Research Article

SPECIFICITY OF LEARNING: Why Infants Fall Over a Veritable Cliff

Karen E. Adolph
New York University

Abstract—*Nine-month-old infants were tested at the precipice of safe and risky gaps in the surface of support. Their reaching and avoidance responses were compared in two postures, an experienced sitting posture and a less familiar crawling posture. The babies avoided reaching over risky gaps in the sitting posture but fell into risky gaps while attempting to reach in the crawling posture. This dissociation between developmental changes in posture suggests that (a) each postural milestone represents a different, modularly organized control system and (b) infants' adaptive avoidance responses are based on information about their postural stability relative to the gap size. Moreover, the results belie previous accounts suggesting that avoidance of a disparity in depth of the ground surface depends on general knowledge such as fear of heights, associations between depth information and falling, or knowledge that the body cannot be supported in empty space.*

Falling over a cliff can have dire consequences for an animal's survival. Since Lashley and Russell's (1934) first demonstrations that dark-reared rats match the force of their jumps to the size of a drop-off, the role of experience in promoting adaptive motor responses to depth information has been of central concern to developmentalists (Walk, Gibson, & Tighe, 1957). Precocial species such as chicks and goats do not require experience to avoid going over the edge of an impossibly large precipice (Gibson & Walk, 1960; Walk, 1966; Walk & Gibson, 1961). In contrast, human infants and other altricial species require a protracted period of locomotor experience (Campos, Bertenthal, & Kermoian, 1992; Held & Hein, 1963; Richards & Rader, 1983). In the classic experimental paradigm, babies are tested on a "visual cliff" to ensure their safety. The apparatus looks like a sheer drop-off because the visible ground surface lies far below a sheet of safety glass. Several studies have shown that the duration of infants' crawling experience predicts avoidance of the visual cliff, independently of the age at which infants begin crawling or their age at testing. For example, at 7.5 to 8.5 months of age, only 35% of inexperienced crawlers (11 days of experience) avoided the visual cliff, but 65% of more experienced crawlers (41 days of experience) steadfastly refused to go across (Bertenthal, Campos, & Barrett, 1984).

Despite strong evidence linking adaptive responses with locomotor experience, the question remains as to what infants may learn via crawling that facilitates the coordination between perception and action. Clearly, avoiding a cliff does not depend solely on depth perception. Months before they begin crawling, infants display sensitivity to depth information (e.g., Campos, Langer, & Krowitz, 1970; Slater & Morison, 1985; Yonas & Hartman, 1993). Several other accounts have been proposed. Most widely cited is Campos and colleagues' (1992) proposal that experience induces fear of heights and fear mediates avoidance responses. Although there is no association between experiences of falling and cliff avoidance (Scarr & Salapatek, 1970), researchers have suggested that wariness may arise from minor scrapes and tumbles and from negative near-falling experiences as infants peer over the edge of sheer drop-offs or vigilant parents grab them at the edge of the bed or changing table (Bertenthal, Campos, & Kermoian, 1994; Thelen & Smith, 1994). According to this account, crawling experience facilitates avoidance responses through repeated associations between depth information and the perceptual consequences of disequilibrium and near-falling. Alternatively, fear of heights may arise from a discrepancy in infants' typical crawling experience on solid ground and the novel perceptual input at the brink of a precipice. Experience locomoting with their faces near the floor may lead infants to expect particular correlations between visual and vestibular input. At the edge of a cliff, visual coding of angular acceleration is quite different because the visible texture elements are farther away from infants' faces. Thus, a discrepancy in expected correlations between visual and vestibular input might promote wariness at the edge of the novel surface (Campos et al., 1992). Finally, other researchers have proposed that experience leads to an appreciation of the properties of the ground surface for supporting the body (e.g., Bertenthal & Campos, 1990; Gibson & Schmuckler, 1989). In particular, experience crawling over solid ground might teach infants that locomotion is impossible without a surface that they can see and feel beneath their bodies.

Recent findings suggest that none of these accounts is sufficient for explaining how experience facilitates adaptive responses to depth information for a drop-off. If infants learn to avoid a discrepancy in depth of the ground surface because they are afraid of heights, associate heights with the perceptual consequences of falling, or know that the body cannot be supported in empty space, then they should show similar avoidance responses regardless of the posture in which they are tested. To the contrary, my colleagues and I found that learning is specific to each postural milestone in development.

THE SWAY MODEL

Typically, motor development in infancy is marked by a series of postural milestones—sitting, crawling, cruising sideways along furniture, and walking. To keep balance in these postures, infants must maintain their bodies within a region of permissible postural sway (Riccio, 1993; Riccio & Stoffregen, 1988). Babies will fall over if their bodies move outside this region because they lack sufficient muscle strength to pull themselves back into position. Variations in surface properties threaten balance control because the region of permissible sway narrows and infants' bodies move more rapidly toward the outer limits. To judge possibilities for action, infants must gauge their available muscle torque for counteracting destabilizing torque

Address correspondence to Karen E. Adolph, Psychology Department, New York University, 6 Washington Pl., Room 401, New York, NY 10003; e-mail: adolph@psych.nyu.edu.

relative to surface properties (size of a precipice, degree of slant, etc.).

The sway model proposes that the coordination between perception and action is organized within postural systems, so that experience with an earlier-developing skill does not transfer automatically to a later-developing skill (Adolph & Eppler, 1998, in press). Experience promotes learning about balance control, and infants learn to detect threats to balance and discover compensatory strategies for recovering balance when it is disrupted. Learning may be posture-specific because each postural milestone represents a different perception-action system with different relevant control variables. Sitting, crawling, and walking postures, for example, involve different regions of permissible sway for different key pivots around which the body rotates (e.g., the hips for sitting, the wrists for crawling, and the ankles for walking). In addition, each postural milestone involves different muscle groups for executing movements and for generating compensatory sway; different vantage points for viewing the ground; different patterns of optic flow as the body sways back and forth; different correlations between visual, kinesthetic, and vestibular information; and so on. Thus, extensive experience with each postural milestone in development may be required to define the relevant control variables for the new perception-action system and to facilitate their on-line calibration.

SPECIFICITY OF LEARNING

The disparity in depth at the brink of a steep slope, as on a cliff, presents a challenge for balance control and locomotion. In accordance with the sway model, in a longitudinal study, I found that learning to avoid descent of impossibly steep slopes does not transfer across developmental changes from crawling to walking postures (Adolph, 1997). In their first weeks of crawling, infants observed on an adjustable sloping walkway (0°–36°) plunged headfirst down impossibly steep slopes. Over weeks of crawling, however, the infants' judgments became increasingly accurate. By their last weeks of crawling, they consistently crawled down safe slopes and slid down or avoided risky ones. Surprisingly, in their first weeks of walking, the same babies attempted to walk down the same impossibly risky slopes that they had so recently avoided in the crawling posture. In fact, new walkers showed no transfer from their old, familiar crawling posture to their new, upright walking posture on consecutive trials at the same risky slope. Over weeks of walking experience, errors decreased but learning was no faster the second time around.

The present experiments show that specificity of learning is not limited to locomotion down slopes or to developmental changes from crawling to walking postures. The experiments provided a stronger test of the specificity of learning predicted by the sway model by testing infants in two postures, sitting and crawling, within the same test session. In both postures, babies were perched at the brink of an adjustable gap. They were encouraged to span the gap by leaning forward while extending an arm. At the smallest gap distances, balance was trivial. At intermediate distances, the infants had to gauge the necessary forces required to span the gap. This test is similar to Lashley and Russell's (1934) classic jumping-stand task in which rats launched themselves over an adjustable gap. At the largest distances, gap size exceeded the infants' limit of permissible sway. As on the visual cliff, avoidance was the appropriate response to impossibly large gaps. However, in contrast to the visual cliff, the gap apparatus was a veritable cliff with no protective safety glass. Visual and haptic exploration yielded concordant information for depth. Errors in judgment resulted in falling into the precipice, requiring rescue by the experimenter.

The experimental design capitalized on the fact that most infants display a period of overlap between sitting and crawling milestones. Typically, they have many weeks of experience keeping balance in the sitting posture at the same time that they are novices at maintaining balance in the crawling posture. If experience leads to either fear of heights, negative associations with falling, or knowledge that the body cannot be supported in empty space, infants should respond similarly in these two postural conditions. However, if the coordination between perception and action is organized so that the utilization of depth information is specific to each postural control system, then infants who are experienced at sitting but novices at crawling should show more adaptive responses in their more experienced sitting posture.

EXPERIMENT 1: SITTING AND CRAWLING

Method

Nineteen 9-month-old infants (11 boys, 8 girls) were tested in an experienced sitting posture ($M = 104$ days of sitting experience) and a less familiar crawling posture ($M = 45$ days of crawling experience). Two additional infants did not complete testing because of fussiness or fatigue. Parents reported infants' prior experiences with sitting, crawling, and falling.

The gaps apparatus was composed of a large, stationary starting platform and a movable landing platform. The landing platform could be moved back and forth to adjust the gap between the platforms (76 cm deep). As shown in Figure 1a, in the sitting condition, infants were encouraged to lean forward and extend their arm out over the gap. Flat toys were attached to the end of a stick to provide infants with an incentive to span the gap. An assistant moved the stick back and forth to create gaps of 0 to 90 cm between the toy and the edge of the starting platform. Gap distance was varied by moving the stick rather than the landing platform to prevent pinching infants' legs in the gap and to keep infants from propping their feet or free hand on the far side of the gap to aid in balance control.

In the crawling condition (see Fig. 1b), infants were encouraged to lean forward and extend their arm toward the landing platform as they crawled over the gap. Toys were placed on the landing platform to provide infants with an incentive to span the gap. An assistant moved the landing platform back and forth to create gaps of 0 to 90 cm between the edges of the two platforms.

In both conditions, parents stood at the far side of the landing platform and coaxed their infants to retrieve the toys. An experimenter (shown in Fig. 1) followed closely alongside infants to ensure their safety but did not provide physical support unless they fell into the gap. Previous research with infants on slopes shows that infants tackle such tasks independently and do not rely on the experimenter to catch them (e.g., Adolph, 1997). Trials lasted 30 s.

Because infants of the same age have widely varying body dimensions and motor skill, a psychophysical staircase procedure (Adolph, 1995, 1997) was used to estimate the boundary between gaps that were safe and risky relative to each infant's body size and skill in each condition. The staircase procedure is an on-line method for estimating

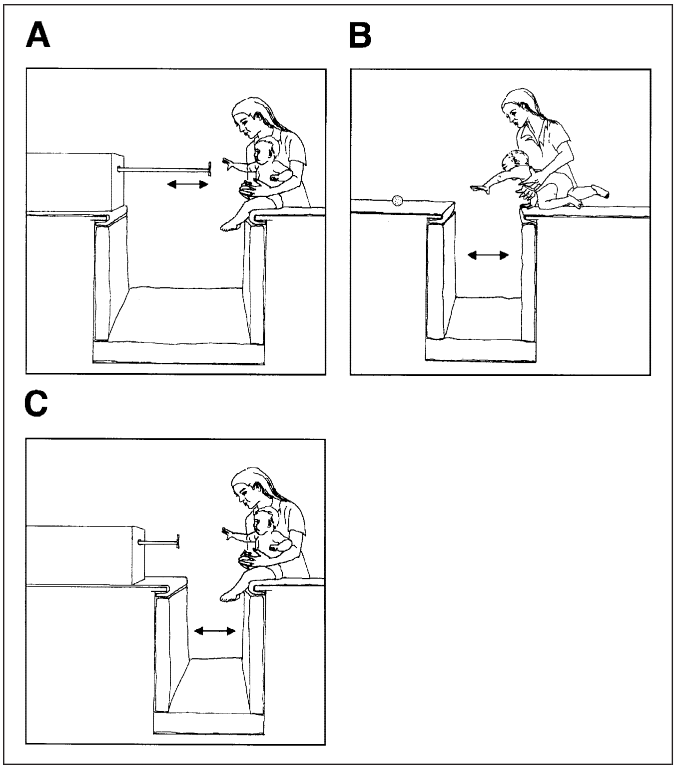

Fig. 1. The adjustable gap apparatus in various experimental conditions: (a) sitting condition with movable stick (Experiment 1), (b) crawling condition (Experiments 1 and 2), and (c) sitting condition with movable landing platform (Experiment 2).

a threshold using a minimal number of trials. Trials were coded as either successful attempts (contacting the toy safely), failed attempts (falling into the gap), or avoidance (no attempt to span the gap). For the purpose of the staircase procedure, failed attempts and avoidance responses were treated as equivalent, unsuccessful outcomes. After successful trials, the experimenter increased gap size by 6 cm. After unsuccessful trials, the experimenter repeated the same gap size for reliability; then, to maintain infants' motivation, she presented an easy baseline gap (4 cm for crawling and 10 cm for sitting); next, gap size was decreased by 4 cm relative to the last unsuccessful trial. This process of presenting larger and smaller gaps continued until converging on a gap boundary to a 67% criterion (largest gap infant managed successfully on at least 2/3 of trials). The "plus 6 cm, minus 4 cm" rule ensured that gap boundaries were determined in 2-cm increments.

After the gap boundary was identified, additional trials were presented, beginning with safe gaps (6 cm smaller than boundary) and proceeding to increasingly risky gaps (6 cm, 12 cm, and 18 cm larger than boundary), with 2 trials at each gap distance. Infants also received 2 trials at the largest, 90-cm, gap to assess their responses when absolute gap size was the same dimension as the standard visual cliff. In total, infants received 17 to 42 trials in the sitting condition and 21 to 38 trials in the crawling condition. Nine infants were tested first in the sitting condition and then in the crawling condition, and 10 were tested with the conditions in the reverse order.

Data from the staircase trials and the additional trials were rescored from videotapes in terms of success, failure, and avoidance; interrater reliability showed 97% agreement. In addition, coders noted whether infants tested their region of permissible sway at the edge of gaps by leaning forward while extending an arm without touching the far side of the gap, then leaning backward while retracting the arm; interrater reliability showed 95% agreement.

If infants perceived the depth information accurately in relation to their region of permissible sway, then they would attempt safe gaps, for which the probability of falling was low, and avoid risky gaps, for which the probability of falling was high. Perfect perceptual judgments would be indicated by a match between the probability of avoiding and the probability of falling. Alternatively, if infants did not accurately relate the perceptual information to possibilities for action, then they would fall into impossibly large gaps. If infants learned from falling on one trial, then they would avoid the same gap on the next trial. Most important, if learning about balance control does not transfer across developmental changes in postures, then infants would avoid risky gaps in their more experienced sitting posture, but fall into risky gaps in their less familiar crawling posture.

Results and Discussion

Gap boundaries were larger for all infants in the sitting condition ($M = 26.6$ cm) compared with the crawling condition ($M = 10.1$ cm). However, individual infants differed widely in their gap boundaries (range: 20–32 cm for sitting and 2–18 cm for crawling). Thus, a safe gap for sitting could be risky for crawling, and a safe gap for a more skilled infant could be risky for a less skilled one. The experimental design roughly equated relative amount of risk to allow comparisons between sitting and crawling postures and between infants with different gap boundaries. In the sitting condition, the probability of falling increased from .04 at the gap boundary to .93 at distances 12 cm larger than the boundary. In the crawling condition, the probability of falling increased from .14 at the gap boundary to .94 at gaps 12 cm larger.

The experiment yielded two surprising results that are consistent with the sway model but are not predicted by accounts based on fear of heights, negative associations with falling, or knowledge about ground surfaces. First, avoidance of risky gaps did not generalize across changes in posture. Second, there was no evidence of within-session learning as a result of falling.

With regard to generalization across postures, at every risky gap distance, the rate of adaptive avoidance responses was higher in the experienced sitting posture than in the less familiar crawling posture (see Fig. 2a). All infants closely matched avoidance responses to the probability of falling in the sitting posture, but grossly overestimated their ability to span gaps in the crawling posture. A 2 (postural condition) × 4 (risky gap distance) repeated measures analysis of variance revealed main effects for postural condition, $F(1, 11) = 15.76$, $p < .002$, and gap distance, $F(3, 33) = 15.51$, $p < .000$. Paired comparisons revealed significant differences between sitting and crawling conditions at each risky gap distance (all ps < .04). In fact, 6 infants showed finely tuned avoidance responses in the sitting posture but no capacity to gauge their ability in the crawling posture. They attempted all gap distances in the crawling posture, including the 90-cm gap, which was tantamount to crawling into thin air. The remaining 13 infants scaled their responses to their gap boundaries in both postures, but much more accurately in the sitting condition. For this group, avoidance responses were significantly higher in the sitting condition than the crawling condition at the boundary and at the +6-cm and +12-cm increments (all ps < .03).

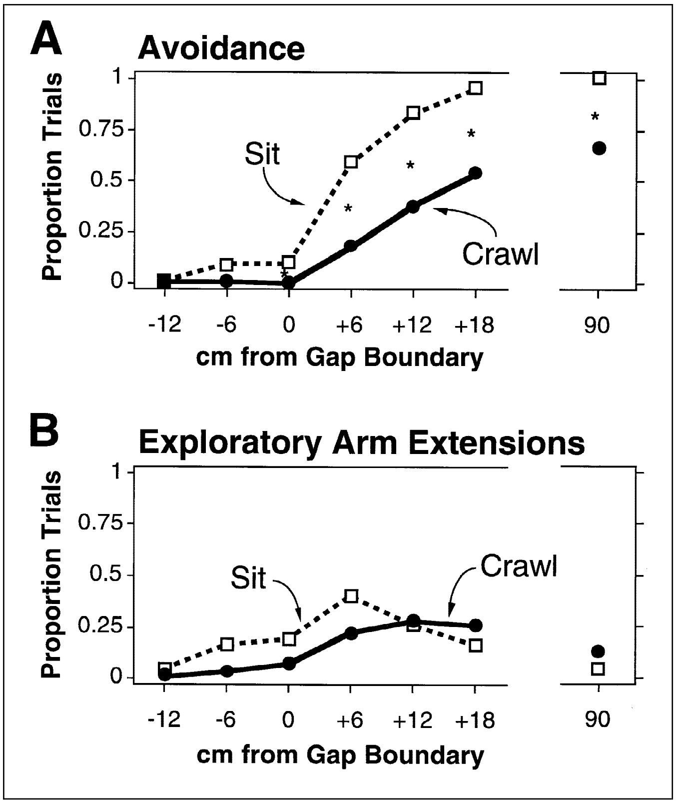

Fig. 2. Proportion of trials with avoidance responses (a) and exploratory arm extensions (b) in Experiment 1. The data are plotted according to relative degree of risk. The 0 point on the *x*-axis represents each infant's gap boundary in each condition. Negative numbers on the *x*-axis denote safe gaps (gaps smaller than the boundary), and positive numbers denote risky gaps (gaps larger than the boundary). Data are also included for the largest, 90-cm, gap. Asterisks denote significant differences between the sitting and crawling conditions.

Because the data in Figure 2a are based on relative amount of risk, this analysis raises the possibility that the dissociation between postures was merely a consequence of the fact that infants' gap boundaries for sitting were larger than those for crawling. Hence, if infants simply attempted to reach over the same small gaps and avoided the same large gaps in the two postures, this would lead to a spurious dissociation. However, examining the rate of avoidance responses at each absolute gap size shows that this was not the case. Every infant showed different levels of avoidance responses to the same gap size in the sitting and crawling postures. The 6 reckless crawlers obviously showed different responses to the same absolute gap size depending on postural condition because they never avoided the gap while crawling. The remaining 13 infants also showed different levels of avoidance responses to the same gap sizes in sitting and crawling postures. Unlike the reckless crawlers, they were more likely to avoid gaps between 14 cm and 32 cm in the crawling posture than in the sitting posture. But, as Figure 3 shows, this avoidance rate still grossly overestimated their ability to span the gap in the crawling posture; that is, the probability of avoiding was significantly lower than the probability of falling, even when the probability of falling was 1.0. In contrast, the infants' avoidance rate in the sitting posture closely matched the probability of falling (curves are superimposed).

The second surprising result was that infants showed no evidence of learning from falling. Most infants fussed slightly when they fell, suggesting that falling downward into the gap was aversive. Infants rarely fell in the sitting posture ($M = 19\%$ of trials with risky gaps), giving them few opportunities to learn from falling. In the crawling posture, infants fell often ($M = 61\%$ of trials with risky gaps), but they showed no evidence of learning from these experiences. Each time that infants fell in their first attempt at a particular gap distance, the same gap size was repeated on the next trial. If the infants had associated depth information with the negative consequences of falling, they would have avoided the gap on the repeated trial. They did not. On 88% of such immediately repeated trials, infants attempted to span the same risky gap distance. Furthermore, there were no effects of condition order to suggest learning from falling on earlier trials. Nor was infants' aversion to falling related to experiencing minor falls at home, and none of the infants had experienced a serious fall incurring injury at home.

In addition, the infants did not simply learn to rely on the experimenter. Because the experimenter provided physical support only after they began to fall, they experienced the perceptual consequences of self-induced disequilibrium in both postures as they swayed to and fro at the brink of the gap. They appeared to test the limits of their region of permissible sway by leaning forward as they extended an arm without contacting the far side of the gap, then leaning backward as they retracted it. Exploratory arm extensions increased on risky gaps, $F(2, 30) = 3.55$, $p < .04$, and were equally frequent in the two postures (see Fig. 2b). Furthermore, if the infants had merely relied on

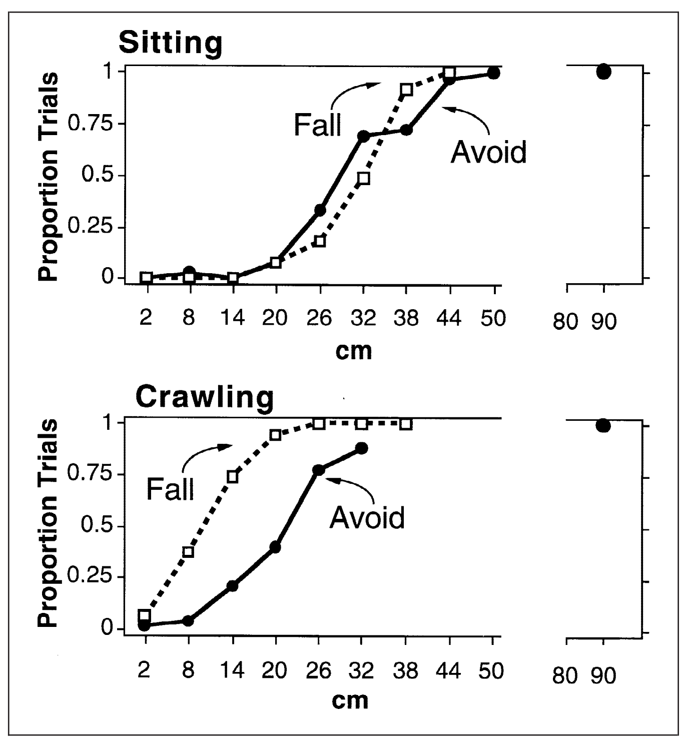

Fig. 3. Avoidance responses in the 13 infants who showed some sensitivity to gap size in the crawling condition, Experiment 1. The data are plotted according to absolute gap size in both conditions. Solid curves show the probability of avoiding the gap, and dashed curves show the probability of falling.

the experimenter to catch them or considered falling to be a kind of game, then they should have responded indiscriminately to all gap sizes in both postural conditions. However, many infants avoided the largest gaps in the crawling posture (which appeared latest in the test session), there were no effects of condition order, and all children avoided risky gaps in the sitting condition.

EXPERIMENT 2: REPLICATION

A new, mechanized gaps apparatus was constructed to rule out the possibility that the infants in Experiment 1 avoided risky gaps in the sitting posture simply because the landing platform was always 90 cm away. For both postures, gap distance was varied by moving the landing platform along a calibrated track (0–90 cm). In the sitting condition, a toy was presented on the end of a stick, with the toy always perpendicular to the edge of the landing platform (see Fig. 1c). Baseline gap size was increased to 20 cm in the sitting condition to prevent pinching infants' legs inside the apparatus. The experimenter repeated trials on which infants propped their legs or free hand on the far side of the gap to aid in balance control. In the crawling condition, the toy was placed on the landing platform as before. Seventeen infants (6 girls, 11 boys) were tested in an experienced sitting posture (M = 104 days) and a less familiar crawling posture (M = 55 days). Four additional babies did not complete testing because of fussiness or fatigue.

With the new gaps apparatus, Experiment 2 replicated all results from Experiment 1. All infants could safely span larger gaps when sitting ($M = 27.29$ cm) than when crawling ($M = 13.33$ cm). Most important, in their experienced sitting posture, all infants closely matched avoidance responses to the probability of falling, but in their less familiar crawling posture, they attempted impossibly risky gaps and fell (see Fig. 4). A 2 (postural condition) × 4 (risky gap distance) repeated measures analysis of variance revealed main effects for postural condition, $F(1, 8) = 7.22$, $p < .028$, and gap distance, $F(3, 24) = 9.14$, $p < .000$. Paired comparisons showed significant differences between postures at each risky gap distance (all ps $< .05$). Eight infants fell into the 90-cm gap in the crawling condition but not in the sitting condition, showing striking specificity of knowledge about balance control.

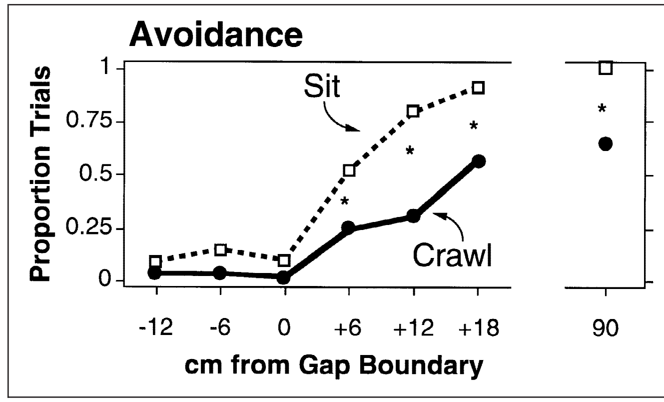

Fig. 4. Proportion of trials with avoidance responses in Experiment 2. The data are plotted according to relative degree of risk (see Fig. 2). Data are also included for the largest, 90-cm, gap. Asterisks denote significant differences between sitting and crawling conditions.

GENERAL DISCUSSION

The present experiments involving infants reaching over gaps and the earlier longitudinal investigation of infants descending slopes indicate that experience with an earlier-developing skill does not transfer automatically to a later-developing one. Together, these studies point to surprising specificity of learning across three major postural milestones in development—sitting, crawling, and walking. Apparently, the coordination between perception and action that is required to use depth information to plan actions adaptively is specific to the particular postural control system being engaged in the task. This dissociation between postures belies previous accounts suggesting that adaptive responses to disparity in depth of the ground surface depend on a general sort of knowledge such as fear of heights, on associations between depth information and falling, or on knowledge that the body cannot be supported in empty space.

However, a more subtle type of transfer does occur. Apparently, learning transfers from uneventful, everyday experience coping with balance on safe, solid ground to the potentially risky situations in the novel gaps and slopes tasks. In the gaps studies, neither prior experiences of falling or near-falling from heights nor experiences incurred during the test session were related to adaptive avoidance responses to risky gaps. Similarly, in the longitudinal study of infants descending slopes, learning did not depend on experience falling from heights or falling down slopes during testing. Moreover, learning to avoid risky slopes did not depend on experience coping with slopes. Infants in a control group, matched for age and duration of crawling and walking experience, behaved similarly to the babies tested repeatedly on laboratory slopes, and no infants had experience on slopes outside the laboratory.

Within postures, however, infants showed generalization of learning across changes in their own bodies and skills. In the slopes study, it was possible to track changes in infants' body dimensions, locomotor skills, and locomotor experiences on a weekly basis and to relate these factors to changes in the laboratory task. Each week, infants' bodies and skills changed considerably, in ways that affected the biomechanics of keeping balance. Thus, a slope that was risky one week could be safe the next, and a slope that was previously safe could become risky. Despite these changes, within postures, infants' responses continually improved. It was uneventful, everyday experience coping with each posture in development that predicted the adaptiveness of the infants' responses.

Together, the findings from both studies indicate that infants' learning is not confined to acquisition of particular facts about the environment (e.g., a particular gap size is too large or a particular degree of slope is too steep), particular facts about themselves (being a highly skilled sitter or a poorly skilled crawler, having top-heavy body dimensions or more maturely proportioned ones), or any type of fixed association between particular environmental properties and particular motor responses. In fact, such inflexibility in learning would be maladaptive because infants' bodies and skills change from week to week and the everyday terrain is variable. Instead, the results are consistent with the sway model: Infants must learn, posture by posture in the course of development, how to discover on-line their region of permissible sway and to use this information for prospective control of action. According to this account, learning in the course of development may be both far more specific and far more flexible than previously recognized.

Acknowledgments—This research was supported by National Institute of Child Health and Human Development Grant HD33486 to Karen Adolph and by Small Undergraduate Research Grants from Carnegie Mellon University to Katherine Melton and Heather Arnet. Portions of this research were presented at the International Conference on Infant Studies, Atlanta, Georgia, April 1998 and at the International Conference for Perception and Action, Edinburgh, Scotland, August 1999. I gratefully acknowledge Katherine Melton, Heather Arnet, and Anthony Avolio for their invaluable assistance in designing and implementing Experiment 1; Andrew Leo and Anthony Avolio for their help with Experiment 2; students at Carnegie Mellon University and New York University for their help with data collections and coding; and Peter Gordon, Marion Eppler, and the members of the Infant Motor Development Laboratory at New York University for their thoughtful criticism and comments.

REFERENCES

Adolph, K.E. (1995). A psychophysical assessment of toddlers' ability to cope with slopes. *Journal of Experimental Psychology: Human Perception and Performance*, *21*, 734–750.

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).

Adolph, K.E., & Eppler, M.A. (1998). Development of visually guided locomotion. *Ecological Psychology*, *10*, 303–321.

Adolph, K.E., & Eppler, M.A. (in press). Flexibility and specificity in infant motor skill acquisition. In J. Fagan & H. Hayne (Eds.), *Progress in infancy research*. Norwood, NJ: Ablex.

Bertenthal, B.I., & Campos, J.J. (1990). A systems approach to the organizing effects of self-produced locomotion during infancy. In C. Rovee-Collier & L.P. Lipsitt (Eds.), *Advances in infancy research* (Vol. 6, pp. 1–60). Norwood, NJ: Ablex.

Bertenthal, B.I., Campos, J.J., & Barrett, K.C. (1984). Self-produced locomotion: An organizer of emotional, cognitive, and social development in infancy. In R.N. Emde & R.J. Harmon (Eds.), *Continuities and discontinuities in development* (pp. 175–210). New York: Plenum Press.

Bertenthal, B.I., Campos, J.J., & Kermoian, R. (1994). An epigenetic perspective on the development of self-produced locomotion and its consequences. *Current Directions in Psychological Science*, *3*, 140–145.

Campos, J.J., Bertenthal, B.I., & Kermoian, R. (1992). Early experience and emotional development: The emergence of wariness of heights. *Psychological Science*, *3*, 61–64.

Campos, J.J., Langer, A., & Krowitz, A. (1970). Cardiac responses on the visual cliff. *Science*, *170*, 196–197.

Gibson, E.J., & Schmuckler, M.A. (1989). Going somewhere: An ecological and experimental approach to development of mobility. *Ecological Psychology*, *1*, 3–25.

Gibson, E.J., & Walk, R.D. (1960). The "visual cliff." *Scientific American*, *202*, 64–71.

Held, R., & Hein, A. (1963). Movement-produced stimulation in the development of visually guided behavior. *Journal of Comparative and Physiological Psychology*, *56*, 872–876.

Lashley, K.S., & Russell, J.T. (1934). The mechanism of vision: XI. A preliminary test of innate organization. *Journal of Genetic Psychology*, *45*, 136–144.

Riccio, G.E. (1993). Information in movement variability about the qualitative dynamics of posture and orientation. In K.M. Newell & D.M. Corcos (Eds.), *Variability and motor control* (pp. 317–357). Champaign, IL: Human Kinetics Publishers.

Riccio, G.E., & Stoffregen, T.A. (1988). Affordances as constraints on the control of stance. *Human Movement Science*, *7*, 265–300.

Richards, J.E., & Rader, N. (1983). Affective, behavioral, and avoidance responses on the visual cliff: Effects of crawling onset age, crawling experience, and testing age. *Psychophysiology*, *20*, 633–642.

Scarr, S., & Salapatek, P. (1970). Patterns of fear development during infancy. *Merrill-Palmer Quarterly*, *16*, 53–90.

Slater, A., & Morison, V. (1985). Shape constancy and slant perception at birth. *Perception*, *14*, 337–344.

Thelen, E., & Smith, L.B. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: MIT Press.

Walk, R.D. (1966). The development of depth perception in animals and human infants. *Monographs of the Society for Research in Child Development*, *31*(5, Serial No. 107), 82–108.

Walk, R.D., & Gibson, E.J. (1961). A comparative and analytical study of visual depth perception. *Psychological Monographs*, *75*(15, Whole No. 519).

Walk, R.D., Gibson, E.J., & Tighe, T.J. (1957). Behavior of light- and dark-reared rats on a visual cliff. *Science*, *126*, 80–81.

Yonas, A., & Hartman, B. (1993). Perceiving the affordance of contact in four- and five-month-old infants. *Child Development*, *64*, 298–308.

(RECEIVED 5/11/99; REVISION ACCEPTED 11/15/99)