

Why Toddlers Don't Perceive Risky Ground Based On Surface Friction

Te-Wen Lo, Anthony M. Avolio, Sherrie A. Massop
& Karen E. Adolph

Department of Psychology, New York University, USA

Friction plays a central role in locomotion by allowing the feet to grip the ground for maintaining balance. With too much friction, people trip. With too little friction, they slip. Despite many well-known facts about biomechanical effects of friction on walking, to date, there are no empirical studies of whether people can control locomotion prospectively based on surface friction or how such an ability might develop.

Friction presents a unique opportunity to examine prospective control of locomotion because it requires visual and tactile exploration in serial order. Visual information is unreliable because slippery surfaces can be shiny or matte. Although tactile information is reliable, touching requires direct contact and walkers are unlikely to interrupt their gait to probe a patch of ground unless prompted by visual cues. This conundrum may explain why accidents due to variations in surface friction are the leading cause of injury from falling (Lin, Chiou, & Cohen, 1995). We report two experiments showing that prospective control is impaired without appropriate exploratory movements to generate information about surface friction.

Experiment 1: Interleaved Friction Conditions

Method

Sixteen 14-month-old toddlers were tested on slippery vinyl and sticky rubber surfaces covering an adjustable, sloping walkway (0°- 90°). Babies wore nylon stockings to exaggerate effects of friction ($\mu_{\text{nylon/vinyl}}=0.3$, $\mu_{\text{nylon/rubber}}=1.2$). The high friction surface

permitted safe walking on steep slopes, but the low friction surface was challenging even at 0°. Therefore, the same degree of slant could be safe in the high friction condition but risky in the low. Because infants' walking skill varies widely, we defined safe and risky slopes relative to each baby's walking skill in each friction condition. We used a psychophysical double staircase procedure (Adolph, 1995) to estimate the steepest slopes each infant could walk down to a 75% criterion. Slopes shallower than this "boundary slope" were safe by definition and steeper slopes were increasingly risky. The double staircase procedure involved frequent changing of surface friction and slant over the course of 44-77 trials, requiring infants to judge on-line whether slopes were safe or risky. We examined the process of prospective control by comparing exploratory activity prior to descent with the accuracy of infants' perceptual judgments. Visual and tactile information were available by peering over the brink and touching the slope with feet or hands.

Results and Discussion

All babies could walk down steeper high friction slopes ($M=12.5^\circ$, range= 6° - 22°) than low ($M=3.1^\circ$, range= 0° - 6°). Thus, information about surface friction was necessary to decide whether a particular degree of slant was safe or risky. Figure 1 shows exploratory activity and perceptual judgments normalized to relative degree of risk in each friction condition. Responses based on surface friction would be indicated by high and low friction curves superimposed for each outcome measure. As in previous studies (e.g., Adolph, 1995), exploratory activity and perceptual judgments were based on variations in surface slant. However, infants did not respond adaptively to changes in surface friction. They explored risky high friction slopes by prolonged looking and touching, but started down low friction slopes without prior exploration. As a result, on high friction slopes, infants closely matched their attempts to walk to the probability of walking successfully, but on low friction, they attempted impossibly risky slopes on trial after trial, requiring rescue by an experimenter. At every risky slope, exploratory activity predicted whether infants fell. Also, infants modified their gait on high friction slopes by taking slower steps, but on low friction, they ran right down.

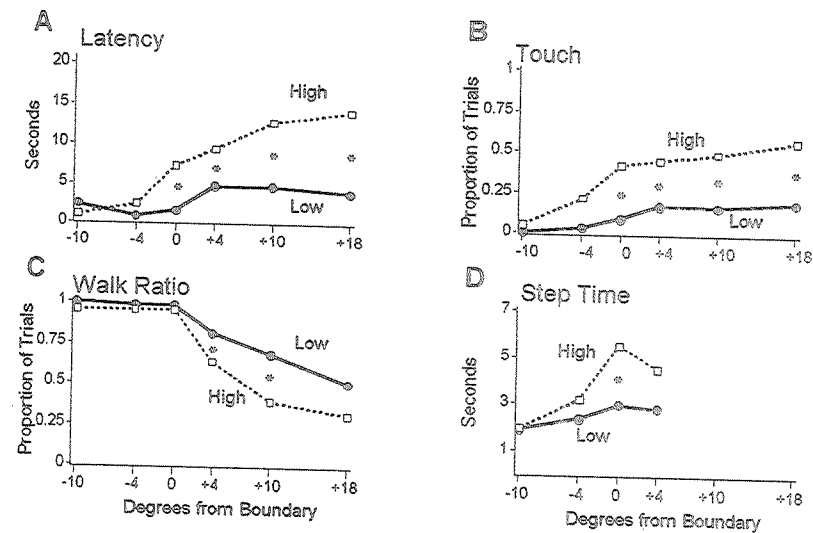


Figure 1. Exploratory activity, perceptual judgments, and gait modifications normalized to relative degree of risk in each friction condition. Vertical dashed lines represent the steepest slope each infant could walk successfully (75% criterion). Negative numbers on the x-axis represent safe slopes and positive numbers represent risky slopes. Asterisks denote significant differences between conditions (all $p < .05$). (a) Latency. (b) Touching. (c) Perceptual judgments indexed by the ratio of attempts to walk divided by the total number of trials. (d) Gait modifications in step time.

Experiment 2: Blocked Trials

Method

To examine whether failure to use information about surface friction was due to confusion from interleaving friction conditions, we tested 15 additional 14-month-olds with friction conditions blocked. As before, we defined safe and risky slopes relative to each infant's walking skill in each friction condition using the psychophysical staircase procedure. In addition, we tested babies on a steep 46° slope in each condition.

Results and Discussion

Each finding from Experiment 1 was replicated. All infants walked down steeper slopes on high friction ($M=14.27^\circ$, range= 6° - 26°) than on low ($M=4.27^\circ$, range= 0° - 6°). They engaged in less exploratory looking and touching on low friction slopes and subsequently attempted impossibly risky slopes and fell (Figure 2).

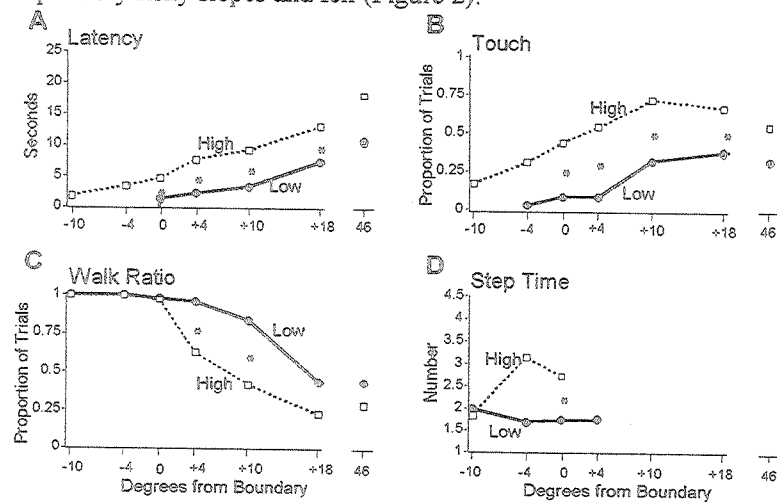


Figure 2. Exploratory activity, perceptual judgments, and gait modifications normalized to relative degree of risk in each friction condition. Asterisks denote significant differences between conditions (all $p < .05$). (a) Latency. (b) Touching. (c) Perceptual judgments. (d) Gait modifications.

Results of both experiments show that toddlers do not distinguish safe from risky slopes based on changes in surface friction. The serial order of visual and tactile exploration may explain why infants fared so poorly on low friction slopes. Trials began only after infants made visual contact with the slope. If this brief glimpse hinted that something was amiss, infants engaged in more prolonged visual and tactile exploration. Very shallow low friction slopes looked safe but were actually risky. Without appropriate visual cues (e.g., seeing a steep slope), infants failed to explore risky slopes and fell. Apparently, the breakdown in

prospective control resulted from inadequate visual and tactile exploration.

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.
- Lin, Chiou, & Cohen. (1995). Slip and Fall Prevention: A Review of Research, Practice, and Regulations. *Journal of Safety Research*, 26, 203-212.