were created in a block arrangement (measuring 22.45° × 22.45° in total), with eight background images (measuring 7.57° × 7.57° each) of the same category, and one target image (same size as background pictures). Images were separated with a 2 pt. wide white border. All four targets were presented in each of the nine possible locations; among both types of background image. Thus, the stimuli set consisted of 72 matrices, i.e. nine trials of each of the eight conditions. The trials were presented in two 36-trial blocks, randomized. See Fig. 1 for exemplars of the final stimuli set.

The stimuli appeared on a 17-inch LCD Touchscreen colour monitor with a visible area of 15 in. and a resolution of 1366 × 768, refresh rate and sampling rate of 60 Hz, 24-bit colour format. The stimuli set was presented using PsychoPy Software version 1.83 for Windows (Peirce, 2007).