

Two Steps Forward, One Step Back

Emily W. Bushnell
Department of Psychology
Tufts University

There is much to like in Campos et al.'s (this issue) comprehensive and thoughtful target article on the psychological changes impelled by the onset of self-produced locomotion. The critical role of motor abilities in development is reestablished in the midst of an era preoccupied with infants' precocious worldly knowledge and children's emerging theories of mind. The complexity, indirectness, and nonlinearity of development are also wonderfully illustrated. Who would have thought that crawling promotes the understanding of referential gestures, until Campos et al. point out an obvious connection via the increase in parents' distal prohibitions and commands? The article also draws on a wealth of evidence, showcasing all of the classic methodologies in developmental psychology, from deprivation designs and parent interviews to animal models and cross-cultural comparisons. It will be a terrific article to teach from in methods and design courses.

Along with its many virtues, however, Campos et al.'s strong emphasis on locomotor experience as an agent of change seems to sharpen several distinctions that developmental psychologists have been working hard to blur. The first of these is the well-known "nature versus nurture" dichotomy, once the reason for and now the bane of the discipline's existence. Early in the article, Campos et al. state their aim of showing that the broad-scale transition in infancy involving search for hidden objects, secondary intersubjectivity, reactions to heights, and so forth "is not necessarily mediated by maturational factors (i.e., by the unfolding of a genetic blueprint for psychological changes), but instead, is intimately linked to experience" (pp. 153–154). They go on to argue persuasively that these diverse cognitive and social acquisitions are related to experiences and attentional biases that in turn are the inevitable consequences of self-produced locomotion. Hence, once an indi-

vidual infant begins to crawl, the other (cognitive and social) developments are bound to follow, and Campos et al. present an impressive array of data supporting this ontological pattern.

But current views of development do not pit maturation and experience against one another so starkly. Rather, these previously opposed forces are now held to be inextricably intertwined and allied. As stated by Elman et al. (1996) in their seminal book *Rethinking Innateness*, "The interaction between biology and environment is so profound that it is misleading to try to quantify the percentage of behavior attributable to both" (p. 321), and "individual development cannot be fully understood without understanding its evolutionary basis" (p. 20). In this view, the linkages exposed by Campos et al. between locomotion and other developments could be a prime example of "chronotopic nativism" or genetically modulated timing relations. Consider, for example, the increased monitoring of mother's whereabouts, greater attention to distant objects, and wariness of heights that follow hard upon the onset of crawling. Functionally speaking, having such strong feelings about these things is of little use (and might even be a hindrance) to an infant who cannot follow, approach, or avoid particular people and places. However, a baby who can locomote but lacks strong feelings about these things could get into a peck of trouble. Thus one can posit evolutionary pressure for attachment, fear of heights, and so forth to develop in synchrony with locomotion. The genome might not independently or precisely specify the timetables for crawling, attachment, and fear of heights, but it might specify or ensure somehow that whenever the one began, the others would then begin also. Genes have all kinds of indirect ways to "turn on" other genes, processes, or heightened sensitivity to input. In such a scheme, experience is responsible for the link between self-produced locomotion and other developments as Campos et al. maintain, but it is evolutionary experience rather than personal experience, or most likely, it is some sort of special role for personal experience that has been determined by evolutionary experience. Trying to separate the environmental from the biological influences here is a bad idea.

Another element of progress that seems to have been lost in Campos et al.'s article has to do with the direction of causality. In the middle section of the article, the role of locomotor experience in the development of depth perception and spatial cognition is discussed. More specifically, the authors attribute improvements in size and shape constancy and changes in A-not-B performance and infants' behavior on other spatial referencing tasks to the onset of self-produced locomotion. As with their other arguments, they support this case with ample data showing synchrony between locomotor experience and these perceptual and cognitive developments. Campos et al. lay out an appealing explanation that these links are indirect ones, mediated by the fact that locomotion compels infants to attend to visual information that they previously ignored, such as peripheral optic flow, objects and events in far space, motion-parallax information, and so forth. Thus they

invoke J. J. Gibson's (1966) idea that motor factors or action "educates" attention, which then has a further cascade of consequences.

It is certainly true that infants' newfound ability to go places must sharpen their attention to information useful for motivating and regulating these movements. I have recently experienced this kind of altered perception myself, in the context of learning to locomote through white water in a canoe. After running a number of rapids, some successfully and others with compounding errors, I now genuinely "see" flow forces, channel directions, and relations between rocks that I am sure I never noticed before. However, it is not likely that the relations between acting and perceiving, either in my case or in that of the newly locomotor infant, are unidirectional. In the physical world of billiard balls, electrical contacts, and such, there are clearly antecedent causes to subsequent effects, but in the psychological world, developmental psychologists have come to emphasize the reciprocating, spiraling nature of cause-effect relations. This was initially acknowledged in the domain of parent-child interactions, as Bell (1968; see also Crockenberg, 1986) pointed out that an infant's inherent temperament and behavioral tendencies may "provoke" certain parenting styles and tactics, in addition to the parent shaping the child as is usually assumed. Patterson (1976, 1982) then elaborated the concept of bidirectional effects with his work on "coercive families," in which parents and children fall into negative cycles of increasingly defiant behavior and escalating attempts to exert control. In sensorimotor development, the idea of mutually determining causes and effects is reflected in Piaget's (1952, 1954) concept of the circular reaction and in the cycles of exploring, perceiving, and knowing highlighted by E. Gibson and her students (see Adolph, 1995; Adolph, Eppler, & Gibson, 1993; Gibson et al., 1987).

With regard to the acquisitions discussed by Campos et al., bidirectionality in development means that spontaneous attention to things in the distance and a growing appreciation of where they are located could instigate crawling and promote its improvement just as much as the reverse. Indeed, we know that this is true from the extreme case of blind infants, who are delayed in the onset of independent locomotion though not so much in other motor skills (Adelson & Fraiberg, 1974; Fraiberg, 1977); presumably, there is no incentive from things beyond arm's length to propel them forward. In the normal case, crawling and spatial perception and understanding must mutually affect one another in an accumulation of small developmental steps. The first instance or an advance in one leads to the first instance or an advance in the other, which in turn leads to a further improvement in the first, and so on. With this kind of chicken-and-egg development, it cannot be specified and it does not matter what comes first. What is important developmentally is getting the cycle started somehow (or breaking it somehow, in the case of negative cycles). Campos et al. are right in emphasizing the determining role of self-locomotion, but they are wrong in overemphasizing it.

A final line that Campos et al. draw rather too clearly is that between active and passive experience. The evidence rallied throughout the article involves contrasts

between infants who move themselves by hands-and-knees crawling and those who are “without locomotor experience” (p. 154) or are “entirely prelocomotor” (p. 158), and in their conclusion, Campos et al. emphasize that the wide-ranging consequences they discuss are “critically dependent on self-produced locomotion rather than locomotion in general” (p. 208). This active–passive distinction is especially dwelled on in the section outlining locomotion’s influence on sensitivity to optic flow, where the authors rightly note that self-produced locomotion generates correlated or “coupled” visual, vestibular, and somatosensory information, whereas passive locomotion in strollers and the like may involve a wide variety of essentially random associations between visual and proprioceptive sensations. Nowhere is the distinction more obvious than in the intriguing proposal to duplicate the classic Held and Hein (1963) kitten experiment, with some infants actively driving a small go-cart via a joystick while their identical twins go along for a passive parallel ride (Anderson, Campos, Barbu-Roth, & Uchiyama, 1999). I cannot wait to read the write-up and results of this study!

However, in real life, there is a large grey area between truly active and truly passive motor behavior. Developmental psychologists acknowledge this murkiness, and also its importance, with concepts such as scaffolding, framing, the zone of proximal development, apprenticeship, and guided participation. These various terms all call on the fact that human development takes place in a decidedly social context, with older and more expert partners structuring the learning contexts, carrying some of the load, and making it possible for infants to discover things and enjoy successes that they would not and could not on their own. For example, Lockman and McHale (1989) showed that even with regard to simple play with single objects, mothers demonstrate special perceptual features such as texture to their infants and physically guide the infants’ hands through appropriate exploratory movements. With respect to locomotion, I recall how my infant daughter’s young babysitter “walked” her around by holding her wrists for literally hours on end. In this supportive context, the baby was not responsible for correcting her postural errors and did not need to look where she was heading, yet surely the experience gave her a taste for going places and exposure to the meaning of certain optic flow patterns, visual cliffs, and the like. Indeed, my daughter was a very early walker, as were the infants in a more objective experiment when Zelazo, Zelazo, and Kolb (1972) had mothers “practice” their infants’ stepping reflexes during the first half-year of life.

Infants engage in all kinds of “semi-independent” locomotor efforts such as my daughter’s aided walking, and these challenge just how “self”-propelled infants have to be to reap the benefits identified by Campos et al. What might infants learn while “cruising,” for instance, where even before they start to crawl, infants may inch along upright while leaning against furniture? How about when infants “make” their strollers move by wiggling and vocalizing, compelling mom to stop chatting and get going again? How about when they are “actively” looking while

riding in the stroller, turning their heads systematically to follow interesting sights as the stroller moves past? Isn't it possible that this would facilitate a more objective understanding of spatial relations? Finally, what might infants learn from just astutely watching other people locomote? After all, the motor skill literature amply documents "practice" effects derived from imagery exercises and video demonstrations, and neuroscientists have discovered so-called mirror neurons, which fire both when one executes a particular goal-directed movement and when one simply observes someone else execute the movement (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). There are even instances where the person most expert in how to do a certain movement cannot actually perform it himself or herself (gymnastics coach Bela Karolyi comes to mind). These intentionally provocative cases serve to convey just how complex the developmental interplay between motor behavior and perceptual, cognitive, and social events must be. In their article on the impact of crawling during infancy, Campos et al. thankfully lead us down a very interesting path, but they have portrayed it as deceptively straight and narrow. Travel does indeed broaden the mind, but it is a twisting, winding road with many forks and roundabouts between here and there.

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