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Letter

'Helpless' infants are active, goal-directed agents: response to Cusack *et al.*

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Why are humans born 'helpless'? In their recent article in *TiCS* [1], Cusack *et al.* propose an explanation for the limited behavioral repertoires of human infants compared with those of other animals. The proposal builds a compelling argument from comparative neuroimaging research that human neural development and sensory processing are relatively mature at birth, undermining the idea that infants are helpless because their brains are immature. Instead, the authors propose that infants' helplessness has learning benefits analogous to training foundation models in machine learning. They argue that the infant's 'limited repertoire of adaptive behavior' affords a period of self-supervised learning in which representations are 'not yet connected to outputs and are therefore not acted upon' [1]. This 'pretraining' stage of sensory data crunching makes the acquisition of later abilities more efficient.

We agree that infants' ability to learn from statistical regularities is a key driver of early development. However, we challenge Cusack *et al.*'s stage-like proposal that sensory learning is initially disconnected from motivations and goal-directed actions [1]. This claim is inconsistent with core empirical findings, and underestimates the many ways in which infants' behavior is adaptive. We encourage researchers to 'think like a baby': that is, to assume the infant's agential perspective to see the goals and rewards that drive their early learning. Four insights from developmental science are at odds with Cusack *et al.*'s proposal [1].

First, infants are born active, goal-directed agents [2]. Statistical learning does not precede active learning; rather, active learning and statistical learning interact in developmental cascades from the beginning of life. Fetuses learn sensorimotor contingencies *in utero* [3]. Neonates' behavior simultaneously shapes their environments and enables them to learn about contingencies between their actions and outcomes [4]. Within weeks, they exhibit reinforcement learning, targeted crying, and imitation behaviors that attract caregivers [4,5]. Between 2 and 5 months of age, infants begin vocalizing specifically to elicit contingent responses from adults, engaging a social feedback loop that supports phonological maturation [6]. Although Cusack *et al.* acknowledge the possibility that infants are 'actively learning from their environment' [1], their core proposal is that infants are learning representations that are disconnected from behavioral outputs and action policies. This conflicts with evidence that much of infants' learning is grounded in goal-directed, endogenously motivated actions [2].

Second, statistical learning is integrated with learning across domains (e.g., vision, motor skills, and language) [7]. By 3 months of age, infants' own action experience changes their predictions about the actions of others [8]. Their experience manipulating physical objects supports the development of visual memory [7]. Learning is 'supervised' in the sense that language begins to shape infants' visual attention and category learning as early as 3–4 months of age [9]. Early learning is driven by the complex interplay of rapidly developing skills across perceptual, motor, and cognitive domains, not a stage-like succession in which statistical learning first lays a foundation for later capacities.

Third, Cusack *et al.*'s proposal ignores a fundamental aspect of development: variability. Almost every skill that infants develop is characterized by tremendous variability across individuals and cultural contexts [10]. The onset of many motor milestones varies by an order of months, depending on caregiving practices and other environmental factors. Despite this variability, all infants learn cognitive representations that afford efficient generalization. In Cusack *et al.*'s proposal, shorter durations of 'pretraining' (before the onset of specific motor behaviors) should predict downstream costs in learning generalizable representations, yet, if anything, the opposite is true (e.g., earlier walking predicts earlier-emerging language skills) [10].

Finally, Cusack *et al.*'s proposal assumes that infants have a relative 'lack of adaptive behaviors' [1]. By focusing on adult endpoints, such as walking and fluent language production, the proposal overlooks the extent to which human infants in fact exhibit many adaptive behaviors ('behavior that enables an animal to cope in their environment with greatest success' [1]). For example, the newborn rooting reflex simultaneously stimulates a source of nutrients and fosters mother–infant bonding; other neonate behaviors, such as seeking eye contact and smiling, recruit potential caregivers [5]. Many of the earliest goal-directed behaviors of neonates enable them to learn about their capabilities by directly influencing others [4]. This observation supports an alternative explanation for humans' protracted immaturity relative to other animals: it enables a period of targeted social learning, building the unique social skills crucial to our species' success [11]. Learning of this kind is only possible by virtue of infants' goal-driven actions adapted to a social world.

We share Cusack *et al.*'s enthusiasm for using computational tools to theorize about cognitive development. However, we predict that computational approaches that do not reckon with the characteristic features of infant development reviewed here – that infant learning is active from the beginning, shaped by interdependencies between

Box 1. Key directions for future research on infant learning

What can we learn from dense, longitudinal samples of infants' everyday experiences?

Large-scale, naturalistic datasets (e.g., using infant headcams [12]) increasingly capture babies' lives moment by moment. These datasets are powerful test beds for computational models. They also provide opportunities for generating new ideas about how infants learn. We predict that lasting insights will come from descriptive efforts to understand learning from infants' agential perspectives.

What are infants' learning goals?

Refining our understanding of infants' goals will improve models of development. For example, infants rarely pursue the goal of learning words directly. Instead, their underlying motivations are communicative. The socially interactive nature of language development explains otherwise puzzling findings, such as many early-learned words being grounded in social routines ('bye-bye', 'uh-oh') [4].

How are variability in motor and cognitive development related?

Investigating how precocial motor development relates to cognitive development, within and across cultures and contexts, can help clarify whether longer periods of limited motor skills are linked to improved efficiency in learning cognitive skills, as predicted in [1].

Is social ecology related to 'helplessness' in other animals?

Comparing early social behavioral development across species can shed light on a possible general relation between extreme neonatal dependence and social learning [11].

motor and perceptual learning, subject to experientially and culturally shaped variability, and attuned to the social environment – will fall short as models of infant learning. Box 1 highlights several directions for future research that may advance theories and models of infant development.

A neural network learning a foundation model is in fact helpless: it passively forms statistical representations, carving up the input without motivations, ecological context, or integration with developing actions. Infants, by contrast, are active learners driven by a diverse set of goals and highly attuned to what their evolving behavioral repertoires make possible. Once viewed through the lens of their exquisite adaptation to the social environment, infants are far less helpless. Computational theories of infant learning must be firmly rooted in insights from developmental science, understanding infants as adapted to their own social ecological niche.

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Declaration of interests

The authors declare no competing interests.

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