CHILD DEVELOPMENT PERSPECTIVES

The Costs and Benefits of Development: The Transition From Crawling to Walking

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ABSTRACT—***The transition from crawling to walking requires infants to relinquish their status as experienced, highly skilled crawlers in favor of being inexperienced, low-skilled walkers. Yet infants willingly undergo this developmental transition, despite incurring costs of shaky steps, frequent falls, and inability to gauge affordances for action in their new upright posture. Why do infants persist with walking when crawling serves the purpose of independent mobility? In this article, we present an integrative analysis of the costs and benefits associated with crawling and walking that challenges prior assumptions, and reveals deficits of crawling and benefits of upright locomotion that were previously overlooked. Inquiry into multiple domains of development reveals that the benefits of persisting with walking outweigh the costs: Compared to crawlers, walking infants cover more space more quickly, experience richer visual input, access and play more with distant objects, and interact in qualitatively new ways with caregivers.***

KEYWORDS—*developmental transitions; motor development; crawling; walking; locomotion; posture; head-mounted eye tracking*

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Development often involves a qualitative transition from a set of less effective strategies to a set of more effective strategies. Presumably, increased effectiveness is why children abandon earlier solutions for later ones. One of the most dramatic examples of a qualitative developmental transition is the switch from crawling to walking. The transition from traveling on all fours to moving upright entails different body postures, patterns of coordination between limbs, and relations between the body and the environment. In short, affordances[1] for balance and locomotion are radically different.

The change from crawling to walking represents a puzzle regarding the relative effectiveness of the two strategies. In the weeks encompassing the transition, infants switch from being experienced crawlers with a high level of crawling skill to novice walkers with a low level of walking skill. The puzzle concerns why infants *persist* with walking when they have already mastered crawling. More generally, why do children persist with new strategies that initially incur costs—not benefits—when presumably they cannot know that the new solution will eventually trump the old? This puzzle has been termed a utilization deficiency to reflect persistent use of a new, more mature strategy with decrements or no improvement in initial performance (Bjorklund, 2013; Bjorklund, Miller, Coyle, & Slawinski, 1997; Bray, Hersh, & Turner, 1985; DeMarie-Dreblow & Miller, 1988).

EXPERIENCED CRAWLING AND NOVICE WALKING

Everyone knows that walking *eventually* surpasses crawling. On every metric, skilled walking is a more effective way of getting around than is skilled crawling. However, skilled walking takes months to develop (Adolph, Vereijken, & Shrout, 2003; Hallemans, De Clercq, & Aerts, 2006). On the basis of a century of work on the development of locomotion, it seems reasonable to assume that skilled crawling as a method of locomotion is superior to novice walking. Indeed, crawling yields all the benefits of

[1]*Affordance*, a term coined by Gibson (1979), refers to the possibilities for action allowed by the fit between body and environment.

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independent mobility. Skilled crawlers can move through the environment, explore new surfaces and places, navigate obstacles, and control their proximity to objects and people (Campos et al., 2000; Gibson, 1988; Rheingold & Eckerman, 1970).

Perhaps most impressive, experienced crawlers perceive affordances for locomotion with adult-like precision. For example, experienced 12-month-old crawlers gauge possibilities for crawling down slopes and drop-offs with near-perfect accuracy (Adolph, 1997; Adolph, Tamis-LeMonda, Ishak, Karasik, & Lobo, 2008; Kretch & Adolph, 2013). They crawl headfirst down slopes and over drop-offs within their abilities and avoid, slide down, or back down obstacles that are beyond their abilities—discriminating safe from risky slopes within 2° of accuracy and drop-offs within 1 cm of accuracy.

In contrast, novice walkers do not enjoy these benefits. For them, every step is jerky and precarious, falling is endemic in the best of circumstances, and infants do not perceive affordances for their new upright posture. In trial after trial, novice 12-month-old walkers step straight over the brink of impossibly steep slopes and high drop-offs and fall (Adolph, 1997; Adolph, Tamis-LeMonda, et al., 2008; Kretch & Adolph, 2013). Novice walkers traipse over the edge of a 50° slope on 75% of trials and over the brink of a 90-cm drop-off on 50% of trials. Yet new walkers persist in their new upright posture, despite the incurred costs. In fact, when new walkers are placed at the top of a steep slope in their old familiar crawling posture, about half the time they do not slide safely down as they had done in previous weeks as experienced crawlers. Instead, they stand themselves up, walk over the brink, and fall (Adolph, 1997). If not for the experimenter who rescues them, novice walkers would suffer serious injury. Indeed, falling is a leading cause of injury and death in toddlers (Pickett, Streight, Simpson, & Brison, 2003; Unni, Locklair, Morrow, & Estrada, 2012). Similarly, outside the laboratory, infants behave as if they are determined to face the world upright, despite the costs. In their first days of walking, falls interrupt every few steps. Even after infants can string together a series of consecutive steps, new walkers fall dozens of times every day. Nonetheless, new walkers pick themselves up and try again (Adolph et al., 2012).

In laboratory tasks and daily life, infants have ample opportunity to compare the costs and benefits of crawling and walking. For most infants, the transition from crawling to walking spans a number of weeks in which they sometimes crawl and sometimes walk (Adolph, Robinson, Young, & Gill-Alvarez, 2008). So why do infants persist with walking when crawling is apparently the more optimal solution?

Until recently, research on the developmental transition from crawling to walking was limited largely to characterizing infants' perception of affordances. If the switch to walking puts infants in harm's way, what ontogenetic factors might ensure developmental progress? A focus on the effects of this transition across several domains of development yields some surprises: Experienced crawling is not as effective across the board as one might think, and walking infants immediately reap benefits in areas of development that researchers had not noticed.

ADVANTAGES OF WALKING

Go More

One reason why experienced crawlers might persist with learning to walk is that they can go farther faster. On the surface, this benefit seems counterintuitive because novice walkers have difficulty gauging affordances for navigating obstacles. Indeed, the most striking aspect of novice walking is how frequently infants fall, even on flat ground—presumably a high cost for persisting with a new locomotor skill. However, the relative cost is not so high. Counter to common intuition, infants fall frequently while crawling: Twelve-month-old experienced crawlers average 17 falls per hour (Adolph et al., 2012). Although 12-month-old novice walkers fall nearly twice as often as do experienced crawlers—32 falls per hour—they enjoy the benefits of increased time in motion and covering a greater distance. That is, when the fall rates of novice walkers and experienced crawlers are normalized by how much and how far infants move, the difference between groups completely disappears (Adolph et al., 2012). Specifically, novice walkers walk more than experienced crawlers crawl. Walkers are in motion 33% of the time, whereas crawlers are in motion only 20% of the time. Novice walkers take twice as many steps as experienced crawlers (*M*s = 1,456 and 636 steps per hour), and they travel 3 times the distance (*M*s = 297 and 100 m per hour).

Moreover, infants do not slow down in the transition from crawling to walking (see Figure 1). When observed longitudinally, locomotor speed increases steadily over weeks of crawling (Adolph, Vereijken, & Denny, 1998). But speed continues to increase after infants begin walking (Adolph, 2008). In other words, infants do not incur a greater cost of falling in the transition from crawling to walking, and what they gain in space and speed has implications for exploration and engagement with the surrounding environment.

See More

A second reason why infants might persist with walking is that they can see more in an upright posture than in a crawling position. This notion challenges the long-standing assumption of many developmental theorists that crawling offers infants rich and dynamic visual access to objects, surfaces, and people (Gibson, 1988; Rheingold & Eckerman, 1970). In fact, crawling is touted as a setting event in which the visual experiences obtained while crawling facilitate wariness of heights, balance control, distance perception, and enhanced attention to distal objects (Campos et al., 2000). Based on *third-person* observations of crawling infants (cameras recording infants from across the room), infants "directed their gaze almost exclusively in the direction of motion as they crawled toward a distal goal" (Higgins, 1994, 1996, in Campos et al., 2000, p. 178).

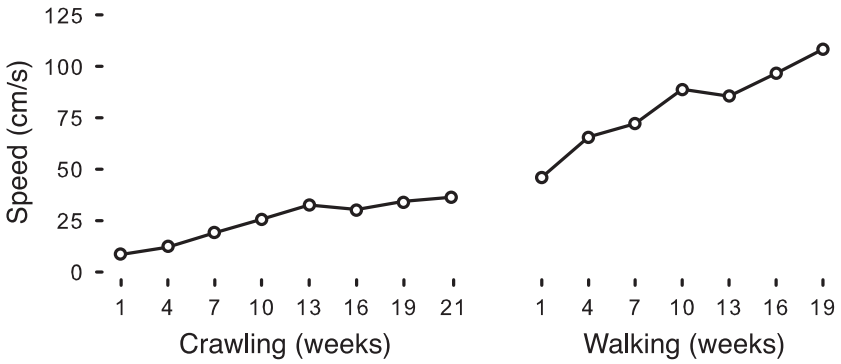

Figure 1. Changes in speed over weeks of crawling and walking in 28 infants observed longitudinally from their first week on hands and knees until 19 weeks after they began walking.

But a first-person view provided by head-mounted eye trackers or head cameras shows that the assumptions of rich visual input and goal-directed crawling are mistaken (see Figure 2). Crawling does not provide enhanced access to visual information for distant objects, elevated surfaces, and people. In a prone position, the neck is naturally parallel to the floor and the eyes point downward, whereas in an upright position, the neck is perpendicular to the floor and the eyes point outward. Thus, while crawling, infants primarily see the floor in front of their hands, but while walking, infants can see the whole room (Franchak, Kretch, Soska, & Adolph, 2011; Kretch, Franchak, & Adolph, 2014). Even when an infant's mother is straight ahead, crawlers rarely see her face or the toys in her hand; walkers see both (Frank, Simmons, Yurovsky, & Pusiol, 2013; Kretch et al., 2014).

Of course, crawlers can get around the deficits imposed by a prone posture by sitting or standing up. When they do so, the whole room swoops into view (Kretch et al., 2014). But these workarounds are imperfect and come at a cost. Changes in posture take time and effort. Infants must stop moving to shift from crawling to sitting, and they must pull up on furniture or walls to stand. Moreover, changes in posture result in discontinuities in the visual landscape. When infants shift from crawling to sitting, they roll over one hip. This maneuver lands them in a legs-out sitting position, but it also turns their bodies 90–180° away from the direction in which they were headed (Soska, Robinson, & Adolph, 2014). As a consequence, infants are no longer looking where they were going originally.

Play More

A third reason why infants may persist with walking is that they can interact with objects in qualitatively new ways due to gains in locomotor space and speed, their new visual vantage on the world, and the freeing of hands for transporting objects. Researchers have considered only recently the potential benefits of walking for object play because independent mobility per se,

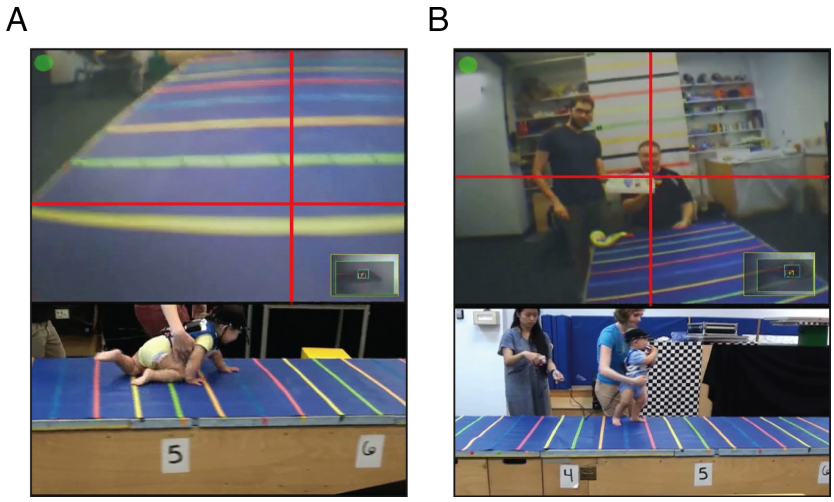

Figure 2. Typical first-person perspectives of (A) a 13-month-old crawling infant and (B) a 13-month-old walking infant moving over a raised walkway toward their mothers who were holding toys and offering verbal encouragement. While crawling, infants see primarily the floor; while walking, they can see their mothers and the far wall. Cross-hairs (top panels) show the infant's direction of gaze as revealed by a head-mounted eye tracker. Bottom panels show the third person view recorded by an external camera perpendicular to the walkway.

rather than upright locomotion, was viewed historically as the major catalyst for changes in infants' interactions with objects.

Specifically, researchers have long supposed that infants crawl to get to objects. In Gibson's (1978) words,

> Exploratory skills in a human infant begin with looking around the world; everything within the baby's field of view provides an incentive. When mobility is achieved, the baby first reaches for, then creeps toward and final walks (or runs) for the attractive goal he or she spies. (p. 610)

This supposition is largely incorrect. The first-person viewpoint described earlier reveals that infants do not see objects across the room while they are crawling (Kretch et al., 2014). And when they shift from sitting (where they do see distant objects) to crawling (where they do not), the change in postures causes them to face in an entirely new direction (Soska et al., 2014). Perhaps as a consequence of differential visual access to objects, experienced 13-month-old crawlers crawl to retrieve distant objects on average only 4 times an hour, whereas novice 13-month-old walkers walk to distant objects 12 times an hour (Karasik, Tamis-LeMonda, & Adolph, 2011). Relatedly, crawlers are more likely to play with proximal objects within arms' reach (M = 39 bouts per hour) than are walkers (M = 26 bouts per hour), whereas walkers are more likely than crawlers to play with distal objects that require a trip to acquire them (Karasik et al., 2011).

Crawlers and walkers also differ in how often they carry objects (see Figure 3). Although 13-month-old crawlers *can* carry objects, they average only 6 bouts of carrying per hour compared to 13-month-old walkers who average 43 bouts of carrying per hour (Karasik, Adolph, Tamis-LeMonda, & Zuckerman, 2012). Crawlers hold objects in their hands as they crawl, push objects along the ground while supporting their body weight, and cruise along furniture while holding onto objects. However, consistent with the benefits to speed and distance described earlier, walkers tend to take more steps per carrying bout (M = 13.85) than do crawlers (M = 10.50), and they take more steps per second (M = 2.31) than do crawlers (M = 1.58) while carrying objects.

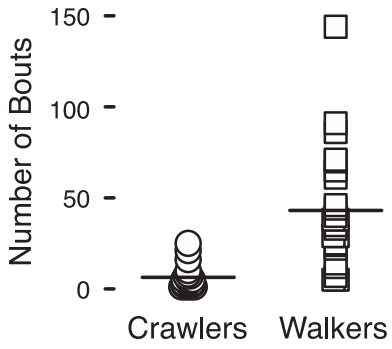

Figure 3. Number of carrying bouts per hour in 13-month-old crawling and walking infants. Each symbol represents one infant; horizontal lines denote group averages.

The frequent carrying observed in novice walkers is in some ways surprising because carrying objects while moving might be expected to compromise walking skill. In laboratory studies, loads strapped to infants' bodies disrupt walking gait and make new walkers more likely to fall (Garciaguirre, Adolph, & Shrout, 2007; Vereijken, Pedersen, & Storksen, 2009). However, when novice walkers carry objects in their hands during spontaneous activity, they are *less likely* to fall compared to walking while their hands are free (Karasik et al., 2012). In fact, object carrying in toddlers affects only arm position, not foot placement, measures of gait maturity (Mangalindan, Schmuckler, & Li, 2014).

Notably, differences in the *quality* of object engagement between crawlers and walkers (i.e., interactions with distal objects, carrying objects) are not an epiphenomenon of differences in total time engaging with objects. Experienced 13-month-old crawlers and novice 13-month-old walkers engage with objects for the same amount of time—about 30 min per hour of spontaneous activity in the home (Karasik et al., 2011).

Interact More

Infants acquire independent mobility in a social context. Thus, social pressures may be a fourth reason why infants persist with walking. Across cultures, caregivers encourage mobility, especially walking. Indeed, infants' first upright steps are typically into a caregiver's open arms (think of Van Gogh's famous painting, "First Steps"). Some cultures even promote the onset of walking with special standing and stepping exercises to strengthen infants' legs and facilitate upright balance (Adolph, Karasik, & Tamis-LeMonda, 2010b; Hopkins & Westra, 1988, 1990; Super, 1976). In other cultures, caregivers build contraptions to promote infant walking, such as infant-sized parallel bars (Mead & Macgregor, 1951).

The rare cases where children continue to crawl as their primary means of locomotion into adulthood may result—at least in part—from a lack of social encouragement to walk or upright models to imitate. In one family in a remote area of Turkey, several adult siblings crawled on hands and feet rather than walked. The parents reported that all crawled on hands and feet as infants, all observed older siblings continue to crawl into the preschool period, and none had therapy to promote walking (Humphrey, Skoyles, & Keynes, 2005).

Once infants begin walking, it alters their interactions with primary caregivers (Biringen, Emde, Campos, & Appelbaum, 1995, 2008). For example, the developmental transition from crawling to walking changes the way infants share objects with their mothers. At 13 months of age, both experienced crawlers and novice walkers use objects to bid for mothers' attention (Karasik et al., 2011). However, although the total number of bids is similar, the *quality* of object bids is not (see Figure 4). Crawlers bid from a stationary position: They hold up an object, vocalize, and wait for caregivers to respond with words or by coming over to them. In contrast, walkers display moving bids: They pick up an object and carry it over to mother, even when

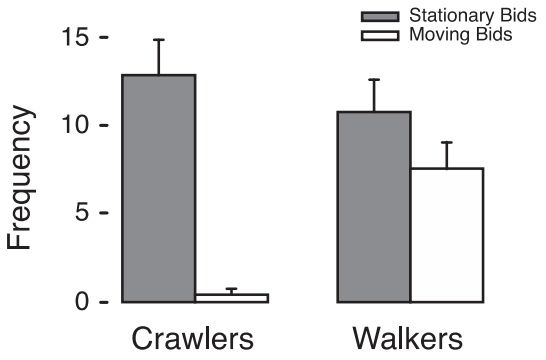

Figure 4. Average frequency of stationary and moving bids in 13-month-old crawling and walking infants as they vied for their mothers' attention using objects.

mother is in a different room (Karasik et al., 2011). Freeing hands to carry objects for sharing provides new opportunities for establishing and maintaining joint attention (Yu & Smith, 2013). These differences in how infants share objects with mothers—stationary versus moving—likely result from the various changes that accompany the transition from crawling to walking. As described earlier, walking infants *go* more (cover more distance quicker), *see* more (including where their mothers are located in space), and *play* more (enabling them to access and carry objects across space) than crawling infants. Drawing on these recent talents, it is no wonder that novice walkers bring objects over to their mothers for sharing.

Moreover, the increase in moving bids across the transition from crawling to walking is associated with changes in maternal responsiveness. Mothers are more likely to ignore stationary bids than moving bids. When they do respond to stationary bids, mothers reply with verbal affirmations such as, "Thank you," and descriptions such as, "That's the orange ball." In contrast, mothers' verbal responses to moving bids are more likely to contain information about object actions, such as what to do with an object (e.g., "Read the book," "Throw the ball") than their responses to stationary bids (Karasik, Tamis-LeMonda, & Adolph, 2014). The difference in maternal response is not simply a consequence of infants' transition to walking. Mothers respond the same way to crawlers in the infrequent event that crawlers pick up an object and carry it to mothers. Thus, it is not walking per se that elicits new forms of verbal response, but the new opportunities for actions and interactions that walking affords infants.

CAVEATS

Two caveats are in order. We provided several lines of evidence to explain infants' persistence with walking once they have taken their first independent walking steps, but to our knowledge, no one knows what prompts infants to walk in the first place. The serendipitous experiences associated with pulling up, standing, and cruising, in combination with imitation, social encouragement, and evolutionary pressures might prompt an infant to let go of the couch or a caregiver's hands and step unsupported into space. However, we suggest that the feedback regarding immediate benefits of independent walking encourages infants to persist with their newfound mode of locomotion.

Second, infants do not completely abandon crawling in order to walk; instead, the two forms of locomotion change in frequency of expression. Crawling still exists in children's (and adults') repertoires. And if the cost–benefit structure is altered appropriately, walking infants, children, and adults will switch to crawling. For example, experienced walking infants revert to crawling to descend steep slopes and large drop-offs, to navigate obstacles such as stairs and other elevations, and when their abilities are compromised by the addition of Teflon-soled shoes (Adolph, 1997; Adolph, Karasik, & Tamis-LeMonda, 2010a; Kretch & Adolph, 2013).

CONCLUSIONS

Why would an infant who is skilled at crawling abandon a familiar and effective strategy for getting about in favor of an unfamiliar and precarious mode of locomotion? Because, contrary to the historically romanticized notion that experienced crawlers navigate their physical and social worlds expertly, crawling has limits. Research that integrates findings across many domains of development reveals a developmental cascade that accompanies the transition from crawling to walking: increased benefits for exploration, visual access to the world, and interactions with objects and people. Moreover, the benefits of walking are instantaneous. In their first weeks of walking, when infants cannot gauge affordances for upright locomotion, novice walkers cover more distance faster than before, experience richer visual input while on the move, spend more time accessing and engaging with objects that are far afield, capitalize on new ways of sharing objects with others, and elicit new forms of verbal input from their primary caregivers. Presumably, infants are motivated to persist with walking because they can immediately go more, see more, play more, and interact more.

REFERENCES

Adolph, K. E. (1997). Learning in the development of infant locomotion. *Monographs of the Society for Research in Child Development*, *62*(3, Serial No. 251). doi:10.2307/1166199

Adolph, K. E. (2008). The growing body in action: What infant locomotion tells us about perceptually guided action. In R. Klatzy, M. Behrmann, & B. MacWhinney (Eds.), *Embodiment, ego-space, and action* (pp. 275–321). Mahwah, NJ: Erlbaum.

Adolph, K. E., Cole, W. G., Komati, M., Garciaguirre, J. S., Badaly, D., Lingeman, J. M., … Sotsky, R. B. (2012). How do you learn to walk? Thousands of steps and dozens of falls per day. *Psychological Science*, *23*, 1387–1394. doi:10.1177/0956797612446346

Adolph, K. E., Karasik, L. B., & Tamis-LeMonda, C. S. (2010a). Using social information to guide action: Infants' locomotion over slippery

slopes. *Neural Networks*, *23*, 1033–1042. doi:10.1016/j.neunet.2010.08.012

Adolph, K. E., Karasik, L. B., & Tamis-LeMonda, C. S. (2010b). Motor skills. In M. H. Bornstein (Ed.), *Handbook of cross-cultural development science: Vol. 1. Domains of development across cultures* (pp. 61–88). Hillsdale, NJ: Erlbaum.

Adolph, K. E., Robinson, S. R., Young, J. W., & Gill-Alvarez, F. (2008). What is the shape of developmental change? *Psychological Review*, *115*, 527–543. doi:10.1037/0033-295X.115.3.527

Adolph, K. E., Tamis-LeMonda, C. S., Ishak, S., Karasik, L. B., & Lobo, S. A. (2008). Locomotor experience and use of social information are posture specific. *Developmental Psychology*, *44*, 1705–1714. doi:10.1037/a0013852

Adolph, K. E., Vereijken, B., & Denny, M. A. (1998). Learning to crawl. *Child Development*, *69*, 1299–1312. doi:10.1111/j.1467-8624.1998.tb06213.x

Adolph, K. E., Vereijken, B., & Shrout, P. E. (2003). What changes in infant walking and why. *Child Development*, *74*, 474–497. doi:10.1111/1467-8624.7402011

Biringen, Z., Emde, R. N., Campos, J. J., & Appelbaum, M. I. (1995). Affective reorganization in the infant, the mother, and the dyad: The role of upright locomotion and its timing. *Child Development*, *66*, 499–514. doi: 10.1111/j.1467-8624.1995.tb00886.x

Biringen, Z., Emde, R. N., Campos, J. J., & Appelbaum, A. (2008). Development of autonomy: Role of walking onset and its timing. *Perceptual and Motor Skills*, *106*, 395–414. doi:10.2466/PMS.106.2.395-414

Bjorklund, D. F. (2013). Cognitive development: An overview. In P. Zelazo (Ed.), *Oxford handbook of developmental psychology* (pp. 447–476). New York, NY: Oxford University Press.

Bjorklund, D. F., Miller, P. H., Coyle, T. R., & Slawinski, J. L. (1997). Instructing children to use memory strategies: Evidence of utilization deficiencies in memory training studies. *Developmental Review*, *17*, 411–441. doi:10.1006/drev.1997.0440

Bray, N. W., Hersh, R. E., & Turner, L. A. (1985). Selective remembering during adolescence. *Developmental Psychology*, *21*, 290–294. doi:10.1037/0012-1649.21.2.290

Campos, J. J., Anderson, D. I., Barbu-Roth, M. A., Hubbard, E. M., Hertenstein, M. J., & Witherington, D. C. (2000). Travel broadens the mind. *Infancy*, *1*, 149–219. doi:10.1207/S15327078IN0102_1

DeMarie-Dreblow, D., & Miller, P. H. (1988). The development of children's strategies for selective attention: Evidence for a transitional period. *Child Development*, *59*, 1504–1513.

Franchak, J. M., Kretch, K. S., Soska, K. C., & Adolph, K. E. (2011). Head-mounted eye tracking: A new method to describe infant looking. *Child Development*, *82*, 1738–1750. doi:10.1111/j.1467-8624.2011.01670.x

Frank, M. C., Simmons, K., Yurovsky, D., & Pusiol, G. (2013). Developmental and postural changes in children's visual access to faces. In M. Knauff, M. Pauen, N. Sebanz, & I. Wachsmuth (Eds.), *Proceedings of the 35th annual meeting of the Cognitive Science Society* (pp. 454–459). Austin, TX: Cognitive Science Society.

Garciaguirre, J. S., Adolph, K. E., & Shrout, P. E. (2007). Baby carriage: Infants walking with loads. *Child Development*, *78*, 664–680. doi:10.1111/j.1467-8624.2007.01020.x

Gibson, E. J. (1978). C'est moi. *Contemporary Psychology: A Journal of Reviews*, *23*, 609–614.

Gibson, E. J. (1988). Exploratory behavior in the development of perceiving, acting, and the acquiring of knowledge. *Annual Review of Psychology*, *39*, 1–41.doi: 10.1146/annurev.ps.39.020188.000245

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin.

Hallemans, A., De Clercq, D., & Aerts, P. (2006). Changes in 3D joint dynamics during the first 5 months after the onset of independent walking: A longitudinal follow-up study. *Gait and Posture*, *24*, 270–279. doi:10.1016/j.gaitpost.2005.10.003

Hopkins, B., & Westra, T. (1988). Maternal handling and motor development: An intracultural study. *Genetic, Social and General Psychology Monographs*, *114*, 379–408.

Hopkins, B., & Westra, T. (1990). Motor development, maternal expectations, and the role of handling. *Infant Behavior and Development*, *13*, 117–122. doi:10.1016/0163-6383(90)90011-V

Humphrey, N., Skoyles, J. R., & Keynes, R. (2005). *Human hand-walkers: Five siblings who never stood up*. *LSE Research Online*. Retrieved from http://eprints.lse.ac.uk/archive/00000463

Karasik, L. B., Adolph, K. E., Tamis-LeMonda, C. S., & Zuckerman, A. (2012). Carry on: Spontaneous object carrying in 13-month-old crawling and walking infants. *Developmental Psychology*, *48*, 389–397. doi:10.1037/a0026040

Karasik, L. B., Tamis-LeMonda, C. S., & Adolph, K. E. (2011). Transition from crawling to walking and infants' actions with objects and people. *Child Development*, *82*, 1199–1209. doi:10.1111/j.1467-8624.2011.01595.x

Karasik, L. B., Tamis-LeMonda, C. S., & Adolph, K. E. (2014). Crawling and walking infants elicit different verbal responses from mothers. *Developmental Science*, *17*, 388–395. doi:10.1111/desc.12129

Kretch, K. S., & Adolph, K. E. (2013). Cliff or step? Posture-specific learning at the edge of a drop-off. *Child Development*, *84*, 226–240. doi:10.1111/j.1467-8624.2012.01842.x

Kretch, K. S., Franchak, J. M., & Adolph, K. E. (2014). Crawling and walking infants see the world differently. *Child Development*, *85*, 1503–1518. doi:10.1111/cdev.12206

Mangalindan, D. M., Schmuckler, M. A., & Li, S. A. (2014). The impact of object carriage on independent locomotion. *Infant Behavior and Development*, *37*, 76–85. doi:10.1016/j.infbeh.2013.12.008

Mead, M., & Macgregor, F. M. C. (1951). *Growth and culture: A photographic study of Balinese childhood*. New York, NY: Putnam.

Pickett, W., Streight, S., Simpson, K., & Brison, R. J. (2003). Injuries experienced by infant children: A population-based epidemiological analysis. *Pediatrics*, *111*, e365–e370. doi:10.1542/peds.111.4.e365

Rheingold, H. L., & Eckerman, C. O. (1970). The infant separates himself from his mother. *Science*, *168*, 78–83. doi:10.1126/science.168.3927.78

Soska, K. C., Robinson, S. R., & Adolph, K. E. (2014). A new twist on old ideas: How sitting reorients crawlers. *Developmental Science*. Advance online publication. doi:10.1111/desc.12205

Super, C. M. (1976). Environmental effects on motor development: The case of "African infant precocity." *Developmental Medicine and Child Neurology*, *18*, 561–567. doi:10.1111/j.1469-8749.1976.tb04202.x

Unni, P., Locklair, M. R., Morrow, S. E., & Estrada, C. (2012). Age variability in pediatric injuries from falls. *American Journal of Emergency Medicine*, *30*, 1457–1460. doi:10.1016/j.ajem.2011.12.001

Vereijken, B., Pedersen, A. V., & Storksen, J. H. (2009). Early independent walking: A longitudinal study of load perturbation effects. *Developmental Psychobiology*, *51*, 374–383. doi:10.1002/dev.20377

Yu, C., & Smith, L. B. (2013). Joint attention without gaze following: Human infants and their parents coordinate visual attention to objects through eye-hand coordination. *PLoS One*, *8*, e79659. doi:10.1371/journal.pone.0079659