



Fear in Development

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Abstract

In this chapter, we will provide an overview of the development of fear across infancy and early childhood. First, we describe various theoretical accounts of emotion and their implications for studying fear across development. Next, we describe the perception of threat, including how infants and young children first come to recognize and differentiate a fearful face from other emotional expressions and when they begin to detect signals of threat in the environment. We then describe the developmental trajectory of fearful behavior starting with infancy. We discuss the most commonly experienced fears from infancy to adulthood and how these fears might be acquired. Finally, we describe the neurological underpinnings of fear learning throughout development and close with a few thoughts on future directions for studying fear over the life span.

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Fear is an emotion we have all experienced. Whether you are reluctant to get on a roller coaster, feel nervous in a crowded elevator, or the sight of a spider makes your skin crawl, we all know what it feels like to be afraid. Given the commonality of this experience, you might assume that defining fear and studying it in humans would be easy. Indeed, when do psychologists get the opportunity to study a phenomenon that is common across every single member of a species? Surprisingly, however, studying fear in the laboratory is quite difficult. Researchers agree that fear is an affective response to imminent threat (Delgado, Olsson, & Phelps, 2006; Ferrari, 1986), but they do not agree on the specifics of what constitutes a fearful response, or whether fear is appropriately described when using paradigms that likely measure a simpler threat response (see LeDoux, 2012). Despite widespread acceptance that a variety of behavioral and physiological responses are reasonable indices of fear (e.g., “fearful” facial expressions, accelerated heart rate, increased skin conductance responses), we still have no gold standard, no clear, objective, definitive set of criteria for identifying fear. Instead, many behaviors can reflect a single emotion and the same behavior can be in the service of multiple emotions (Campos, Frankel, & Camras, 2004). As a result, several researchers use self-report as the one reliable way to ensure that individuals are indeed afraid. However, this fail-safe method for

identifying fear poses a problem if your participants have difficulty using language to describe their emotions (like toddlers), or if they cannot use language at all (like infants). So how then do we study fear over the course of development, especially in the first few years of life?

The ongoing debate about defining fear and its requisite behaviors has resulted in various theoretical frameworks for the study of emotion, each with different implications for identifying fear across development. The classic and most popular theory in social psychology is discrete emotions theory (DET), which postulates that a fixed set of “basic” emotions—including fear—are discrete, natural kinds. These basic emotions are innate, evolutionary adaptations to specific environmental challenges, and each has a distinct physiology and dedicated brain circuitry (e.g., Ekman & Cordaro, 2011; Izard, 2007; Panksepp, 2007). The state of a basic emotion like fear would produce a narrow set of stereotyped responses that are highly intercorrelated and unique from other emotions. In infants and young children, this set of responses includes fearful facial expressions (e.g., raised eyebrows and eyelids, mouth gaping open), crying or negative vocalizations, physiological changes such as accelerated heart rate, and behavioral avoidance (Izard, 2007). For some researchers, the requisite set of responses is also accompanied by the subjective feeling of fear (e.g., Ekman & Friesen, 1971), which would allow researchers to infer emotional experiences based on facial expressions and other behavioral indices (for review, see Lewis, 2013). Based on the similarity of fearful facial expressions in adults from different cultures, evidence of a spontaneous “fear face” in infants as young as 2 months of age, and stereotyped fear responses in animals when specific brain regions are stimulated, some researchers claim that fear is one of our basic and universal emotions, emerging early in development (Ekman, 1993; Ekman & Friesen, 1971; Izard, 1990, 1994; Izard, Heubner, Risser, McGinnes, & Dougherty, 1980; Panksepp, 2008; Reissland, Francis, Mason, & Lincoln, 2011).

In contrast to the discrete emotions approach, *emergent* theories—which we use as an umbrella

term for constructivist, dimensional, and appraisal views—characterize fear as a process instead of a state (Coan, 2010; Lewis & Douglas, 1998). In the early stages of the process, subcortical brain regions (e.g., amygdala) are activated and accompanied by autonomic arousal which prepares the body for action. In subsequent stages, physiological changes in the body (accelerated heart rate, sweating, etc.) and additional information about the stimulus and its context are represented in the prefrontal cortex, allowing for comparison of previous events with the present situation (Cunningham & Zelazo, 2007, 2009). Fear emerges as a discrete emotion late in the process when early information is combined with interpretations of the environment and predictions about the future (Barrett, 2006; Clore & Ortony, 2000; Coan, 2010; Cunningham, Dunfield, & Stillman, 2013; Lewis & Douglas, 1998). At this point, individuals might display fearful facial expressions and vocalizations, show behavioral avoidance, and experience the subjective feeling of fear.

These two opposing theories differ in the predictions they would make about what fear might look like over the course of development. According to discrete accounts, activation of fear should elicit a number of stereotypical responses that are common across individuals and highly correlated. In contrast, according to emergent theories, the process of emotional expression is sufficiently flexible to stop short of fear. A sudden change in the environment, for example, might elicit elevated physiological responses, but the process would terminate if later appraisals dismiss the potential threat (Clore & Ortony, 2000; Coan, 2010). Thus, no single measure—except the subjective feeling of fear—necessarily implicates fear. Indeed, neural responses in the amygdala and accelerated heart rate, for example, can be elicited by changes in arousal and are associated with other feelings, including anger and happiness, and contextual situations (Coan, 2010; Kagan, 1988). Moreover, people show a wide range of individual differences in expressions of fear, and research suggests that various fear measures are not strongly intercorrelated (Barrett, 2006; Coan, 2010). Thus, researchers

adopting an emergent view require several converging measures to infer fear, absent the participant's report of feeling afraid (Barrett, 2006; Buss, 2011).

The two views also differ regarding the expected age at which infants might display fear. Again, the discrete emotions theory expects evidence of fear in very young infants because the suite of fearful responses could require only the activation of the requisite neural circuits, which are functional early in life since they are relatively automatic and evolutionarily conserved. In contrast, the emergent account expects a more protracted developmental trajectory because the subjective feeling of fear requires evaluation of contextual information, specifically an evaluation of imminent threat. In this account, discrete emotions such as fear are not present early in development. Instead, expressions of distress in young infants reflect only general negative affect. As infants acquire the ability to represent more contextual information, negative emotions would become increasingly differentiated and discrete (Camras, 2011; Lazarus, 1991; Lewis & Douglas, 1998; Sroufe, 1997).

Although the debate between DET and emergent theories dominates the areas of social psychology and affective neuroscience, the developmental literature has two additional approaches—the functionalist and dynamic systems perspectives—that often guide the design of developmental research. Functionalists conceptualize emotions by the potential adaptive functions that they serve. According to this perspective, no single outcome measure (e.g., like facial expressions for DET) is necessarily privileged in determining whether a behavior is emotional, and, instead, the presence or absence of an emotion is determined by whether an event has significance to the individual. In contrast, a dynamic systems approach does not make assumptions about, or privilege, the function of a particular emotion and, instead, focuses on the process by which emotions emerge across development based on context and individual difference factors (for a review of both accounts, see Witherington & Crichton, 2007). In both approaches, emotions can be viewed as a com-

plex multicomponent system in which context is crucial, suggesting a potential fit with emergent perspectives. However, like DET, many functionalists view emotion as a system that evolved to cope with recurrent environmental challenges, and thus the functionalist approach could also be used alongside a broader discrete emotions perspective (e.g., Keltner & Gross, 1999).

In the following review, we take an emergent perspective, demonstrating that over the course of development, infants first recognize and express general negative affect, and the expression of fear and other discrete negative emotions develops slowly with concurrent changes in cognition and experience. We review the developmental trajectory of normative fears, defining a normative fear as a response to imminent threat that should increase as the proximity of the threat increases. These normative fears are different from clinical fears or phobias which are unreasonable or excessive responses that interfere with daily life and are not necessarily proportional to the proximity of the threat (Broeren, Lester, Muris, & Field, 2011; Lang, Davis, & Öhman, 2000). Consistent with this definition and fitting most closely with a process-based approach to emotion, we discuss the role of both situational context and individual differences in the expression and acquisition of fear throughout life and emphasize how a continuous developmental approach that makes use of multiple measures across varying contexts might be the most useful way of helping researchers understand the development of fear across the life span.

Perception of Fear

Given that we define fear as a response to imminent threat, an individual must detect the presence of a potentially threatening stimulus (usually indexed by attention to angry faces) and recognize the stimulus' threatening or emotional valence (usually indexed by attention to fearful faces) in order to experience and express fear. In the following section, we first describe how infants and young children come to recognize emotionally valenced stimuli—and fearful

expressions in particular—in the first few years of life. We then review the literature on the detection of threatening stimuli, including both social and non-social threats, and its implications for the development of fear and anxiety over the life span.

Perception and Recognition of Fear

Emotion perception begins very early in life. In fact, there is evidence that infants can differentiate between several emotional expressions, including happy, sad, and surprised faces, only hours after birth (Field, Woodson, Greenberg, & Cohen, 1983), and that they can discriminate between other discrete emotional expressions shortly thereafter (Barrera & Maurer, 1981; Farroni, Menon, Rigato, & Johnson, 2007; Young-Browne, Rosenfeld, & Horowitz, 1977). By the age of 4–5 months, infants differentiate between specific negatively valenced emotions, such as fear, sadness (Serrano, Iglesias, & Loeches, 1992), and anger (Schwartz, Izard, & Ansul, 1985), and further, their ability to categorize emotional expressions becomes even more refined in the second half of the first year. By 6–7 months of age, infants can categorize a number of variable expressions as the same emotion (Nelson, Morse, & Leavitt, 1979) and even detect category boundaries between faces when they are slowly morphed from one emotion to another (Kotsoni, de Haan, & Johnson, 2001).

Although infants show evidence that they can categorize various emotional expressions early in infancy, it is likely that this discrimination is based on categorical differences between the features of each facial expression and that infants are unable to interpret the emotional meaning associated with a fearful or threatening face before 5–7 months of age. For example, while very young infants differentiate between fearful and other facial expressions in the first few months of life, infants do not appear to *respond* differentially to fearful faces before 7 months of age (e.g., Peltola, Leppänen, Mäki, & Hietanen, 2009). Around 7 months, there is evidence that infants can both discriminate between various

negative emotional expressions and that they might be beginning to understand the meaning of these faces by showing a distinct *bias* for fear, allocating more attention to fearful than to happy or neutral expressions based on both looking time measures and event-related potential (ERP) responses (e.g., Leppänen, Moulson, Vogel-Farley, & Nelson, 2007; Nelson & De Haan, 1996; Peltola, Leppänen, Mäki, & Hietanen, 2009).

While studies in adults suggest that such a bias for fearful faces is related to the processing of threat-relevant stimuli specifically, it is unclear whether this is the case for infants (Peltola, Leppänen, Mäki, & Hietanen, 2009). One hypothesis is that differential responding to fearful faces in infancy reflects a simple novelty preference. Indeed, although infants see a large number of happy, smiling expressions early in life, parents generally refrain from expressing negative emotions to their newborns (Malatesta & Haviland, 1982), and they do not regularly express fearful expressions until their infants become capable of independent locomotion (Campos et al., 2000; Serrano et al., 1992). Further, infants with highly positive mothers show a larger bias for looking at fearful over happy faces when compared to mothers who generally exhibit less positive affect (de Haan, Belsky, Reid, Volein, & Johnson, 2004), while the opposite is true for infants of depressed mothers or mothers who generally demonstrate more negative affect (Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986; Field, 1992), providing support for the novelty preference hypothesis.

Conversely, others have argued that the emergence of a fear bias in face perception is evidence that infants are capable of recognizing threat for the very first time. Indeed, although infants show heightened responding to fear faces by 7 months of age, they show no such preference for angry faces (Krol, Monakhov, San Lai, Ebstein, & Grossmann, 2015) or for other novel facial expressions (Peltola, Leppänen, Palokangas, & Hietanen, 2008). Further, besides longer looking and heightened ERP responses to fearful faces, 7-month-olds (like adults) also take longer to *disengage* from a fearful face compared to a happy

face (Leppänen et al., 2010; Peltola et al., 2008; Peltola, Leppänen, Vogel-Farley, Hietanen, & Nelson, 2009). That is, when infants are presented with an image of an emotional facial expression in the center of a screen, they have difficulty disengaging from the face if it is fearful (when compared to happy or neutral) in order to look at a probe that appears simultaneously to the right or left side of the center image. Importantly, this effect remains even when researchers control for the salience of the fearful faces' eyes, suggesting that this response cannot be explained by simple perceptual differences between the emotion categories (Peltola, Leppänen, Vogel-Farley, et al., 2009).

Although it is still unclear whether infants understand the meaning of a fearful face by 7 months of age, there is clear evidence that by 12 months, infants can interpret a fear face as a sign of threat and use this social information to guide their behavior in novel situations. For example, 12-month-olds spend less time playing with a novel toy when it is previously paired with a fearful face or voice than when paired with a happy or neutral face/voice (Mumme & Fernald, 2003; Mumme, Fernald, & Herrera, 1996). Infants of the same age also play less with a novel toy when mothers tense their grip on the infants' abdomens after the toy is presented (Hertenstein & Campos, 2001) and move closer to their mothers when they see an experimenter pose a fearful face toward a novel object (Klinnert, 1984).

Some researchers have argued that these behaviors are evidence for a general negativity bias, and not necessarily a bias for fear in particular, citing the adaptive value of avoiding *any* stimulus that others find unpleasant (e.g., Vaish, Grossmann, & Woodward, 2008). However, although infants do show heightened attention to all negative facial expressions, avoidance behavior is most often reported for fearful faces, even when compared to other negative emotional expressions. For example, in a classic study by Sorce, Emde, Campos, and Klinnert (1985), 12-month-old crawling infants were presented with a visual cliff—a glass covered surface with a shallow side and a deep side. The visual cliff was designed specifically to present infants with

an ambiguous or novel situation: It gives the appearance of a dangerous drop-off, but, in reality, there is no real danger of falling. After being placed on the shallow side of the cliff, infants' mothers stood on the deep side posing one of three facial expressions—happy, sad, or fearful—and the infants were then encouraged to crawl across. The researchers reported that when mothers posed a happy face, most of the infants crossed to the deep side; when mothers posed a sad face, some of the infants crossed; and when the mothers posed a fearful face, almost *none* of the infants attempted to venture onto the deep side of the cliff. These findings suggest that while any negative facial expression can elicit avoidance behavior, a fear face elicits the most avoidance responses (Sorce et al., 1985).

It is important to note that infants' avoidance responses in the presence of a fearful face are only evident in novel situations or in response to novel stimuli; avoidance behavior is not generally evident in situations that are familiar, where infants already have experience with an object or situation. For example, although Sorce et al. (1985) found evidence that 12-month-olds avoid crossing an ambiguous visual cliff when their mothers pose a fearful face, Tamis-LeMonda et al. (2008) found that avoidance responses are only evident at ambiguous heights and not for incredibly deep or shallow drop-offs. Using a real adjustable cliff (with no safety glass), these researchers first determined what kinds of drop-offs were actually safe (e.g., 1 cm), risky (e.g., 9 cm), and impossible (e.g., 90 cm) for 18-month-old walking infants to descend. They then asked mothers to pose either happy or fearful expressions on the other side of these safe, risky, and impossible drop-offs. The researchers reported that infants only heeded their mothers' advice for risky or ambiguous (e.g., 9 cm) drop-offs: When the drop-offs were safe (e.g., 1 cm), infants descended despite their mothers' fearful faces, and, when the drop-offs were impossible (e.g., 90 cm), infants avoided descending even when their mothers encouraged them to come (Tamis-LeMonda et al., 2008). In a follow-up study, the researchers reported that the same pattern was true for 12-month-old experienced crawlers, but

not for 12-month-olds who were novice walkers; 12-month-old novice walkers used their mothers' advice less consistently and for only the largest (i.e., 90 cm) drop-offs (Karasik, Tamis-LeMonda, & Adolph, 2016).

After the infancy and toddlerhood period, researchers generally study the development of emotion recognition by examining children's ability to label photographs of adults posing for various emotional expressions or by asking them to match emotion labels with stories that have corresponding elicitors. This body of work suggests that while children can produce the labels for most basic emotion categories before the age of 3, their ability to apply these labels correctly to various emotional expressions and situations develops gradually over the preschool and middle childhood years (Widen, 2013). For example, between the ages of 2 and 5, children first develop the ability to accurately attribute happy, angry, and sad labels to photographs of emotional expressions, with accurate labeling of fear faces (along with surprise and disgust) developing later (Widen & Russell, 2003). Importantly, children's errors in these tasks are systematic, and children most often mistake facial categories for other categories of the same valence (e.g., incorrectly labeling a fearful face as sad or angry; Widen, 2013; Widen & Russell, 2008). This suggests that children first develop the ability to attribute broad valence-based labels to facial expressions before they can recognize and label discrete negative emotions like fear. In fact, based on a large sample of over 1000 2- to 8-year-old children, Widen (2013) reported that over 80% of children showed this developmental pattern, first demonstrating accurate labeling of broad valence-based categories and only later developing the ability to accurately use more specific discrete category labels for emotional expressions.

These studies and others typically use highly iconic emotional stimuli, demonstrating that by middle childhood, children's ability to identify and label photographs of basic emotional expressions reaches that of adults. However, a handful of more recent studies using facial expressions of more varied intensities has shown that while children between the ages of 7 and 10 are highly

accurate at identifying high intensity emotional expressions, there is a much longer developmental trajectory for accuracy in recognizing lower intensity faces. Further, this trajectory differs for different categories of emotion (e.g., happy versus disgusted), suggesting that emotional face recognition may not reach maturity until adulthood (Gao & Maurer, 2010; Thomas, De Bellis, Graham, & LaBar, 2007). These changes likely reflect cognitive advancements in theory of mind and experiential developments in the ability to predict emotional outcomes from social interactions, but further research is needed to determine the exact mechanisms that guide developmental change in this domain (Widen, 2013).

Altogether, developmental research on the recognition of fear suggests that it begins early in life but develops continuously throughout childhood. Even newborns can differentiate between positive and negative emotional expressions, but categorical perception of discrete negative emotions like fear versus anger and sadness develops over the course of the first few months of life. Further, evidence that infants recognize and understand the meaning behind these emotions develops even later, in second half of the first year, possibly beginning when infants begin to attend more to fearful faces over other emotional facial expressions, and clearly emerging by 12 months of age when infants begin to use fearful faces to guide action in ambiguous or novel situations. The ability to label emotional expressions and match emotion words with corresponding elicitors shows a similar developmental pattern that begins in the preschool years and continues into later childhood and adolescence. This developmental progression suggests that emotion perception begins early in life with the categorical perception of faces and becomes more nuanced as children develop the cognitive ability and experience to determine the meaning behind a fearful or threat-relevant expressions.

Threat Detection

In addition to the ability to perceive and differentiate fearful expressions in others, the ability

to detect signals of threat in the environment more generally is important for the experience and expression of fear, and for human survival. Humans have *attentional biases* for certain kinds of threatening stimuli—detecting them more quickly than other stimuli—starting in early childhood and even infancy. For example, when presented with a 3×3 matrix of images with a single target among 8 distracters, 3- to 5-year-old children and adults detect threatening targets like snakes and spiders more quickly than non-threatening targets like flowers, frogs, caterpillars, mushrooms, or cockroaches (LoBue, 2010a; LoBue & DeLoache, 2008). They also detect threatening faces—both angry and fearful—more quickly than happy, neutral, or even sad expressions (LoBue, 2009). In fact, when presented with side-by-side images of a snake and a flower, or an angry and happy face, even 9- to 12-month-old infants turn more quickly to look at snakes than flowers, and angry faces than happy faces (LoBue & DeLoache, 2010). Infants' physiological responses match their attention data: 6- to 9-month-olds show faster startle and lower heart rate in response to snake videos than to videos of other animals, indicative of heightened attention (Thrasher & LoBue, 2016).

One important question is whether attention biases for threat are related to fear. The traditional evolutionary model of threat detection proposes that humans have domain-specific mechanisms for the automatic detection of evolutionarily recurrent threats, like snakes and spiders and threatening conspecifics (e.g., angry faces); these mechanisms are proposed to be part of an “evolved fear module” that is automatically activated upon contact with threat, leading to fear and subsequent avoidance (Öhman & Mineka, 2001). According to this model, which is similar to the discrete emotions framework, a subset of threats should automatically activate the fear module, which would then cause a series of stereotypical fear responses to emerge. The results described above generally support this model, suggesting that rapid attention to threat is early developing, normative, and relatively stable across the life span.

Other studies demonstrate that some of these early developing attentional biases are not necessarily related to fear at all and can be elicited by the simple perceptual features of threatening stimuli. For example, presenting adults and children with low-level stimulus features common to snakes (i.e., their curvy shape) and angry faces (i.e., their “V”-shaped brow) are sufficient for eliciting rapid detection without any additional information (LoBue, 2014; LoBue & DeLoache, 2011; LoBue & Larson, 2010). Further, preschool-aged children detect coiled objects like hoses and wires more quickly than other stimuli, and when snakes are presented in an uncoiled position or when only the snake's face is shown, neither children nor adults detect them more rapidly than other stimuli (LoBue & DeLoache, 2011). This work suggests that rapid detection of some threats might be driven purely by their perceptual features and do not require participants to have knowledge about the stimuli, valenced information, or a specific emotional response.

However, additional work has demonstrated that threatening information or a fearful state can augment existing attention biases. For example, while all adults detect snakes and spiders more quickly than flowers and mushrooms, snake and spider phobic participants detect the object of their fear even more quickly than non-phobic controls (Öhman, Flykt, & Esteves, 2001). Further, labeling a curvy shape as a “snake” or inducing fear before asking participants to engage in a visual search task facilitates rapid detection of a curvilinear or snake-like shape, suggesting that cognitive and emotional factors might bolster existing attentional biases (LoBue, 2014).

There is also evidence that new attentional biases can be learned from negative experiences. Several studies using fear conditioning paradigms have shown that after pairing a neutral stimulus (i.e., a gray box, a neutral face, or a non-threatening animal) with an aversive shock, adults detect that stimulus more quickly than they detect other perceptually similar stimuli (Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004; Milders, Sahraie, Logan, & Donnellon, 2006; Purkis & Lipp, 2009). While adults detect a variety of modern threats like

knives and syringes more quickly than non-threatening stimuli like spoons and pens, 3-year-olds quickly detect syringes—a stimulus with which they all had negative experiences via painful vaccinations—but not knives—a stimulus with which they had little or no direct experience (LoBue, 2010b). This suggests that learning to associate a previously neutral stimulus with threat can lead to the development of a new attentional bias.

There is also evidence that early developing attentional biases interact with infant temperament to facilitate the development of fear and anxiety. Operationally, fear and anxiety are generally considered to be separate and distinct. Fear is an emotion, which is a valenced response to a specific event (Lazarus, 1994). Anxiety is generally considered to be a disposition (i.e., anxious mood) or a trait (i.e., temperamentally anxious) instead of a state (as in discrete emotions theory) or process (as in emergent theories). Further, anxiety does not necessarily have to be linked to a particular event. Anxiety can also be longer lasting than an emotion and can create conditions under which fear might be more likely to occur (Lazarus, 1994).

Importantly, as early as 2–4 years of age, children who are temperamentally shy, and are thus at risk for the development of social anxiety, show a heightened attention bias for social threats (i.e., angry faces) when compared to non-shy controls (LoBue & Pérez-Edgar, 2014; Pérez-Edgar et al., 2010, 2011). Further, while children who are behaviorally inhibited at ages 2 and 3 are socially withdrawn or shy, at age 5, this effect is moderated by an attentional bias to threat: The relationship between behavioral inhibition and social withdrawal was only significant in children who showed a heightened bias for angry versus happy faces (Pérez-Edgar et al., 2011). A second study reported a similar relationship in adolescents (Pérez-Edgar et al., 2010).

Although this work demonstrates a clear relation between attention biases for social threats and anxiety, it is still unclear whether biased attention to threat is a correlate, a risk factor, or simply a symptom of anxiety. Developmental research in this domain is still

quite limited, but very recent work has shown that the relationship between attentional biases for threat and negative affect begins to develop within the first 6 months of life. Normative attentional biases for threatening stimuli—both non-social threats like snakes and social threats like angry faces—first emerge between the ages of 4 and 48 months of age (LoBue, Buss, Taber-Thomas, & Pérez-Edgar, 2017). However, for infants who are temperamentally high in negative affect, attending longer to angry faces is associated with slower subsequent fixations to other stimuli (Pérez-Edgar et al., 2017). In other words, for infants who show the highest levels of temperamental negative affect, the presence of threatening faces already impacts subsequent processing as early as 4 months of age (Pérez-Edgar et al., 2017). This is not the case for non-social threats. A bias for snakes appears by 4 months of age, is stable from 4 to 24 months, and is unrelated to negative affect (LoBue et al., 2017).

Altogether, this work demonstrates that attention biases for threat are early developing, normative, and stable across the life span, consistent with the traditional evolutionary model of threat detection. However, there is also evidence that some attention biases indeed change over time, new biases can be learned based on negative experience, and that individual differences can play a role in shaping attention biases over time. Further, recent work with infants suggests that attention biases for different kinds of threatening stimuli might have different developmental trajectories. For example, while attention biases for non-social threats like snakes appear to be normative, stable across the first 2 years of life, and unrelated to negative affect, attention biases for social threats might work in concert with individual differences in temperament to shape the developmental trajectory of social fear and anxiety. As a whole, this body of work suggests that attention biases for threat develop flexibly over the first few years of life, with different developmental trajectories for different kinds of threats that vary based on their perceptual features and individual differences in both temperament and experience.

Fearful Behavior

As mentioned above, fearful behaviors have traditionally been measured in a variety of ways based on a researcher's theoretical orientation. Many proponents of DET, for example, highlight the importance and universality of facial expressions of fear and might privilege a fearful face when measuring fearful behavior (e.g., Ekman & Cordaro, 2011). Other researchers, such as those who adopt a functionalist perspective, might privilege the function or goal of a behavior, and thus a fearful face or visible negative affect would not be necessary to conclude that an individual is afraid (e.g., Campos et al., 2004). Those who argue for an emergent or multicomponent perspective would not necessarily privilege any one single behavior in the expression of fear and, instead, view fear as a process that involves the interaction between multiple behaviors simultaneously (e.g., Coan, 2010).

Here, we take the latter, emergent, perspective to describe the development of fearful behavior, arguing that developmental data generally favor the notion that fear is a multicomponent system that requires converging measures to accurately identify. Indeed, no single behavior has been found to reliably and definitively indicate the presence of fear in any species (Marks, 1987), and previous research supports only a weak correlation between behavioral, physiological, and, in adults, self-report measures of emotion categories, including fear (Barrett, 2006; Lewis, Brooks, & Haviland, 1978). For example, Nesse et al. (1985) examined measures of distress during in vivo exposure therapy in phobic individuals. Although participants displayed increases in subjective anxiety, pulse, blood pressure, plasma norepinephrine, epinephrine, insulin, cortisol, and growth hormone, there was only modest convergence in the "magnitude, consistency, timing, and concordance" of their measures.

Classically, Lang (1968) proposed that emotions including fear consist of three main response systems, including subjective feelings and cognitions (verbal or cognitive responses), behavioral changes (avoidance and negative affect), and physiological changes. Thus, in the absence of

verbal report, accurately identifying fear requires multiple measures (Buss, 2011), including both behavioral changes such as negative affect and avoidance, accompanied by physiological changes such as accelerated heart rate (Izard, 2007). In typical fear assessments designed for infants and young children, fear is often viewed as a profile of responses that includes measures of negative facial expressions (both the presence and intensity), bodily signs of fear (e.g., tense muscles, freezing, trembling), startle response, distress vocalizations (e.g., fussing, crying), and attempts to escape, as in the Lab-Tab—a standardized assessment of early temperament in infants, toddlers, and preschool-aged children (Goldsmith & Rothbart, 1999).

Emotional Expression in Infancy

As with the discrimination of discrete emotional expressions, infants also *express* discrete emotional facial expressions including fear, disgust, anger, sadness, happiness, and surprise as early as 1–2 months of age (e.g., Izard et al., 1980). However, these expressions are generally produced somewhat randomly, and not in response to an appropriate elicitor (e.g., Camras & Shutter, 2010), suggesting that although the facial musculature is in place to produce various emotional expressions at or shortly after birth, these early expressions do not necessarily correspond to any underlying emotional state. Infants do express negative affect (e.g., crying or fussing) within the first few months of life in response to various negative elicitors, such as being exposed to a bitter taste or having their arms restrained (Camras et al., 2007; Camras, Oster, Campos, Miyake, & Bradshaw, 1992; Camras & Shutter, 2010; Camras, Sullivan, & Michel, 1993; Ekman & Oster, 1979; Oster, Hegley, & Negel, 1992), but they do not produce discrete negative emotional expressions to appropriate elicitors until after several months of development.

Between 8 and 12 months of age—around the same time they begin to show evidence of understanding the meaning of a fearful face—infants begin to produce discrete fearful facial

expressions and other fearful behaviors in response to appropriate elicitors. Historically, developmental researchers have measured fear in infants using the visual cliff and the stranger approach paradigms, generally because it is widely believed that fears of strangers and heights are normative and appear in the first year of life (Slater & Quinn, 2012). However, more recent analyses suggest that while fear of strangers does develop in some infants by 12 months of age, fear of heights may not, and importantly, neither fear can be attributed to *all* typically developing infants at any age (e.g., Adolph, Kretch, & LoBue, 2014; LoBue & Adolph, 2019).

Using the visual cliff, classic research has shown that pre-locomotor infants do not demonstrate behavioral differences when presented with the shallow and deep sides of the cliff, but after several weeks of crawling experience, infants both avoid the deep side of the cliff and show heart rate acceleration when being lowered onto it (e.g. Campos, Bertenthal, & Kermoian, 1992). Many have interpreted these findings to suggest that self-produced locomotion leads to the development of fear of heights, which in turn produces avoidance behavior and heart rate acceleration on the visual cliff (Bertenthal, Campos, & Barrett, 1984; Campos et al., 1992, 2000; Campos, Hiatt, Ramsay, Henderson, & Svejda, 1978; Saarni, Campos, Camras, & Witherington, 2006).

Interestingly, none of the infants in these studies demonstrate evidence of negative affect of any kind. In fact, the predominant affective response to the visual cliff, even the deep side, is smiling (Saarni et al., 2006). Developmental researchers who adopt a functionalist perspective on emotional development have typically explained the absence of negative affect and, often, the presence of positive affect in these studies by arguing that the emotional system in infancy is not sufficiently coherent to produce negative affective displays in response to fear-eliciting situations (Campos et al., 2004). However, the lack of fearful or even negative emotional expressions is puzzling given that infants are capable of expressing general negative affect in response to an appropriate elicitor much earlier in development. This inconsistency has

led others to question whether infants' behavior on the visual cliff really represents fear.

First, besides not producing any signs of negative affect, infants who show accelerated heart rate in response to being lowered onto the cliff often happily crawl across, suggesting that these converging measures of fear do not, in fact, converge (Ueno, Uchiyama, Campos, Dahl, & Anderson, 2011). Second, when infants are presented with a real cliff or other similar obstacle, such as a risky slope or gap in the floor, infants with weeks of locomotor experience do not avoid the drop-off at all; in fact, they spend most of their time right at the edge of the cliff exploring its properties and find alternative ways of descending when there is no safety glass if they deem crawling or walking to be impossible (e.g., Kretch & Adolph, 2013; see Adolph et al., 2014, for a review). Finally, avoidance in response to a real cliff does not transfer between locomotor postures: When placed in an experienced crawling posture, infants refuse to descend steep drop-offs or slopes but walk right over the edge when placed in an inexperienced walking posture (Adolph, 2000; Adolph, Tamis-LeMonda, Ishak, Karasik, & Lobo, 2008; Kretch & Adolph, 2013). This suggests that locomotor experience does not necessarily teach infants to be afraid of the drop-off per se; instead, it simply teaches infants when actions are possible and impossible for their bodies (Adolph et al., 2014; LoBue & Adolph, 2019).

Fear of strangers provides a much clearer example of a normative fear in infancy, as it produces a rich array of behavioral responses that varies between infants and contexts. Infants show that they can discriminate between strangers and their mothers shortly after birth (Field, Cohen, Garcia, & Greenberg, 1984) and look longer at strangers than at their mothers by 5 or 6 months of age (Bronson, 1972; Lewis et al., 1978; Lewis & Rosenblum, 1974; Sroufe, 1997). By 8–12 months of age, infants' emotional responses to strangers begin to vary based on context. Across most classic studies using the stranger approach paradigm—in which a novel person, often male, slowly walks toward an infant—infants show a rich and complex mix of behaviors ranging from very positive to very negative,

including smiling, affiliative responses such as toy sharing, a “sober” (i.e., a “serious” or neutral) facial expression, a shift from positive to neutral facial expression, gaze aversion, cessation of activity, and, in some less common cases, an increase in heart rate, frowning, moving away, and crying (see LoBue & Adolph, 2019, for a review). Although this range of behaviors might seem strange and inconsistent, they begin to cohere when researchers examine variations based on context.

For example, infants show the most negative responses to strangers—including heart rate acceleration, crying, and attempting to escape—when strangers approach quickly, when infants are seated away from their mothers, or when the stranger is a full-sized male adult. In contrast, they show few or no negative emotional responses—and in fact are more likely to show positive or affiliative behaviors—when the study is conducted in the infant’s home, when infants are seated on their mothers’ laps, or when the stranger is a child (Bronson, 1972; Brooks & Lewis, 1976; Ricciuti, 1974; Smith, 1974; Sroufe, 1997). Infants also show variation in their responses to strangers based on individual differences in temperament, with the most anxious infants showing the most negative responses, and the least anxious infants showing the most positive responses (e.g., Brooker et al., 2013; Buss, 2011; Buss, Davidson, Kalin, & Goldsmith, 2004).

Thus, although both fear of heights and fear of strangers have often been characterized as universal, normative fears that appear developmentally in most (if not all) infants, by our definition, a normative fear is a response to imminent threat that should vary based on proximity of the threatening stimulus; normative fears should thus be highly dependent on both context and experience, and they should not appear in all infants all the time. In fact, based on the lack of potential negative experience with threatening stimuli in the first few years of life, one would expect that only a few fears should be evident at this early age. Indeed, despite long-held claims that fear of heights emerges as a result of locomotor experience, presumably from falling, most infants do

not experience major falls, and such falls are not generally predictive of fear of heights (e.g., Poulton & Menzies, 2002). Further, evidence from infants’ responses to a real drop-off suggests that infants do not avoid them at all; instead, they appear to enjoy exploring at the very edge of a drop-off, they find alternative ways to descend if the height does not afford crawling or walking, and they show no evidence of negative affect in response to real or visual cliffs (Adolph et al., 2014; LoBue & Adolph, 2019).

In contrast, although stranger fear is not a behavior that is evident in all infants all the time, the rich array of responses that can be observed in infants at the approach of a stranger demonstrate the dynamic and complicated nature of fearful behavior. Some presumably familiar and safe contexts—an infant’s home or a mother’s lap—elicit almost no fearful responses from infants at all, while other, “stranger” situations that are more likely to be deemed threatening elicit more negative affect when aggravated by the approach of a stranger. Furthermore, it is worth noting that infants who show the highest levels of anxiety as children often behave as if all novel stimuli are threatening, responding negatively to these stimuli regardless of situation or context (e.g., Buss et al., 2004). In other words, infants who fail to evaluate the approach of a stranger based on contextual factors—children who demonstrate *dysregulated fear*—are most at risk for the development of anxiety disorders (Buss, 2011). Thus, normative fears can be observed and measured in infancy, by 8–12 months of age, but researchers should expect a wide range of individual differences and variability based on context and experience, which can be used to help researchers understand differences in developmental outcomes.

Emotional Expression in Later Childhood and Adolescence

After the infancy and toddlerhood period, fear is usually measured in later childhood and adolescence via parent or child self-report, or via questionnaires, such as the Fear Survey

Schedule for Children-Revised (FSSC-R; Ollendick, 1983). According to studies using the FSSC-R and other similar measures, normative fears follow a consistent developmental trajectory throughout childhood and adolescence. As mentioned above, in infancy and toddlerhood, fear of novel objects and people are most common, as well as to maternal separation, followed by fear of animals in early childhood, fear of injury in middle childhood, and self-evaluative fears in adolescence (Muris & Field, 2011). Phobias follow a similar developmental trajectory with supernatural fears beginning in the preschool years, followed by animal fears and fears of other natural phenomenon (e.g., heights, the dark) as well as fears of blood and injury in middle childhood, and finally the development of social fears such as fear of rejection and evaluation emerging in later childhood and adolescence (Broeren, Lester, Muris & Field, 2011; Muris & Field, 2010).

Although some researchers have suggested that there is an evolutionary basis for this developmental pattern (e.g., Öhman, Dimberg, & Öst, 1985), there is empirical evidence that this pattern is consistent with concurrent developments in cognition. If fear is a response to imminent threat, fear should increase as children begin to understand the nature of threat and change with children's growing experience with threatening stimuli (Muris & Field, 2011). Indeed, the prevalence of scary dreams and fear of fantastical creatures increase between the ages of 4 and 9 alongside children's increasing engagement in magical thinking; by age 9, these fears begin to wane, as worry about performing well in school and fear of rejection become more prominent (Muris, Merckelbach, Gadet, & Moulart, 2000). Further, in a study of over 800 children and adolescents (aged 8–18), researchers reported that an increase in social and evaluative fears could be completely accounted for by cognitive factors, supporting the idea that most fears wax and wane over the course of development as children acquire more advanced social and cognitive capabilities (Westenberg, Drewes, Goedhart, Siebelink, & Treffers, 2004).

Fear Acquisition

Given that the development of fearful behavior follows a clear developmental pattern, many researchers have asked whether there are common mechanisms by which these fears are acquired. Like the data on fearful behavior in children and adolescents, much of the published data on fear acquisition has generally made use of retrospective reports. Unfortunately, such reports, especially in children, are inevitably flawed by memory bias. Thus, in the following section, we will discuss evidence from subjective reports with the addition of experimental data whenever possible. Although experimental data is not as subject to memory bias as retrospective report, experimental data does come with some drawbacks as well, namely, that fear acquisition is difficult to study in the lab because of obvious ethical issues. This poses an important challenge to any experimental study of children's responses to a truly fear-inducing stimulus in the lab. To address this issue, researchers interested in studying fear acquisition experimentally use mild techniques and generally examine "fearful behaviors" that are consistent with Lang's (1968) model, measuring either self-reports of fear, negative affect (e.g., fearful facial expressions), avoidance behavior, physiological changes, or some combination.

Three General Learning Pathways

Before the 1970s, the traditional assumption about fear learning was that all fears were acquired via direct classical conditioning. This model was thought to apply to even the youngest participants after John Watson famously demonstrated that 9-month-old "Little Albert" could be conditioned to fear a white rat after repeatedly pairing its appearance with a loud aversive noise (Watson & Rayner, 1920). Indeed, research from the clinical literature on both adults and children suffering from symptoms of post-traumatic stress disorder (PTSD) after experiencing a trauma confirms that long-lasting fearful behaviors can be acquired

through classical conditioning (Dollinger, O'Donnell, & Staley, 1984; Meiser-Stedman, 2002; Meiser-Stedman, Smith, Glucksman, Yule, & Dalgleish, 2008; Trickey, Siddaway, Meiser-Stedman, Serpell, & Field, 2012; Yule, Udwin, & Murdoch, 1990). However, although classical conditioning is still at the center of most theories of fear acquisition, it does not account for how all—or even most—fears are learned. As a result, researchers now accept that fears can also be acquired through two additional *indirect* pathways, namely via observational learning or by the transmission of verbal information (e.g., Askew & Field, 2008; Field & Purkis, 2011; Mineka & Zinbarg, 2006; Rachman, 1977).

Albeit limited in number, there are experimental studies supporting fear learning in children through these indirect pathways (see Askew & Field, 2007, 2008, Field, 2006, Muris & Field, 2010 for reviews). For example, children between the ages 7 and 10 are slower to approach novel animals that were previously paired with a fearful versus happy facial expression and report a higher rate of fear beliefs about these animals when compared to baseline (Broeren, Lester, Muris & Field, 2011; Askew & Field, 2007). Likewise, 6- to 9-year-olds show increased heart rate and slower approach responses to novel animals after being presented with negative versus positive or neutral verbal information (Field & Lawson, 2003; Field & Schorah, 2007). Importantly, similar effects with observational learning have been reported in infants as young as 15–20 months of age (Dubi, Rapee, Emerton, & Schniering, 2008; Gerull & Rapee, 2002), and the effects of negative verbal information have been shown to last up to 6 months after initial exposure (Field, Lawson, & Banerjee, 2008; Muris, Bodden, Merckelbach, Ollendick, & King, 2003), altogether suggesting that indirect pathways are indeed viable mechanisms for the acquisition of long-term fear responses starting in infancy.

Evolutionary Models

The majority of research on fear acquisition across the life span supports the importance of the three general learning pathways discussed above. Indeed, approximately 94% of children or parents self-report at least one of these three pathways as the primary source of their fears (King, Eleonora, & Ollendick, 1998). However, there are still a number of fears for which participants cannot cite one of these learning pathways (King et al., 1998). Further, fears are not proportionally distributed, with our most common fears consisting of biological or natural threats, including fear of heights, fear of enclosed spaces, fear of blood or injury, and fear of animals like snakes and spiders (Coelho & Purkis, 2009; Marks & Nesse, 1994; Öhman & Mineka, 2001; Seligman, 1971). As a result, several evolutionary theorists have posited that there are domain-specific mechanisms in place that privilege the development of some fears over others (Boyer & Bergstrom, 2011).

For example, according to the *non-associative model* of fear acquisition, fears of some evolutionarily recurrent threats—including heights and water—are early developing or innate and do not require specific experience (Menzies & Clarke, 1995; Poulton & Menzies, 2002). Thus, the developmental question for these fears is not whether we learn them but, instead, whether we can *unlearn* them via habituation. Evidence to support this perspective comes from retrospective reports demonstrating that while a substantial number of individuals cannot recall specific instances of learning for fears of water, spiders, and heights, non-evolutionary fears, like fear of the dentist, can almost always be attributed to specific experiences (for a review, see Poulton & Menzies, 2002). Although these data cast doubt on the general learning model, they have been criticized for reliance on retrospective reports, which depend on adults' limited ability to recall instances of fear learning from their past (Coelho & Purkis, 2009; Poulton, Davies, Menzies,

Langley, & Silva, 1998). Indeed, one study with younger participants demonstrates that 9- to 14-year-old girls with a spider phobia have no problem describing the events that led to their fear learning of spiders (Merckelbach, Muris, & Schouten, 1996). Further, many of the studies supporting the non-associative view only focus on direct conditioning experiences and ignore the potential contribution of indirect pathways (Muris, Merckelbach, de Jong, & Ollendick, 2002).

In contrast to the non-associative model, proponents of the *prepared learning model* acknowledge that all fears are learned via conditioning. However, proponents of this model suggest that fear learning for evolutionarily recurrent threats is privileged and occurs more rapidly than for non-recurrent threats (Seligman, 1971). This rapid learning is governed by an “evolved fear module” (as discussed in the section on *Threat Detection*) or a set of dedicated brain circuitry that is activated automatically upon contact with a threatening stimulus (Öhman & Mineka, 2001). Evolutionary recurrent threats like snakes and spiders would thus be highly represented in clinical fears and phobias because humans would be likely to quickly learn a long-lasting, and perhaps overly strong, fear of these stimuli. Support for the prepared learning model comes from research demonstrating that lab-reared rhesus monkeys quickly develop a fear of snakes (but not flowers) after watching a similar fear response from a conspecific. Further, when adults are conditioned to associate an unpleasant electric shock with photographs of snakes and spiders versus flowers and mushrooms, extinction takes longer when conditioned with snakes and spiders (see Öhman & Mineka, 2001 for a review).

Despite widespread support for the prepared learning model (e.g., Rachman, 2002), it has also garnered some important criticisms. First, it is difficult to identify what kinds of stimuli qualify as “evolutionarily” threat-relevant, as it requires assumptions about what was dangerous in our evolutionary past (Coelho & Purkis, 2009; Kleinknecht, 2002; McNally, 2002). Further, while some stimuli that are deemed “evolutionary” threats are indeed dangerous to humans, oth-

ers are not. For example, while venomous snakebites constitute a significant number of deaths worldwide each year (up to 94,000) (Kasturiratne et al., 2008), only a very small percentage of spiders are actually dangerous to humans (Forrester & Stanley, 2004; McNally, 2002).

Individual Differences and Combined Models

Although these different pathways for fear acquisition are often discussed and tested in isolation, it is unlikely that most fears are acquired from a single isolated experience with a threatening stimulus. Instead, combinations of experiences likely build over time, making most fears the product of an interaction between multiple learning pathways (Muris & Field, 2011). Further, there are other factors that might make some children and some stimuli more susceptible to fear learning than others (Askew, Kessock-Philip, & Field, 2008; Coelho & Purkis, 2009; Field & Purkis, 2011; Mineka & Zinbarg, 2006). First, research suggests that girls exhibit higher levels of fear than boys, African American children exhibit higher levels of fear than Caucasian children, and children from a lower socioeconomic status (SES) exhibit higher levels of fear than children from higher SES groups (e.g., Ollendick, Yang, Dong, Xia, & Lin, 1995). Although it is not clear why this is the case, researchers have suggested that it is likely due to differences in socialization practices (e.g., parents’ greater acceptance of fearful behavior in girls than boys).

Second, developmental fears are sensitive to contextual factors such as parenting, which can either buffer or exacerbate fear-learning experiences. For example, while one study reported that 8- to 10-year-old children who watched news coverage with threatening information were more likely to demonstrate higher levels of fear and worry than other children, this effect was moderated by parenting: Children whose parents helped them understand the threatening content did not exhibit high levels of fear (Buijzen, Van der Molen, & Sondij, 2007). Similarly, another study

reported that a neglectful maternal parenting style was associated with an increase in children's fearful responses to negative verbal information (Price-Evans & Field, 2008). Although research in this domain is still quite limited, these findings suggest that if the environment is warm and supportive, children might be less receptive to fear learning, and likewise, if the environment is negative, children might be more prone to learning from threatening information.

Third, there is a large body of research suggesting that individual differences in the presence of fear and anxiety are associated with child temperament, or his/her own individual style of emotional responding to novel stimuli. Children who have a more inhibited or reactive temperament—and thus respond to novel stimuli with more negative affect—are more likely to acquire specific fears and anxiety problems when compared to children with less reactive temperaments (e.g., Buss, 2011; Buss et al., 2004; Field & Price-Evans, 2009; Field & Purkis, 2011; Reynolds, Askew, & Field, 2018), suggesting that fear learning is susceptible to individual differences in a child's own way of responding to the environment.

Finally, early developing attentional biases might also make fear acquisition for some stimuli more likely than others. As described above, countless studies have shown that human adults have attentional biases for threat, detecting various threatening stimuli—including snakes, spiders, and threatening faces—more rapidly than benign control displays, and that these attentional biases are associated with higher levels of specific fear and anxiety (e.g., Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001). One possibility is that stimuli that elicit physiological or attentional responses might be particularly easy to associate with fear. Such differential responses could draw attention to a stimulus or even prime subsequent appraisals, making learning easier in the presence of threatening information (Davey, 2002; LoBue, 2013, 2016; LoBue & Adolph, 2019; LoBue & Rakison, 2013; LoBue, Rakison, & DeLoache, 2010).

More recent models allow for individual differences in fear acquisition and acknowledge that

different learning pathways might work in conjunction to shape the development of specific fears. Several of these models still consider direct conditioning to be central for fear learning but argue that verbal information and social information could create expectancies and possibly facilitate fear learning if conditioning were to take place, particularly when combined with individual difference factors like temperament (e.g., Davey, 1997; Mineka & Zinbarg, 2006). For example, hearing repeated negative information could create a store of past knowledge about the threatening properties of a stimulus, resulting in expectancies that make later conditioning easier (Field & Purkis, 2011). Likewise, negative verbal or social information might function to intensify fears that already exist (Muris & Field, 2010).

Other combined models allow for social and verbal information to be the primary pathway for fear acquisition but propose that the mechanism for learning is still associative in nature. For example, Field (2006) suggested that negative verbal information, for example, could elicit associative learning through children's mental representations. In other words, if a child hears about a snake biting another child, he could subsequently imagine the snake biting *him* and experience fear. In this example, threatening information is the primary source for fear acquisition, but the mechanism for learning is still associative if the child's mental representation of the snake is paired with his fearful response. The same can happen through children's experience with media: A child might watch a movie and experience fear while seeing a scary clown kidnap another child; later, the child might imagine the clown kidnapping him, producing a fear response. Again, the primary source for fear acquisition is the content of the movie, but the mechanism for learning is still associative (see Field & Purkis, 2011, for a detailed review of fear conditioning).

In summary, there are several theoretical models that describe various pathways for fear acquisition over the course of development. All of these models agree that fears can be learned through classical conditioning, and most endorse indirect pathways such as vicarious conditioning

and the transmission of verbal information as well. Despite the fact that all three of these domain-general learning mechanisms have been shown to produce fearful behaviors, several researchers have pointed out that fears are unevenly distributed, and some fears—such as fears of snakes, spiders, heights, and blood/injury—are indeed more common than others. As a result, more recent combined models of fear acquisition often view fear learning as part of a continuum, where some fears are learned more easily than others, and where some children are especially susceptible to fear learning based on individual differences and contextual factors (e.g., Davey, 1997; Field, 2006; Marks, 2002; Mineka & Zinbarg, 2006). Although evolutionary models suggest that domain-specific mechanisms are responsible for the fact that some fears are acquired quickly with little or no learning, combined models suggest that attentional or physiological changes could instead lead to facilitated learning or that prior experience (i.e., through negative verbal information) could result in expectancies that make conditioning easier (Field & Purkis, 2011). Future research is still needed to determine the exact nature of facilitated fear learning and how individual differences might interact with the various learning pathways to result in some of our most common fears.

Fear in the Brain: Developmental Implications

A key brain region involved in emotional responses is the amygdala—an almond-shaped structure located in the medial temporal lobe (Swanson & Petrovich, 1998). More specifically, the amygdala is involved in emotional processing irrespective of valence (Janak & Tye, 2015) with responses more pronounced based on the intensity of stimuli (Anderson, Christoff, Panitz, Rosa, & Gabrieli, 2003). The amygdala's role in emotion can have an impact on several cognitive processes and behavior (e.g., memory; Cahill & McGaugh, 1998) with consequences to long-term well-being (Roosendaal et al., 2009). Notably, neuroscience research across several species

highlights the prominent involvement of the amygdala in the processing of threat-related information or fear (Phelps & LeDoux, 2005). The amygdala has been associated with basic processes, such as the perception and expression of fear, that are intertwined with more dynamic learning processes which foster fear acquisition. While most of the knowledge gained from neuroscience on fear processes has emerged from a rich animal literature and neuroimaging and neuropsychological studies of the adult human brain, more recent investigations in the developing brain support these findings and raise important questions for future consideration.

In the adult brain, the human amygdala is often activated in neuroimaging experiments focusing on the presentation of stimuli that signal potential threat in the environment, such as fearful faces (e.g., for review see Adolphs, 2008) or alarming sounds (e.g., screams; Lau et al., 2011). In support of such studies, patients afflicted with lesions in the amygdala show deficits in recognizing fearful faces, but less so with other emotional faces, presenting more causal data on the involvement of the amygdala in the perception of fear (Adolphs, 2008). Interestingly, studies have also suggested that failure to attend to specific features of the fearful face, such as the fearful eye expression, can account for some of the amygdala deficits and highlight how certain features of biologically relevant stimuli could signal threat (Adolphs et al., 2005).

Beyond responding to the presence of potential threat stimuli, the amygdala is also involved in learning about such threats. The classic experimental approach to study how fears are acquired is Pavlovian conditioning. Rodent models elegantly demonstrate that conditioned stimuli associated with the delivery of an aversive stimulus (e.g., shock or aversive tone) elicit conditioned responses such as freezing, increases in sympathetic responses and hormonal changes, and that such responses are mediated by the integrity of the amygdala (for review see Phelps & LeDoux, 2005). The human amygdala is also recruited during fear conditioning paradigms using functional magnetic resonance imaging (fMRI; LaBar, Gatenby, Gore, LeDoux, & Phelps, 1998).

Further, patients with lesions in the amygdala fail to show sympathetic responses to conditioned stimuli, measured via skin conductance responses, despite explicit recognition of the association (Anderson & Phelps, 2000).

The putative role of the amygdala in fear acquisition extends to indirect forms of learning previously discussed in this chapter, from instruction-based learning where participants are told what the contingency is (Phelps et al., 2001) to more social types of learning that may occur via observation (Olsson, Nearing, & Phelps, 2007). Indeed, the evidence across species and methodologies is that the amygdala is essential for learning about fears. Importantly, the perception and experience of fear can also generalize to other non-threatening stimuli based on the intensity of the stimulus (Dunsmoor, Mitroff, & LaBar, 2009), with physiological expression of fear (e.g., skin conductance responses) correlating with increased amygdala activation (Dunsmoor, Prince, Murthy, Kragel, & LaBar, 2011) and highlighting a pathway to the overgeneralization of fear common across anxiety disorders (Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015).

Given the integral role of the amygdala in the acquisition and expression of fear, and the potential of this activity to generalize and foster chronic stress and anxiety-like symptoms, getting rid of fear representation is a priority research topic with translational implications for clinical applications beyond the scope of this chapter. Nevertheless, it is important to note that the critical relationship between the prefrontal cortex and amygdala allows for emotion regulation processes to develop during an individual's lifetime.

The prefrontal cortex projections to the amygdala can serve the role of inhibiting amygdala responses, and often an inverse relationship is observed between the two structures in studies of aversive processing and emotion regulation (Kim & Whalen, 2009; Urry et al., 2006). Specifically, greater connectivity between the prefrontal cortex and amygdala—where prefrontal cortex serves to inhibit amygdala activity—is observed in processes such as extinction learning (Phelps, Delgado, Nearing, & LeDoux, 2004), emotion

regulation of conditioned threat (Delgado, Li, Schiller, & Phelps, 2008) or other aversive stimuli (Ochsner & Gross, 2005), and reversal learning (Schiller, Levy, Niv, LeDoux, & Phelps, 2008), underscoring the importance of the connectivity between prefrontal regions and amygdala in promoting change to emotional representations that can become maladaptive (Hartley & Phelps, 2010; Schiller & Delgado, 2010).

There are important structural and functional differences in the neurocircuitry involved in fear across development. Such differences are characterized by an overdependence on amygdala-related signals early in life, prior to the maturation of cortical connections that can better serve an emotion regulatory role. The amygdala is a structure that is postulated to be intact early in life based on rodent data (Bouwmeester, Smits, & Ree, 2002) with rapid rates of growth prior to adolescence (Gilmore et al., 2012). In contrast, prefrontal cortex development occurs on a slower trajectory (Casey, Jones, & Hare, 2008), with functional connectivity between the amygdala and medial prefrontal cortical sites maturing during adolescence (Gee, Humphreys, et al., 2013). The structural differences in the amygdala and prefrontal cortex translate to enhanced sensitivity to emotional stimuli during critical developmental stages. For instance, acquisition of threat-like information via aversive conditioning paradigms occurs at a high rate in children (Gao, Raine, Venables, Dawson, & Mednick, 2010). Indeed, enhanced sensitivity to aversive stimuli is more apparent in early childhood compared to older individuals (Silvers et al., 2017). Activity in the amygdala to aversive learning paradigms is also greater in adolescents compared to adults (Lau et al., 2011), although exaggerated amygdala reactivity to threat stimuli (e.g., fearful faces) decreases through adolescence into adulthood (Gee, Gabard-Durnam, et al., 2013).

One interesting hypothesis is that children may have stronger responses to an uncertain and unpredictable environment, which has the adaptive function to train the prefrontal cortex in appropriate threat representation and responses (Tottenham & Gabard-Durnam, 2017). This

could explain why some children, unlike adults, show increased amygdala reactivity to neutral faces (Thomas et al., 2001). Further, unpredictable situations (e.g., threat of an aversive outcome) can foster greater amygdala activity (Davis, Neta, Kim, Moran, & Whalen, 2016) and increased negative evaluation of ambiguous cues (Neta et al., 2017). Given that uncertainty or unpredictability is greater during early stages of childhood, this potentially explains greater amygdala reactivity to aversive stimuli early in childhood. It also highlights the vulnerability of this developmental period to early life stress, which can have maladaptive impacts in behavior later in life due to structural and functional changes in the amygdala as a result of such stress (Hanson et al., 2015).

Since cortical connections are not yet mature during early life and typical emotion regulation processes do not emerge prior to adolescence (Callaghan & Richardson, 2013), alternative mechanisms become imperative in regulating amygdala reactivity. One such mechanism is social buffering, which can occur at various stages of life, with parental care being most important early on, then shifting to peers during adolescence, and more romantic relationships in adulthood (Coan, Schaefer, & Davidson, 2006; Masten, Telzer, Fuligni, Lieberman, & Eisenberger, 2012). Deprivation of parental or caregiver care during infancy leads to an onset of problematic symptomology associated with behavioral disorders (e.g., anxiety, impulsivity; Ellis, Fisher, & Zaharie, 2004), underscoring the critical role of this social buffering mechanism early in life, when cortical regulatory mechanisms are not yet available, in helping to cope with the deleterious impact of stress (Hostinar, Sullivan, & Gunnar, 2014) in an uncertain environment (Tottenham, 2015).

Conclusions and Future Directions

In summary, the literature suggests that fear develops gradually with the perception and expression of negative affect, and slowly becomes a more specific response to imminent threat once

infants gain the experience and cognitive capacity to differentiate between novel and familiar stimuli, and once they can determine when those stimuli might indeed pose a threat. Early in development, fear can be difficult to identify in preverbal infants, but research using the stranger approach and other similar paradigms suggests that the behaviors associated with fear are complex and highly dependent on context and individual differences. Likewise, the acquisition of fear can be explained by several domain-general mechanisms and is similarly affected by individual differences in emotionality, context, and differences in the properties of an individual stimulus.

There are several important issues to address for future research. First, since fear is difficult to study in the lab, there is still much to be learned about the development of specific fears over the life span. And although there is a large amount of data supporting various pathways for fear learning, it is still unclear whether these pathways are differentially effective in producing fear at various stages of development.

For example, despite some agreement among researchers that learning pathways should work together to produce fears developmentally, very few studies have investigated this possibility experimentally. One study, however, did manipulate negative verbal information before children received a direct conditioning experience to examine both the individual and combined strength of each learning pathway. Field and Storksen-Coulson (2007) presented 6- to 8-year-old children with threatening verbal information (or no verbal information) about a novel animal, and then exposed them to a direct conditioning event where children were instructed to touch an animal in a closed box that suddenly started to move. Although both negative verbal information (without the conditioning event) and direct conditioning (in the no verbal information condition) led to an increase in self-reported fear beliefs and avoidance behavior, negative verbal information followed by conditioning had the strongest effect on subsequent behavior. Askew et al. (2008) later replicated these findings with a vicarious learning procedure instead of conditioning, suggesting

that different pathways can indeed work together to produce fearful behaviors.

Another important consideration is whether the efficacy of each of these learning pathways can change over the course of development. For example, while direct conditioning might indeed be the most powerful pathway for fear conditioning across development, it is unlikely that our most common fears—such as fears of snakes and spiders—are acquired via direct negative experiences with these stimuli, leaving open the possibility that observational and instructed learning affect fear acquisition at different ages. Preverbal infants, for example, might learn best by observation, since verbal information or instruction carries little meaning without further language development. As mentioned above, it is common for infants in the second half of the first year to use their mothers' facial expressions as signals for how to behave in novel situations, so it is possible that this particular pathway might be most powerful for fear learning in preverbal infants.

However, after 12–18 months of age, babies less frequently look to their mothers' faces for information than they might have at younger ages (e.g., Kretch, Franchak, & Adolph, 2014). Further, they become more verbal, suggesting that negative verbal information might become an increasingly important pathway for fear learning from infancy to early childhood. Indeed, verbal information sharing is incredibly common between children, their parents, and their peers (Lang, 1968; Muris & Field, 2011). In fact, in a large study of over 1000 children between the ages of 9 and 14, researchers reported that the overwhelming majority of children with fears said that those fears were acquired by hearing or seeing scary things from other people (including parents, teachers, and friends) or from a media source (Ollendick & King, 1991). Media might then play a growing role in fear learning from early to middle childhood, and research has confirmed that children exposed to threat on television are more likely to develop fears than children with less exposure to threat on TV (see Muris & Field, 2011 for a review).

Further, while newer research is beginning to provide some insight into how individual differ-

ences in temperament and attention biases might work together to facilitate the development of fear and anxiety, this area of research is relatively new. Future work that implements longitudinal designs with infant samples would be useful in helping researchers propose a new model of how attention biases develop over time and how they might interact with temperamental and environmental factors to produce adaptive or maladaptive emotional responses (see Field & Lester, 2010; Morales, Fu, & Pérez-Edgar, 2016). Future work embracing an individual differences perspective on fear acquisition that acknowledges the vast amount of variability in emotional expression among individuals is a promising new direction. Again, given the ethical problems with experimental work on fear acquisition, long-term prospective studies on the development of childhood fear and anxiety that take advantage of multiple measures are greatly needed (Muris & Field, 2011). This kind of work—research that takes a developmental perspective and makes use of multiple data collection strategies, including behavioral, physiological, and neural—has the potential of tapping into the dynamic and multifaceted nature of emotional responding and can ultimately advance our understanding of how fear first develops and changes over the course of the life span.

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