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The Role of Fear-Relevant Stimuli in Visual Search: A Comparison of Phylogenetic and Ontogenetic Stimuli

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It has been argued that phylogenetic fear-relevant stimuli elicit preattentive capture of attention. To distinguish between fear relevance and time of appearance in evolutionary history, the authors compare phylogenetic and ontogenetic fear-relevant and fear-irrelevant stimuli in a visual search task. The authors found no evidence for a special role of phylogenetic fear-relevant stimuli; it seems that fear relevance in general is more important than is the evolutionary age. The pattern of results indicates that attention toward threatening stimuli is mainly affected by a late component that prolongs the disengagement of attention.

Fear signals danger and helps people become aware of possibly menacing situations. If confronted with a threat, one should quickly decide whether to attack or to withdraw. Fear serves to interrupt other ongoing behavior, so that people can use all of their resources to cope with the danger (Lang, Davis, & Öhman, 2000). Apart from showing the relevance of the situation, fear might also draw the attention toward threats more quickly than would be the case without the emotion.

Öhman and his colleagues (Öhman, Flykt, & Lundqvist, 2000; Öhman & Mineka, 2001) have proposed a theoretical framework of an evolved module of fear and fear learning that is based on the concept of biological preparedness (Seligman, 1971). This module is thought to be a relatively independent behavioral, mental, and neural system specifically designed to solve adaptive problems arising from potentially life-threatening situations. It facilitates the perception of threatening stimuli and enables the organism to quickly learn associations involving stimuli that signal danger. The module thus helps the organism to effectively deal with threatening stimuli and increases its chances of survival. The neural circuitry subserving the fear module is thought to be organized around the amygdala and includes a short latency pathway from the thalamus to the amygdala termed the *low road* (LeDoux, 1996). Whereas this pathway is related to the auditory modality, Morris and colleagues (Morris, Öhman, & Dolan, 1999) propose a collicular-pulvinar-amygdalar pathway as a shortcut for visual information. Via this pathway, visual information with emotional content might directly reach the amygdala without being diverted to cortical areas. The role of this shortcut has been questioned because the neurons of the superior colliculus are unable to discriminate at high spatial-resolution rates and thus would be unable to compute more complex visual stimuli (Pessoa, Kastner, & Ungerleider, 2002). Although fear-relevant auditory stimuli can travel the low road, it seems more plausible that emotional, visual stimuli reach the amygdala via a cortical path that leads from the corpus geniculatum laterale to the visual cortex, then on to occipitotemporal regions, the inferior temporal area, and finally the amygdala (Gazzaniga, Ivry, & Mangun, 2002).

To back up his proposal of an evolved fear module, Öhman and colleagues have taken into account results from classical conditioning paradigms (Öhman, Eriksson, & Olofsson, 1975; Öhman, Frederikson, Hugdahl, & Rimmö, 1976), masking paradigms (Öhman & Soares, 1993), and visual search tasks (Öhman, Flykt, & Estevez, 2001; Öhman, Lundqvist, & Esteves, 2001). They have argued that the special position of phylogenetic stimuli is demonstrated by observations such as resistance to extinction, nonconscious processing in masking paradigms and preattentive or facilitated processing in visual search tasks. However, in each of these studies the comparison of phylogenetic fear-relevant and fear-irrelevant stimuli confounded fear relevance and a factor that concerns the time of appearance in the evolutionary history. The effects observed with phylogenetic stimuli may have been due to ontogenetic, culturally fear-relevant factors rather than to evolutionary factors.

Studies that have manipulated the evolutionary age of the stimuli have generally reported no special status of phylogenetic compared with ontogenetic stimuli. For example, using the classical conditioning paradigm, Hugdahl and Johnsen (1989) observed faster extinction for slides of snakes and spiders than for slides of guns. Similarly, in a backward masking paradigm Flykt (1999) showed identical masking effects for phylogenetic and ontogenetic stimuli.

Another line of evidence for the fear module consists of studies that use visual detection tasks. Most studies in this area focus on the distinction between parallel and serial search (see, e.g., Treisman & Gelade, 1980; Treisman & Gormican, 1988). Some of the early work on visual search investigated the efficiency of detection of emotional faces (Hansen & Hansen, 1988; but see Purcell, Stewart, & Skov, 1996). More recently, further evidence has been reported to support the claim for a more efficient search for phylogenetic fear-relevant stimuli, namely schematic threatening faces (Öhman, Lundqvist, & Estevez, 2001) and pictures of snakes

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and spiders (Öhman, Flykt, & Lundqvist, 2001). Tipples and colleagues (Tipples, Young, Quinlan, Broks, & Ellis, 2002) replicated Öhman's findings in showing a more efficient search for threatening animals among plant distractors. However, they also found similar patterns when they substituted threatening animals with harmless or friendly animals like kittens and bunnies. In addition, against a background of heterogeneous distractors, searches for plants were shown to be more difficult than searches for animals. The authors hypothesized that the category of animals in general might have more distinct visual properties than do plants, which might be more difficult to process.

The present study is a close replication of Öhman et al. (2001), extended by the inclusion of both ontogenetic fear-relevant stimuli and ontogenetic fear-irrelevant stimuli. The experimental design allowed us to disentangle fear relevance and time of appearance in the evolutionary history. Studies that use classical conditioning and backward masking paradigms have already provided evidence against the special nature of phylogenetic fear-relevant stimuli by comparing them with ontogenetic fear-relevant stimuli (Flykt, 1999; Hugdahl & Johnsen, 1989). The present experiment is the first one to directly compare phylogenetic and ontogenetic stimuli in a visual search task. The main question asked is, is there evidence for a preattentive search that is exclusive to phylogenetic threatening stimuli? If so, we would expect to find an interaction that shows an effect of grid size for all stimulus categories except the phylogenetic threatening category. For this category, there should be little differences in search times as the number of distractors is increased.

Method

Participants

Sixty-three students of the University of Kent (13 men, 50 women) took part in the experiment on an informed consent basis. Participants gained course credit for participation. Ethics approval was obtained from the Department of Psychology Research Ethics Panel at the University of Kent.

Materials

Eight different categories of color pictures (snakes, spiders, flowers, mushrooms, guns, syringes, cups, mobile phones) were used to construct the stimulus grids. Pictures were downloaded from the Internet.[1] Each category contained nine different pictures. The stimulus grids consisted of either 2 × 2 or 3 × 3 images. In the 2 × 2 grids, the pictures appeared on the outer corner position of the 3 × 3 grids. On the computer screen, the grids had a total size of 28 × 30 cm. Participants were positioned 100 cm from the screen. This resulted in a visual angle of 15.6° × 16.7°. Grids belonged either to the target-absent or the target-present condition. In the target-absent condition, all four or nine images were from the same category; in the target-present condition, one of the images, the target, was from a different category than that of the distractor images. If the target was from a threatening category, the distractor images were taken from a single nonthreatening category and vice versa. Each target category was used equally often. The target was placed in one of the four possible positions in the 2 × 2 grid or in one of the eight noncentral positions of the 3 × 3 grid. All positions were used equally often for each target category. The position of the distractor images was randomized. The order of the presentation of the grids was randomized with the restriction that no more than three matrices with or without a target were presented in sequence. Thus, a total of 128 3 × 3 and 64 2 × 2 grids were presented for both the target-absent and the target-present conditions. All stimuli were presented on an IBM-compatible PC. The experimental control software was written with E-Prime (Psychology Software Tools, 2002).

Procedure

Participants were instructed to decide whether all presented pictures belonged to one category or whether one of the pictures belonged to a different category. First, a fixation cross appeared in the center of the screen for 1,000 ms, followed by the stimulus grid. The grid remained on screen until the participants responded. After the response, the next fixation cross appeared immediately. If all pictures belonged to one category, participants pressed the *C* key with their left hand; if a target was present, they pressed the *M* key with their right hand. Labels with the inscriptions *C: same category* and *M: different category* were attached to the lower part of the computer monitor. The participants were explicitly told that in 50% of the grids all pictures belong to one category, and in 50% there would be one picture from a different category. Each session began with 11 practice trials that included stimuli both with and without targets. Then the 384 grids were shown in two blocks of 192, interrupted by a 1-min break.

Results

Nine participants were excluded from the analysis because of error rates higher than 10%.[2] The remaining 54 participants had an average error rate of 4.9%. Only reaction times (RTs) to correctly identified targets and correctly rejected nontargets were included in the analysis. Before the analysis RTs were filtered for outliers, all RTs lying more than three standard deviations above or below the individual mean were excluded from the analysis. The percentage number of trials removed by this procedure was 1.5%.

Analysis of Target-Present Trials

An analysis of the RTs for different target locations in the 3 × 3 grid revealed differences between the inner (the four end locations of an imaginary +) and outer (the four corners of an imaginary ×) target locations. Outer locations have longer RTs (1,214 ms) compared with inner locations (1,149 ms), $t(53) = 6.36$, $p < .001$. To eliminate the biasing effect of location, we report analyses only for the outer locations of the 3 × 3 grid. Note that these locations are identical to the locations of the 2 × 2 grid. The pattern of results, however, did not change by eliminating the biasing effect of location.

RTs were analyzed with age (phylogenetic, ontogenetic), threat (threatening, nonthreatening) and grid (2 × 2, 3 × 3) as within-subject variables. The analysis of variance (ANOVA) revealed main effects for age, $F(1, 53) = 37.838$, $p < .001$, partial $\eta^2 = .42$; threat, $F(1, 53) = 139.142$, $p < .001$, partial $\eta^2 = .72$; and grid, $F(1, 53) = 8.163$, $p = .006$, partial $\eta^2 = .13$. In addition, significant interactions were found between Age × Threat, $F(1, 53) = 64.80$, $p < .001$, partial $\eta^2 = .55$; Threat × Grid, $F(1, 53) =$

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[1] Pictures were retrieved from the following URLs: http://www.xs4all.nl/~ednieuw/Spiders/thumbnails/spidhome_thumbnails.htm; http://www.pitt.edu/~mcs2/herp/SoNA.html; http://www.flowerpictures.net/; http://www.bms.iwarp.com/photo3.html; and Google image search (www.google.com)

[2] We also analyzed the data by using a less strict error criterion of 15%. However, this did not change the pattern of results reported here.

13.05, $p = .001$, partial $\eta^2 = .20$; and Age × Threat × Grid, $F(1, 53) = 4.68$, $p = .035$, partial $\eta^2 = .08$ (see Table 1).

The three-way interaction was broken down into simple effects. This revealed a significant simple Threat × Grid interaction for phylogenetic stimuli, $F(1, 53) = 15.72$, $p < .001$, partial $\eta^2 = .23$. Post hoc tests showed that nonthreatening RTs were higher in the 3 × 3 grid (1,395 ms) than in the 2 × 2 grid (1,291 ms). This was not the case with threatening targets (1,128 ms and 1,137 ms, respectively). When considering only ontogenetic stimuli, the simple Threat × Grid interaction was not significant, $F(1, 53) = 2.72$, $p = .11$, partial $\eta^2 = .05$. However, the trend was in the same direction as for phylogenetic stimuli: There were higher RTs in the 3 × 3 (1,210 ms) than in the 2 × 2 (1,163 ms) grid for nonthreatening targets, $t(53) = 2.1$, $p = .04$, but not for threatening targets (1,138 ms and 1,134 ms, respectively), $t(53) = .27$, $p > .7$. In addition, there was a significant simple main effect of threat for ontogenetic targets, $F(1, 53) = 11.69$, $p = .001$, partial $\eta^2 = .18$.

Analysis of Target-Absent Trials

A repeated measures ANOVA revealed main effects for age, $F(1, 53) = 16.49$, $p < .001$, partial $\eta^2 = .28$; threat, $F(1, 53) = 510.26$, $p < .001$, partial $\eta^2 = .91$; and grid, $F(1, 53) = 65.54$, $p < .001$, partial $\eta^2 = .55$. RTs were higher for ontogenetic compared with phylogenetic stimuli, for threatening compared with nonthreatening stimuli, and for 3 × 3 grids compared with 2 × 2 grids (see Table 1).

Furthermore, the two-way interactions Age × Threat, $F(1, 53) = 121.06$, $p < .001$, partial $\eta^2 = .70$, and Threat × Grid, $F(1, 53) = 10.03$, $p = .003$, partial $\eta^2 = .16$, were significant. Post hoc tests revealed that the effect of threat was more pronounced for ontogenetic than for phylogenetic stimuli and that the effect of grid was more pronounced for threatening than for nonthreatening stimuli. The three-way Age × Threat × Grid interaction, $F(1, 53) = 21.00$, $p < .001$, partial $\eta^2 = .28$, was also significant. Simple effects analysis showed that when considering only the phylogenetic stimuli there were simple main effects of threat, $F(1, 53) = 170.87$, $p < .001$, partial $\eta^2 = .76$, and grid, $F(1, 53) = 46.38$, $p < .001$, partial $\eta^2 = .47$. When considering only the ontogenetic stimuli, simple main effects of threat, $F(1, 53) = 406.81$, $p < .001$, partial $\eta^2 = .89$, and grid, $F(1, 53) = 74.20$, $p < .001$, partial $\eta^2 = .58$, and the simple Threat × Grid interaction, $F(1, 53) = 21.75$, $p < .001$, partial $\eta^2 = .29$, were found. Analysis of this interaction revealed that the effect of grid was more pronounced for threatening than for nonthreatening stimuli.

Table 1 shows the mean error rates. There were more errors for ontogenetic threatening stimuli than for the other categories, $F(3, 53) = 7.45$, $p < .001$, partial $\eta^2 = .12$, and more errors for 2 × 2 grids than for 3 × 3 grids, $F(1, 53) = 4.76$, $p = .034$, partial $\eta^2 = .08$.

Discussion

Our data replicate Öhman's results showing the Threat × Grid interaction for phylogenetic stimuli. The phylogenetic threatening targets showed flat search slopes, whereas the phylogenetic nonthreatening targets did not. However, the additional ontogenetic stimulus categories make the interpretation of this result more ambiguous. Ontogenetic threatening stimuli also showed flat search slopes. This evidence does not support an exclusive preattentive processing for phylogenetic threatening stimuli. The expected pattern for such exclusive processing would have been higher RTs in the 3 × 3 grids for all stimulus categories except the phylogenetic threatening stimuli. This was not the case; higher RTs in the 3 × 3 grids were found only for the phylogenetic nonthreatening category (with a trend for a similar pattern only for the ontogenetic nonthreatening stimuli).

A preattentive search for threatening and nonthreatening ontogenetic stimulus categories does not seem to be useful in terms of the localization of threatening stimuli in the environment, and it lacks a theoretical basis. One explanation might be related to some low-level confound that facilitates the detection of both ontogenetic categories. Color pictures differ in complexity, luminance, and color saturation, and these variables cannot completely be

Table 1
Reaction Times (in Milliseconds), Error Rates (in Percentages), Difference Scores, and Search Slopes (Milliseconds/Distractor) for Target-Present and Target-Absent Trials

Category	2 × 2 grid		3 × 3 grid		Difference	Slope
	RT	ER	RT	ER		
Target present						
Target						
Phylogenetic threatening	1,137	3.4	1,128	7.6	−9	−1.8
Phylogenetic nonthreatening	1,291	5.0	1,395	16.7	104	20.8
Ontogenetic threatening	1,134	3.5	1,138	8.1	4	0.8
Ontogenetic nonthreatening	1,163	3.8	1,210	7.8	47	9.4
Target absent						
Distractor						
Phylogenetic threatening	1,259	2.7	1,492	1.5	233	46.6
Phylogenetic nonthreatening	1,091	1.9	1,315	1.2	224	44.8
Ontogenetic threatening	1,402	4.0	1,699	3.7	297	59.4
Ontogenetic nonthreatening	1,045	2.9	1,199	1.7	154	30.8

Note. RT = reaction time; ER = error rate.

controlled for. An alternative approach would be to use drawn schematic images. However, by using drawn stimuli we would lose a great deal of the ecological validity that is the main advantage of this kind of study.

The pattern of the grid size effects for ontogenetic stimuli—that is, no effect for threatening stimuli and only a small effect for nonthreatening stimuli—suggests another possible explanation. The use of a relatively homogeneous set of distractors (distractors from the same category) may allow these items to be grouped together and rejected without a serial search. This could explain why there are no effects of grid size for threatening targets (ontogenetic or phylogenetic) and only a small one for ontogenetic nonthreatening targets. However, this does not account for the large grid size effect for phylogenetic nonthreatening targets. The analysis of target–absent trials may provide an explanation.

The analyses of target–absent trials showed longer response latencies to threatening stimuli. In line with previous research (Fox et al., 2000; Tipples et al., 2002), this can be interpreted as representing an attention holding component that prolongs the disengagement of attention from a threatening stimulus. In our study, the ontogenetic threatening stimuli tended to keep attention even longer than did phylogenetic threatening stimuli, presumably because our participants found the ontogenetic threat stimuli more threatening than the phylogenetic stimuli.

The threat effect might have counteracted a hypothetical effect of age, so it is not possible to completely rule out an attentional effect exclusive to phylogenetic stimuli. The flat search slope for ontogenetic threatening stimuli might be due to their high threat value, whereas the flat search slope for phylogenetic threatening stimuli might be due to their phylogenetic status. To completely eliminate this possibility, it would be necessary to match ontogenetic and phylogenetic stimuli according to their threat value and to other attributes, for example, complexity. A pilot study collecting adequate data is currently underway in our laboratory. As for the present article, it is necessary to acknowledge the possibility of the alternative explanation concerning two separate threat and age effects.

The disengagement hypothesis can explain why there were longer response latencies to detect nonthreatening targets. Nonthreatening targets appear in a context of either phylogenetic or ontogenetic threatening distractors. So the search for nonthreatening targets might be slowed down by the threatening distractors. However, the disengagement hypothesis cannot alone account for the difference between ontogenetic and phylogenetic nonthreatening targets, as all distractor categories have been counterbalanced across the targets. One explanation may relate to task difficulty. Tipples et al. (2002) have shown that the category of plants, including flowers and mushrooms, are especially hard to identify compared with many other categories. This is consistent with our data showing longer response latencies and higher error rates for plant (phylogenetic nonthreatening) stimuli. In addition, task difficulty may also explain why the effect of grid size was present with phylogenetic nonthreatening targets but less clearly with ontogenetic nonthreatening targets. We hypothesized that the delay in responding to difficult-to-discriminate stimuli (plants) might have allowed the disengagement effects from threatening distractors to be more pronounced.

The results of the present experiment together with the results by Tipples et al. (2002) and Fox et al. (2000) emphasize the role of a disengagement component in attentional processes for threatening stimuli, at least in a nonpathological population. Although the core result of the Öhman, Flykt, & Lundqvist (2001) article has been replicated several times, the interpretation that the result indicates preattentive processing for phylogenetic threatening stimuli can be questioned. This pattern of RTs has been found for several other categories of stimuli. A great deal of the differences in RTs might be explained by the existence of grouping effects as well as a late attention holding component. No preattentive search processes are needed to explain the results.

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New Editors Appointed, 2007–2012

The Publications and Communications (P&C) Board of the American Psychological Association announces the appointment of three new editors for 6-year terms beginning in 2007. As of January 1, 2006, manuscripts should be directed as follows:

- *Journal of Experimental Psychology: Learning, Memory, and Cognition* (www.apa.org/journals/xlm.html), **Randi C. Martin, PhD,** Department of Psychology, MS-25, Rice University, P.O. Box 1892, Houston, TX 77251.
- *Professional Psychology: Research and Practice* (www.apa.org/journals/pro.html), **Michael C. Roberts, PhD,** 2009 Dole Human Development Center, Clinical Child Psychology Program, Department of Applied Behavioral Science, Department of Psychology, 1000 Sunnyside Avenue, The University of Kansas, Lawrence, KS 66045.
- *Psychology, Public Policy, and Law* (www.apa.org/journals/law.html), **Steven Penrod, PhD,** John Jay College of Criminal Justice, 445 West 59th Street N2131, New York, NY 10019-1199.

Electronic manuscript submission. As of January 1, 2006, manuscripts should be submitted electronically through the journal's Manuscript Submission Portal (see the Web site listed above with each journal title).

Manuscript submission patterns make the precise date of completion of the 2006 volumes uncertain. Current editors, Michael E. J. Masson, PhD, Mary Beth Kenkel, PhD, and Jane Goodman-Delahunty, PhD, JD, respectively, will receive and consider manuscripts through December 31, 2005. Should 2006 volumes be completed before that date, manuscripts will be redirected to the new editors for consideration in 2007 volumes.

In addition, the P&C Board announces the appointment of **Thomas E. Joiner, PhD** (Department of Psychology, Florida State University, One University Way, Tallahassee, FL 32306-1270), as editor of the *Clinician's Research Digest* newsletter for 2007–2012.