Symposium on Emotion

EARLY EXPERIENCE AND EMOTIONAL DEVELOPMENT: The Emergence of Wariness of Heights

Joseph J. Campos,[1] Bennett I. Bertenthal,[2] and Rosanne Kermoian[1]

[1]*University of California at Berkeley*, [2]*University of Virginia*

Abstract—*Because of its biological adaptive value, wariness of heights is widely believed to be innate or under maturational control. In this report, we present evidence contrary to this hypothesis, and show the importance of locomotor experience for emotional development. Four studies bearing on this conclusion have shown that (1) when age is held constant, locomotor experience accounts for wariness of heights; (2) "artificial" experience locomoting in a walker generates evidence of wariness of heights; (3) an orthopedically handicapped infant tested longitudinally did not show wariness of heights so long as he had no locomotor experience; and (4) regardless of the age when infants begin to crawl, it is the duration of locomotor experience and not age that predicts avoidance of heights. These findings suggest that when infants begin to crawl, experiences generated by locomotion make possible the development of wariness of heights.*

Between 6 and 10 months of age, major changes occur in fearfulness in the human infant. During this period, some fears are shown for the first time, and many others show a step-function increase in prevalence (Bridges, 1932; Scarr & Salapatek, 1970; Sroufe, 1979). These changes in fearfulness occur so abruptly, involve so many different elicitors, and have such biologically adaptive value that many investigators propose maturational explanations for this developmental shift (Emde, Gaensbauer, & Harmon, 1976; Kagan, Kearsley, & Zelazo, 1978). For such theorists, the development of neurophysiological structures (e.g., the frontal lobes) precedes and accounts for changes in affect.

In contrast to predominantly maturational explanations of developmental changes, Gottlieb (1983, 1991) proposed a model in which different types of experiences play an important role in developmental shifts. He emphasized that new developmental acquisitions, such as crawling, generate experiences that, in turn, create the conditions for further developmental changes. Gottlieb called such "bootstrapping" processes probabilistic epigenesis. In contrast to most current models of developmental transition, Gottlieb's approach stresses the possibility that, under some circumstances, psychological function may precede and account for development of neurophysiological structures.

There is evidence in the animal literature that a probabilistic epigenetic process plays a role in the development of wariness of heights. Held and Hein (1963), for instance, showed that dark-reared kittens given experience with active self-produced locomotion in an illuminated environment showed avoidance of heights, whereas dark-reared littermates given passive experience moving in the same environment manifested no such avoidance. In these studies, despite equivalent maturational states in the two groups of kittens, the experiences made possible by correlated visuomotor responses during active locomotion proved necessary to elicit wariness of heights.

So long as they are prelocomotor, human infants, despite their visual competence and absence of visual deprivation, may be functionally equivalent to Held and Hein's passively moved kittens. Crawling may generate or refine skills sufficient for the onset of wariness of heights. These skills may include improved calibration of distances, heightened sensitivity to visually specified self-motion, more consistent coordination of visual and vestibular stimulation, and increased awareness of emotional signals from significant others (Bertenthal & Campos, 1990; Campos, Hiatt, Ramsay, Henderson, & Svejda, 1978).

There is anecdotal evidence supporting a link between locomotor experience and development of wariness of heights in human infants. Parents commonly report that there is a phase following the acquisition of locomotion when infants show no avoidance of heights, and will go over the edge of a bed or other precipice if the caretaker is not vigilant. Parents also report that this phase of apparent fearlessness is followed by one in which wariness of heights becomes quite intense (Campos et al., 1978).

In sum, both the kitten research and the anecdotal human evidence suggest that wariness of heights is not simply a maturational phenomenon, to be expected even in the absence of experience. From the perspective of probabilistic epigenesis, locomotor experience may operate as an organizer of emotional development, serving either to induce wariness of heights (i.e., to produce a potent emotional state that would never emerge without such experience) or to facilitate its emergence (i.e., to bring it about earlier than it otherwise would appear). The research reported here represents an attempt to determine whether locomotor experience is indeed an organizer of the emergence of wariness of heights.

Pinpointing the role of locomotion in the emergence of wariness of heights in human infants requires solution of a number of methodological problems. One is the selection of an ecologically valid paradigm for testing wariness of heights. Another is the determination of an outcome measure that can be used with both prelocomotor and locomotor infants. A third is a means of determining whether locomotion is playing a role as a correlate, an antecedent, an inducer, or a facilitator of the onset of wariness of heights.

This research was supported by grants from the National Institutes of Health (HD-16195, HD-00695, and HD-25066) and from the John D. and Catherine T. MacArthur Foundation.

Address requests for reprints to Joseph J. Campos, Institute of Human Development, 1203 Tolman Hall, University of California at Berkeley, Berkeley, CA 94720.

The ecologically valid paradigm we selected for testing was the visual cliff (Walk, 1966; Walk & Gibson, 1961)—a large, safety-glass-covered table with a solid textured surface placed immediately underneath the glass on one side (the "shallow" side) and a similar surface placed some 43 in. underneath the glass on the floor below on the other side (the "deep" side).

To equate task demands for prelocomotor and locomotor infants, we measured the infants' wariness reactions while they were slowly lowered toward either the deep or the shallow side of the cliff. This descent procedure not only allowed us to assess differences in wariness reactions as a function of locomotor experience in both prelocomotor and locomotor infants but also permitted us to assess an index of depth perception, that is, a visual placing response (the extension of the arms and hands in anticipation of contact with the shallow, but not the deep, surface of the cliff [Walters, 1981]).

To assess fearfulness with an index appropriate to both pre- and postlocomoting infants, we measured heart rate (HR) responses during the 3-s period of descent onto the surface of the cliff. Prior work had shown consistently that heart rate decelerates in infants who are in a state of nonfearful attentiveness, but accelerates when infants are showing either a defensive response (Graham & Clifton, 1966) or a precry state (Campos, Emde, Gaensbauer, & Henderson, 1975).

To relate self-produced locomotion to fearfulness, we used a number of converging research operations. One was an *age-held-constant design*, contrasting the performance of infants who were locomoting with those of the same age who were not yet locomoting; the second was an analog of an experiential *enrichment* manipulation, in which infants who were otherwise incapable of crawling or creeping were tested after they had a number of hours of experience moving about voluntarily in walker devices; the third was an analog of an experiential *deprivation* manipulation, in which an infant who was orthopedically handicapped, but otherwise normal, was tested longitudinally past the usual age of onset of crawling and again after the delayed acquisition of crawling; and the fourth was a *cross-sequential lag design* aimed at teasing apart the effects of age of onset of locomotion and of duration of locomotor experience on the infant's avoidance of crossing the deep or the shallow side of the cliff to the mother.

EXPERIMENT 1: HR RESPONSES OF PRELOCOMOTOR AND LOCOMOTOR INFANTS

In the first study, a total of 92 infants, half locomoting for an average of 5 weeks, were tested at 7.3 months of age. Telemetered HR, facial expressions (taped from a camera under the deep side of the cliff), and the visual placing response were recorded. Each infant was lowered to each side of the cliff by a female experimenter, with the mother in another room.

As predicted from the work of Held and Hein (1963), locomotor infants showed evidence of wariness of heights, and prelocomotor infants did not. Only on deep trials did the HR of locomotor infants accelerate significantly from baselevels (by 5 beats/min), and differ significantly from the HR responses of prelocomotor infants. The HR responses of prelocomotor infants did not differ from baselevels on either the deep or shallow sides. Surprisingly, facial expressions did not differentiate testing conditions, perhaps because the descent minimized the opportunity to target these expressions to social figures.

In addition, every infant tested, regardless of locomotor status, showed visual placing responses on the shallow side, and no infant showed placing responses on the deep side of the cliff. Thus, all infants showed evidence for depth perception on the deep side, but only locomotor infants showed evidence of fear-related cardiac acceleration in response to heights.

EXPERIMENT 2: ACCELERATION OF LOCOMOTOR EXPERIENCE

Although correlated, the development of locomotion and the emergence of wariness of heights may be jointly determined by a third factor that brings about both changes. Disambiguation of this possibility required a means of providing "artificial" locomotor experience to infants who were not yet able to crawl. This manipulation was achieved by providing wheeled walkers to infants and testing them after their mothers had reported at least 32 hr of voluntary forward movement in the device.

Infants who received walkers were divided into two groups: prelocomotor walkers (N = 9M, 9F, Mean Age = 224 days, Walker Experience = 47 hr of voluntary forward movement) and locomotor walkers (N = 9M, 7F, Mean Age = 222 days, Walker Experience = 32 hr). The performance of infants in these two groups was compared with the performance of age-matched subjects, also divided into two groups: prelocomotor controls (N = 9M, 9F, Mean Age = 222 days) and locomotor controls (N = 9M, 7F, Mean Age = 222 days). The average duration of crawling experience was only 5 days in the locomotor walker and the locomotor control groups. All infants were tested using the same procedure as in the prior study. No shallow trials were administered in order to minimize subject loss due to the additional testing time required for such trials.

As revealed in Figure 1, the three groups of infants with any type of locomotor experience showed evidence of cardiac acceleration, whereas the prelocomotor control infants did not. It is noteworthy that all 16 infants in the locomotor walker group (who had a "double dosage" of locomotor experience consisting of walker training and some crawling) showed HR accelerations upon descent to the cliff. Planned comparisons revealed significant differences between (1) all walker infants and all controls, (2) all spontaneously locomoting infants and prelocomotor controls, and (3) prelocomotor walkers and prelocomotor controls. These findings show that the provision of "artificial" locomotor experience may facilitate or induce wariness of heights, even for infants who otherwise have little or no crawling experience. Locomotor experience thus appears to be an antecedent of the emergence of wariness.

EXPERIMENT 3: DEPRIVATION OF LOCOMOTOR EXPERIENCE

Although Experiment 2 showed that training in locomotion accelerates the

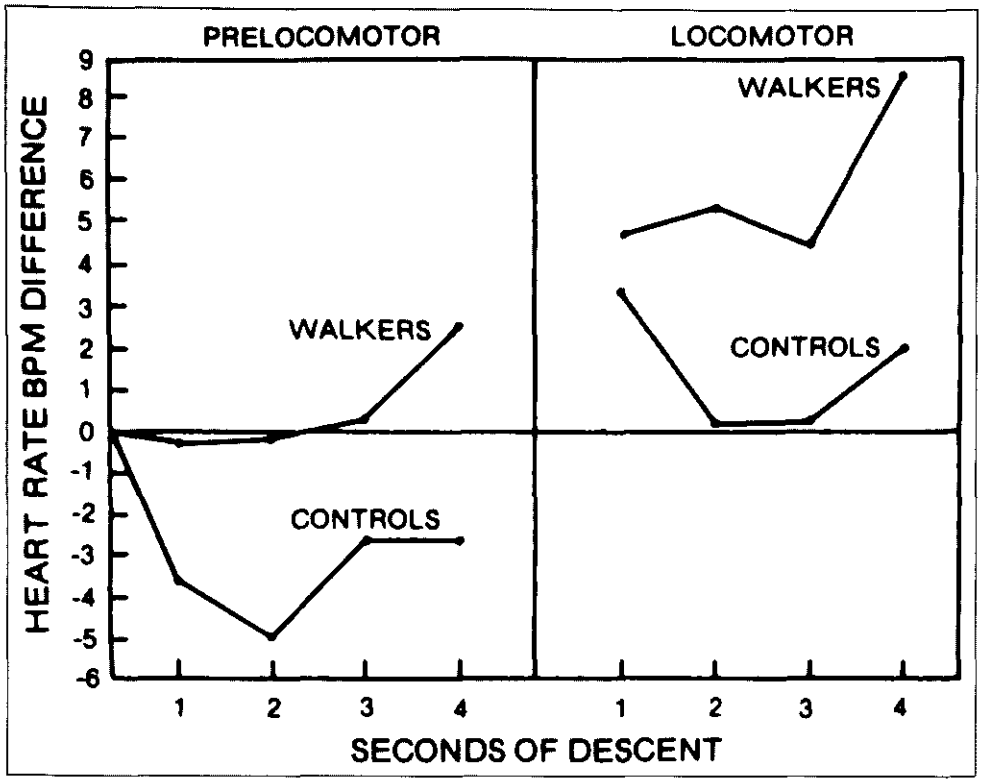

Fig. 1. Heart rate response while the infant is lowered toward the deep side of the visual cliff as a function of locomotor experience. The left panel contrasts the performance of prelocomotor infants with and without "artificial" walker experience. The right panel contrasts the performance of crawling infants with and without "artificial" walker experience. Heart rate is expressed as difference from baseline in beats/min.

onset of wariness of heights, it is possible that this response would eventually develop even in the absence of locomotor experience. To determine whether the delayed acquisition of crawling precedes the delayed emergence of wariness of heights, we longitudinally tested an infant with a peripheral handicap to locomotion. This infant was neurologically normal and had a Bayley Developmental Quotient of 126, but was born with two congenitally dislocated hips. After an early operation, he was placed in a full body cast. The infant was tested on the visual cliff monthly between 6 and 10 months of age using the procedures described above. While the infant was in the cast, he showed no evidence of crawling. At 8.5 months of age (i.e., 1.5 months after the normative age of onset of locomotion), the cast was removed, and the infant began crawling soon afterward.

This infant showed no evidence of differential cardiac responsiveness on the deep versus shallow side of the cliff until 10 months of age, at which time his HR accelerated markedly on the deep side, and decelerated on the shallow. Although we cannot generalize from a single case study, these data provide further support for the role of self-produced locomotion as a facilitator or inducer of wariness of heights.

EXPERIMENT 4: AGE OF ONSET OF LOCOMOTION VERSUS LOCOMOTOR EXPERIENCE

In the studies described so far, HR was used as an imperfect index of wariness. However, we felt that a study using behavioral avoidance was needed to confirm the link between locomotor experience and wariness of heights. We thus used the locomotor crossing test on the visual cliff, in which the infant is placed on the center of the cliff, and the mother is instructed to encourage the infant to cross to her over either the deep or the shallow side. In this study, we also assessed separately the effects of age of onset of crawling (early, normative, or late) and of duration of locomotor experience (11 or 41 days), as well as their interaction, using a longitudinal design.

The results of this study demonstrated a clear effect of locomotor experience independent of the age when self-produced locomotion first appeared. This effect of experience was evident with both nominal data (the proportion of infants who avoided descending onto the deep side of the cliff on the first test trial) and interval data (the latency to descend from the center board of the visual cliff onto the deep side on deep trials minus the latency to descend onto the shallow side on shallow trials). At whatever age the infant had begun to crawl, only 30% to 50% of infants avoided the deep side after 11 days of locomotor experience. However, after 41 days of locomotor experience, avoidance increased to 60% to 80% of infants. The latency data revealed a significant interaction of side of cliff with locomotor experience, but not a main effect of age, nor of the interaction of age with experience. The results of this study further suggest that locomotor experience paces the onset of wariness of heights.

PROCESSES UNDERLYING THE DEVELOPMENT OF WARINESS OF HEIGHTS

The pattern of findings obtained in these four studies, taken together with the animal studies by Held and Hein (1963), demonstrates a consistent relation between locomotor experience and wariness of heights. We propose the following interpretations for our findings.

We believe that crawling initially is a goal in itself, with affect solely linked to the success or failure of implementing the act of moving. Locomotion is initially not context dependent, and infants show no wariness of heights because the goal of moving is not coordinated with other goals, including the avoidance of threats. However, as a result of locomotor experience, infants acquire a sense of both the efficacy and the limitations of their own actions. Locomotion stops being an end in itself, and begins to be goal corrected and coordinated with the environmental surround. As a result, infants begin to show wariness of heights once locomotion becomes context dependent (cf. Bertenthal & Campos, 1990).

The context-dependency of the infants' actions may come about from falling and near-falling experiences that locomotion generates. Near-falls are particularly important because they are frequent, they elicit powerful emotional signals from the parent, and they set the stage for long-term retention of negative affect in such contexts.

There is still another means by which the infant can acquire a sense of wariness of depth with locomotion. While the infant moves about voluntarily, visual information specifying self-movement becomes more highly correlated with vestibular information specifying the same amount of self-movement (Bertenthal & Campos, 1990). Once expectancies related to the correlation of visual and vestibular information are formed, being lowered toward the deep side of the cliff creates a violation of the expected correlation. This violation results from the absence of visible texture near the infant when lowered toward the deep side of the cliff, relative to the shallow side. As a consequence, angular acceleration is not detected by the visual system, whereas it is detected by the vestibular system. This violation of expectation results in distress proportional to the magnitude of the violation. A test of this interpretation requires assessment of the establishment of visual-vestibular coordination as a function of locomotor experience and confirmation that wariness occurs in contexts that violate visual-vestibular coordination.

LOCOMOTOR EXPERIENCE AND OTHER EMOTIONAL CHANGES

The consequences of the development of self-produced locomotion for emotional development extend far beyond the domain of wariness of heights. Indeed, the onset of locomotion generates an entirely different emotional climate in the family. For instance, as psychoanalytic theories predict (e.g., Mahler, Pine, & Bergman, 1975), the onset of locomotion brings about a burgeoning of both positive and negative affect—positive affect because of the child's new levels of self-efficacy; negative affect because of the increases in frustration resulting from thwarting of the child's goals and because of the affective resonance that comes from increased parental expressions of prohibition (Campos, Kermoian, & Zumbahlen, in press). Locomotion is also crucial for the development of attachment (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1973), because it makes physical proximity to the caregiver possible. With the formation of specific attachments, locomotion increases in significance as the child becomes better able to move independently toward novel and potentially frightening environments. Infants are also more sensitive to the location of the parent, more likely to show distress upon separation, and more likely to look to the parent in ambiguous situations.

Locomotion also brings about emotional changes in the parents. These changes include the increased pride (and sometimes sorrow) that the parents experience in their child's new mobility and independence and the new levels of anger parents direct at the baby when the baby begins to encounter forbidden objects. It seems clear from the findings obtained in this line of research that new levels of functioning in one behavioral domain can generate experiences that profoundly affect other developmental domains, including affective, social, cognitive, and sensorimotor ones (Kermoian & Campos, 1988). We thus propose that theoretical orientations like probabilistic epigenesis provide a novel, heuristic, and timely perspective for the study of emotional development.

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