



Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.ehonline.org

Original Article

Do infants associate spiders and snakes with fearful facial expressions?

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ARTICLE INFO

Article history:

Initial receipt 14 March 2015

Final revision received 1 December 2016

Available online xxxxx

Keywords:

Infancy

Fear

Social learning

Preparedness

ERP

ABSTRACT

Do infants preferentially learn to fear stimuli that represent an ancestral danger? This question was addressed using event-related brain potentials in 9-month-old infants ($N = 38$). In Experiment 1, infants saw fearful and neutral faces gazing towards spiders and flowers. Then spiders and flowers were presented again without faces. Infants responded with increased attention (signaled by the Negative central, Nc component) to stimuli associated with fear. In particular, spiders that were gaze-cued with a fearful as compared to a neutral expression elicited an increased Nc response. In Experiment 2, targets were snakes and fish. Snakes elicited increased Nc amplitude compared to fish irrespective of emotion condition. Results speak to the evolution-based fear-relevance of spiders and snakes. Our findings provide partial support for social fear learning and preparedness theory (Experiment 1) and non-associative accounts of fear acquisition (Experiment 2). We conclude that both kinds of fear acquisition seem to play a role in early human development.

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1. Introduction

Why are specific phobias often directed at ancestral threats like spiders and snakes even in regions of the world where these animals do not currently pose a deadly threat to humans (Fredrikson, Annas, Fischer, & Wik, 1996)? Here, we address this question from a developmental perspective by testing predictions from different theoretical accounts proposing fear acquisition as an evolutionary adaptation.

To explain the development of specific phobias, several accounts have been presented in the literature. All of these accounts have in common that specific phobias are considered side effects of adaptive mechanisms of fear acquisition that have evolved in primate phylogeny. At the core of these theories lies the assumption that evolution has provided us with the ability to avoid potential dangers through fear without having to experience direct fear conditioning, i.e. without first having to put ourselves in harm's way. Three theories we discuss here are social learning, preparedness theory, and non-associative accounts of fear acquisition. These accounts differ in terms of the assumed content dependency of the underlying mechanisms. Whereas *social learning* as a general mechanism can be considered content independent, the other two theories posit that fear responses are more likely to occur for specific contents representing ancestral threats such as spiders. According to *preparedness theory* these content specific responses depend on input in the form of vicarious or direct learning experiences. According to

non-associative accounts, in contrast, content specific fear responses towards ancestral threats are deployed without requiring learning.

1.1. Social learning

In daily life, the sight of a spider or a snake is rarely accompanied by pain and injuries due to bites in most regions of the Western world. Therefore, it has been suggested that observational learning rather than direct conditioning may nowadays be more relevant for the development of specific phobias (Mineka, Davidson, Cook, & Keir, 1984; Olsson & Phelps, 2007; Rachman, 1977). In observational learning the fearful emotional expression of a conspecific is supposed to function as the unconditioned aversive stimulus which is associated with the conditioned stimulus leading to the learning of a fear-response (Olsson & Phelps, 2007). This process is not content dependent with regard to the conditioned stimulus, i.e. in principle any stimulus can be associated with fear.

Infants are sensitive to emotional facial expressions from early on. By 7 months of age infants pay increased attention to fearful faces compared with happy or neutral faces (Nelson & de Haan, 1996; Peltola, Leppänen, Maki, & Hietanen, 2009), especially when fear faces look towards a potential threat in the environment (Hoehl, Palumbo, Heinisch, & Striano, 2008; Hoehl & Striano, 2010).

When encountering a novel object, infants by 9 to 12 months of age search for emotional signals from adults (i.e., they show social referencing) and they adjust their behavior towards the object in accordance with the adults' emotional facial and vocal expressions (Hertenstein & Campos, 2004; Hornik, Risenhoover, & Gunnar, 1987; Moses, Baldwin, Rosicky, & Tidball, 2001; Mumme & Fernald, 2003).

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Thus, infants are guided in their behavior by the emotional reactions and instructions they receive from more experienced others.

Social learning can contribute to the emergence of pathological fear when infants and children regularly observe their caregivers' fear reactions in certain situations. For instance, infants of mothers with social phobia increasingly avoid strangers over time after observing their mothers' anxious social behavior (Murray et al., 2008). Infants' and children's strong propensity for social learning enables fear learning without direct fear conditioning, thus allowing for safer learning. However, for children of parents with phobias this means that they are at a high risk to develop an anxiety disorder themselves (Ginsburg, 2009).

Social learning ensures that humans are able to learn from others' reactions early on in development. This alone does not explain why contents of specific phobias are more often ancestral threats than modern threats, such as electric outlets and guns. According to accounts focusing on social fear learning, infants should readily associate a fear expression with any kind of stimulus. Below, we therefore discuss two theories accounting for selectiveness in fear acquisition by proposing evolved content specific mechanisms.

1.2. Preparedness theory

Seligman suggested in the early 1970s that humans have evolved a preparedness to associate fear with animals and situations that have posed a threat in human phylogeny (Mineka & Öhman, 2002; Seligman, 1971). According to preparedness theory, phobias are more likely to be acquired for animals and situations that were dangerous to our ancestors (e.g., spiders, snakes) than to objects that are dangerous nowadays but not in earlier phylogeny (e.g., guns; Mineka & Öhman, 2002).

There is considerable evidence for content specific fear acquisition. In fear conditioning experiments with adults, certain stimuli representing an ancestral danger to humans, such as snakes and spiders, are more readily associated with unconditioned aversive stimuli (e.g. mild electric shocks) than other stimuli, such as flowers (see Öhman & Mineka, 2001, for a review). Furthermore, associations of ancestral threats with aversive sensations and fear seem to be more robust and less prone to extinction than associations with non-threatening stimuli (Cook, Hodes, & Lang, 1986; Öhman & Mineka, 2001).

Relevant research on preparedness using social fear learning tasks has been conducted with non-human primates. Lab-reared rhesus monkeys do not normally show fear of snakes. However, they are able to quickly learn fear reactions from watching wild rhesus monkeys' reactions to snakes (Mineka et al., 1984). In a further experiment lab-reared monkeys saw conspecifics react fearfully to snakes and crocodiles or to flowers and toy rabbits using manipulated video recordings (Cook & Mineka, 1989). Only when monkeys saw fear reactions of their conspecifics to snakes and crocodiles they acquired fear of these stimuli. Together, these results support the notion that primates can learn fear of certain stimuli via observation, thus indicating the relevance of social information in the process of developing fear responses. In addition, primates seem to be prepared to learn fear of animals that represent ancestral threats speaking for content specific mechanisms underlying fear learning. In this view, infants should be prone to associate fear expressions especially with stimuli representing an ancestral threat.

1.3. Non-associative fear acquisition accounts

Alternatively, proponents of non-associative fear acquisition accounts suggested that fears of certain animals and situations do not require direct or vicarious fear learning experiences (Menzies & Clarke, 1995; Poulton & Menzies, 2002). In this view, humans and other primates initially tend to fear certain stimuli and then habituate when experiencing these stimuli as harmless. Thus, the fear system is supposed to be highly content specific without requiring initial input.

Support for non-associative fear acquisition comes from retrospective reports of phobic individuals that rarely contain fear conditioning experiences as well as prospective studies showing that, for instance, individuals who later report fear of heights did not experience more falls resulting in injuries during childhood (Poulton & Menzies, 2002).

Taking all empirical evidence and theoretical accounts together, there is currently no definite answer to the question whether humans and other primates are especially prone to building fear associations with stimuli representing an ancestral danger or whether they initially respond with fear to these stimuli without requiring previous learning experiences. It is also possible that all of the discussed accounts are valid: Humans may initially be fearful of stimuli that have posed a threat in their phylogeny and then normally habituate through safe exposure, but they may still be more likely to associate these stimuli with fear later on (i.e., to re-learn the fear) through direct conditioning and/or social learning. A valuable approach to test these accounts is to examine infants' reactions to different kinds of stimuli associated with fear. In adults and older children the cultural context and prior encounters with spiders and snakes, even when not consciously remembered, may affect their responses. Testing infants, in contrast, allows us to trace back the origins of selective fear to its very beginnings in human ontogeny.

1.4. Infants' responses to ancestral threats

Several studies have tested attention biases for stimuli representing an ancestral danger in infants (LoBue & DeLoache, 2010; Rakison & Derringer, 2008). Infants in these studies, similar to older children and adults (LoBue & DeLoache, 2008), were able to detect snakes and spiders and responded more quickly to these stimuli compared to control pictures depicting other animals. Mechanisms enabling quick detection of spiders and snakes may constitute an adaptation to ancestral environments in which venomous bites from these animals were a real threat to survival. Adults are able to detect a single briefly presented task-irrelevant spider in an inattentive blindness task (but they less often detect modern threats or houseflies) suggesting that the human visual system retains biases to reflectively direct attention towards this ancestral threat (New & German, 2015). These findings are highly interesting but they cannot answer the question whether fear reactions to snakes and spiders require learning because no fear reactions were recorded and no fear associations were induced. The attention biases for ancestral threat stimuli reported in infants and adults may, however, support selective social fear learning.

To our knowledge, only two studies have tested the selectivity of fear associations for stimuli that constitute an ancestral danger in infants (DeLoache & LoBue, 2009; Rakison, 2009). In the study by DeLoache and LoBue (2009) 8- and 16-month-old infants looked longer at movies of snakes but not other exotic animals when listening to a frightened human voice than when listening to a happy voice. In the study by Rakison (2009) 11-month-olds were habituated to a schematic fearful face displayed next to a spider or a snake. At test, female but not male infants looked longer at a novel picture of a spider or a snake paired with a positive schematic face compared with a mushroom or a flower paired with a positive schematic face. No corresponding effect was found if infants were initially habituated to a schematic fearful face displayed next to a mushroom or a flower. These studies support the idea that social information influences infants' behavioral responses especially to stimuli representing an ancestral danger, but corresponding evidence is still sparse and seems to be limited to certain kinds of stimuli (e.g., moving but not static snakes, DeLoache & LoBue, 2009) and populations (e.g., girls but not boys, Rakison, 2009).

The goal of the current study is to further examine the viability of the social learning account and preparedness theory in early human development, using brain measures rather than looking times, and photographs of natural faces instead of schematic faces (Rakison, 2009) or tone of voice (DeLoache & LoBue, 2009).

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