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An analysis of optic flow experienced by infants during natural activities

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Goal: Measuring the natural statistics of optic flow

Self-motion generates optic flow with patterns and speeds that differ based on the motion of the body, trunk, head, or eye, the motion type (translation or rotation), and scene geometry. The statistics of optic flow due to self-motion may change across age due to development in motor abilities, head and body posture, and the relative frequency of passive versus active locomotion (Raudies & Gilmore, *Neural Computation*, in press).

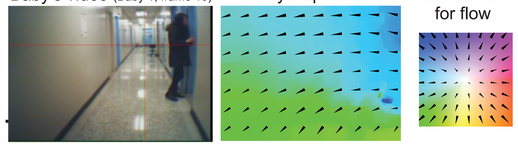
Approach: Estimate flow from head-mounted cameras

We assessed head-centered optic flow observed by infants across a wide range of ages, postures, and scenes (e.g. indoors/outdoors) and compared the frequency of optic flow patterns and overall visual speeds in each setting. Infants wore head-mounted cameras while performing simple natural activities: Walking, sitting, playing, interacting with caregivers, riding in a stroller, or being carried in a front-facing baby carrier. We estimated optic flow from short (~30 sec) segments of the recorded videos. We used the estimated optic flow to estimate the relative frequency of optic flow patterns and visual image speeds.

Estimating optic flow from videos

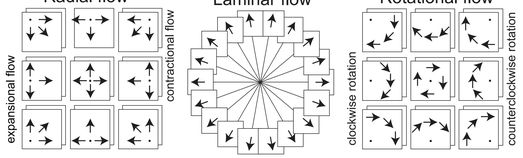
Optic flow is estimated from videos using an algorithm that assumes gray-value-constancy between frames and smoothness for the detected flow.

Baby's video (Baby 1, frame 10) | Baby's optic flow | Color code for flow

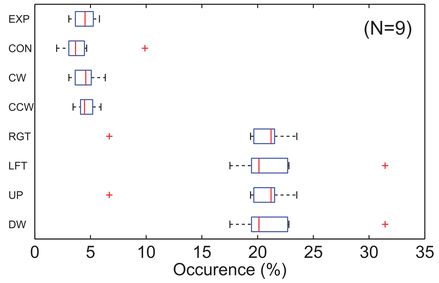


Matching Optic Flow against Flow Patterns

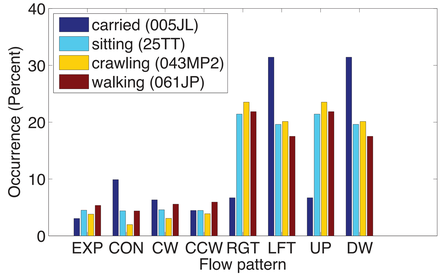
We matched the detected optic flow against a set of flow patterns.



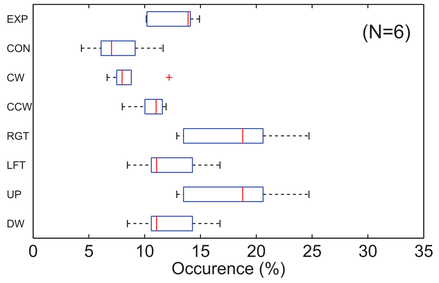
Optic flow patterns from Smith lab videos



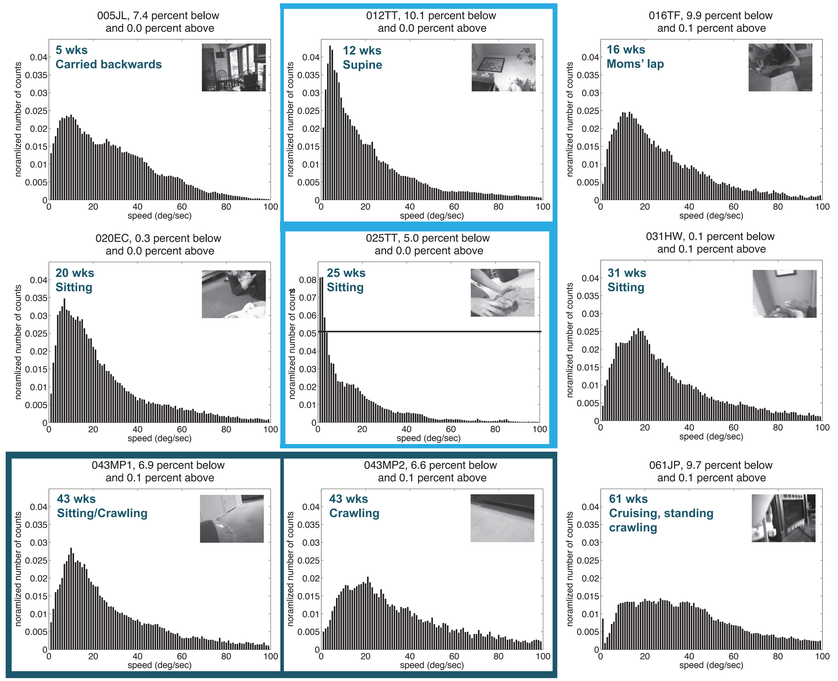
Flow pattern by action type



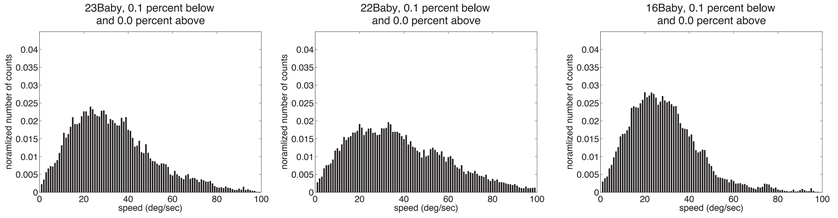
Optic flow patterns from Adolph lab videos



Speed distributions by age and posture/action from Smith lab videos



Speed distributions for 9.5 mo-olds in forward facing carriers from Adolph lab videos



Results: Summary

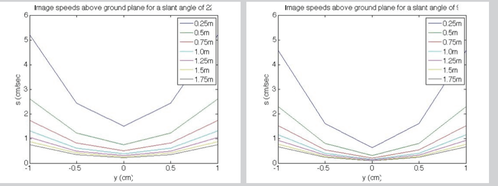
Optic flow patterns experienced by infants in natural activities differ by age, posture, and action context, among other factors.

- Infants who are carried by adults experience more radial flow, either expansion or contraction depending on the direction of self-motion.
- Laminar patterns due to head movement constitute a significant fraction of infants' experienced flow.
- Sitting or supine postures result in slower experienced speed distributions than crawling, cruising, or carrying by adults.
- Infants across a wide age range experience diverse patterns of flow and a wide range of speeds.

Simulating the effects of development on flow

Using the Longuet-Higgins & Prazdny (1980) equations for flow, we can estimate the effects of head position (tilt) and eye height associated with a change from crawling to walking posture (cf. Kretch et al., in press) on optic flow speeds.

$$S = \sqrt{\dot{x} + \dot{y}} = \frac{y\cos(\alpha) + f\sin(\alpha)}{df}\sqrt{x^2 + y^2}vZ$$



Crawling Posture | Walking Posture

Conclusions

Analysis of data collected from head-mounted cameras enables researchers to measure the natural scene statistics of optic flow, including empirical motion priors (Raudies & Gilmore, *Neural Computation*, in press) in developing observers. Changes in posture and viewpoint orientation relative to visible surfaces can change the speed and pattern distribution of optic flow.

Acknowledgments

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