NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD
SCIENCE BRIEFS

NEUROSCIENCE

Critical Periods in the Development of Fear

A review of a recent study identifying the effects of different experiences on critical periods of learning during early brain development.

What did the study find? This study found that the presence of corticosterone in a part of the brain called the amygdala determined whether a normally painful experience was learned as an attractive or fearful event. When animals were treated with corticosterone during the first week after birth, the pairing of peppermint with a shock to the foot resulted in the peppermint being perceived as frightening. However, when animals were treated with a drug that blocks the actions of corticosterone during the second week after birth, the pairing of the peppermint and foot shock resulted in the odor being perceived as attractive. Thus, this study demonstrated the ability to change the time frame for a critical period of learning during which a specific experience is associated with later attraction or fear.

Why was this study done? Human infants learn by associating important early experiences (such as feeding) with a variety of details of their environment (such as smells, sights or sounds). For example, babies show a preference for the odor or voice of their mother or primary caregiver over others because it is linked with the pleasure of being fed. This phenomenon is called associative learning and it is a powerful early experience that is retained for a lifetime. All animals show this type of behavior and its widespread prominence is thought to be an indication of its fundamental importance for survival during the period of greatest vulnerability and least capacity for independence. There is another puzzling and well-known phenomenon in very young animals in which the pairing of a typically painful or aversive stimulus (such as a sharp pin prick or brief shock) with an attractive experience (such maternal smells, sounds or touches) does not change the positive perception of the odor, sound or touch. However, this linked attraction is learned only during a specific, early time in development, known as a critical period, so that the same kind of pairing of a positive experience with a painful stimulus later will result in the attractive odor, touch or sound being perceived as aversive. This phenomenon is also observed in children who express a puzzling attraction to adults who were abusive to them early in their lives. Sullivan and colleagues recognized that the period of time when a positive attraction to typically aversive experiences can occur in rats seemed to coincide with a period when the infant rats do not show a typical stress response (i.e., the so-called "stress hypo-

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SCIENCE BRIEFS summarize the findings and implications of a recent study in basic science or clinical research. Studies are selected for review based on their scientific merit and contributions to understanding early development. No single study is definitive, of course. Understanding of early development is based on many studies that, taken together, permit broad conclusions and human applications. Generalizing to human children the results of studies with animals, for example, must be done cautiously and confirmed by research with children and their families. The National Scientific Council rests its work on a rigorous discussion of the validity of many studies like these conducted over many years and using different methodologies and samples.

responsive" period). The goal of this study was to determine the reason for these observed differences in experiences being perceived as either attractive or fearful by infants.

How was the study conducted? Infant rats were exposed to a specific odor (peppermint) that was paired with either brush stroking (to simulate the positive experience of maternal licking) or a brief electric foot shock (an aversive stimulus), and their preference or aversion to the peppermint was tested at a later time. Under normal conditions, this kind of pairing during the first week after birth results in a lasting preference for the peppermint. However, if the investigators wait to do the pairing during the second postnatal week, the peppermint is perceived as aversive. To determine if the stress hormone, corticosterone, affects whether the infants respond with attraction or fearfulness when the odor is paired with a painful experience, two types of drug treatments were administered. First, corticosterone was injected into the whole animal or directly into the amygdala, which is the brain region that controls fear behavior. Second, a drug that interferes with corticosterone activity in the brain was injected into the amygdala of a second group of animals. The investigators then presented the odor on a cotton swab at one side of a box to determine whether, for each of these conditions, the peppermint was attractive (i.e., the animals spent more time where it was located) or repulsive (i.e., the animal avoided it).

What do the findings mean? These findings in the rat demonstrate that responsiveness to the stress hormone, corticosterone, during infancy determines whether individuals learn to associate a particular experience with either attraction or fear. The lack of responsiveness during the early period after birth may exist to make sure that infants learn to associate any kind of stimulation (such as the mother rat picking them up in her mouth) with survival. However, this biological "insurance policy" also creates a period of vulnerability and provides a plausible explanation as to why babies who have been maltreated may later show an inexplicable attraction towards their abuser. The stress hyporesponsive period in humans is reported to extend from birth through age 12 months. This important window of vulnerability for infants adds further scientific evidence to our growing understanding of the potential life-long consequences of toxic stress in the early months of life.

Study Title and Authors: Moriceau, S, Wilson, DA, Levine, S, and Sullivan, RM (2006). Dual Circuitry for odor-shock conditioning during infancy: Corticosterone switches between fear and attraction via amygdala. J. Neurosci. 26:6337-6347.