From Degraded Inputs to Robust Sensory Cognition: A Computational Perspective on Early Perceptual Development

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Abstract

Human sensory development unfolds in a consistent temporal sequence, with early visual inputs initially degraded. Rather than mere biological constraints, we propose these developmental "limitations" may act as inductive biases that foster more global and robust sensory cognition. Evidence derives from children born blind who later gained sight, effectively bypassing this early degraded period. Despite many otherwise intact visual abilities, they exhibit specific deficits in generalization and extended spatial integration. Simulations with deep neural networks confirm that these deficits can arise from a lack of early degraded inputs. Conversely, training with developmentally-inspired input trajectories yields more robust representations and superior generalization. These findings help illuminate the development of typical and atypical sensory cognition, inform clinical interventions, and inspire more robust computational training procedures. Comparable results from auditory development suggest a broader phenomenon, demonstrating how what may appear to be "limitations" can adaptively shape perception and cognition over time.

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