

Infants' Understanding of communicative signals: A 4E-perspective

Humans are an inherently social species. Our lives are deeply intertwined with others from birth, providing the foundation for communication, language, and culture. Many theoretical accounts have argued that such abilities require specific cognitive adaptations that prioritise others as sources of information (Csibra, 2010; Csibra & Gergely, 2009). I propose that these abilities may instead emerge out of humans' prolonged period of helplessness after birth requiring long periods of post natal care. Human infants are born with large brains in bodies that constrain the ability to explore and affect the environment on their own, requiring them to turn to others to affect the environment on their behalf. This unique developmental trajectory provides the foundation of infants' later social understanding.

In order to understand the emergence of species-specific phenotypes, it is crucial to understand the interactions between genes, bodies and environment (Oyama, 2000). There are many examples of these interactions in humans and other animals. Ducklings only learn to recognise species specific calls if they are able to vocalise and hear their own chirps in the egg (Gottlieb, 1997). In toddlers, short arms constrain the number of objects in their field of view, thereby simplifying word-learning (Yu, Smith, Christensen, & Pereira, 2007). As these examples demonstrate, mental processes are grounded in the interaction between the body and the environment. Under the umbrella of 4E-cognition (that cognition is *embodied*, *embedded*, *enacted*, and *extended*), different philosophical accounts have focussed on the role of the environment and body in cognitive processing (Rowlands, 2009). Taking such a perspective can provide novel insights on the emergence of social and communicative signals in infancy.

Some authors (Csibra, 2010; Csibra & Gergely, 2009) argue for species specific cognitive adaptations that prioritise socially transmitted information over other sources of information, emphasising the discontinuity between the use of social signals in humans and other animals. Other accounts (Heyes, 2012, 2016) suggest that these signals take on meaning through cultural practices. The evidence for a clear demarcation or continuity between human infants' and others animals' use of social signals is mixed. Whilst infants already have perceptual preferences towards social signals, such as eyes and faces by the time they are born (Farroni et al., 2005; Farroni, Menon, & Johnson, 2006; Reid et al., 2017), these preferences are not unique to humans. Infant chimpanzees also prefer direct gaze (Myowa-Yamakoshi, Tomonaga, Tanaka, & Matsuzawa, 2003) and rhesus macaques show a similar developmental trajectory of gaze following across lifespan to humans (Rosati, Arre, Platt, & Santos, 2016). Despite this, other apes do not use social signals to the extent that humans do (Rosati et al., 2016), and differ in theory of mind (Call & Tomasello, 2008) and communicative abilities (Scott-Phillips, 2015). However, by looking at the specific developmental context, 4E-cognition provides a different explanation based on the embodied, embedded, enacted and extended relationship between infants and caregivers.

Human infants spend a significantly longer time constrained in their motor abilities compared to other species requiring significantly longer periods of postnatal care (Piantadosi & Kidd, 2016). For example, young chimpanzees already start walking and engaging with objects by five months (Potì & Spinozzi, 1994; Yerkes & Tomilin, 1935), about half the age of humans. Such constraints on self-directed movement potentially rebalances the incoming information and learning. For example, monkeys can be trained in mirror self recognition if their movement is restrained (Chang, Fang, Zhang, Poo, & Gong, 2015; Chang, Zhang, Poo, & Gong, 2017). The prolonged period of helplessness and post-natal care shifts infants' direct interactions with the environment to interacting with others. Studies in monkeys and apes suggest that an increase in social interactions between neonates and their caregivers increases social behaviour later in life (Bard, Bakeman, Boysen, & Leavens, 2014; Dettmer et al., 2016; Simpson et al., 2019). In humans, these effects are potentially more profound, priming others as affordances for interaction. For example, eight-month-olds attempt to reach for objects that are out of their reach in the presence of caregivers, but not when their caregivers are not present (Ramenzoni & Liszkowski, 2016).

Children's use of social signals closely follows their motor abilities. Human infants can control their head movements without support and lift their head above the floor only after 3 months of age (Payne & Chang, 2020). In these first months, children in Western societies predominantly see ceilings and the faces of their caregivers (Jayaraman, Fausey, & Smith, 2015; Jayaraman & Smith, 2018). Once children start crawling and walking, they are able to explore the environment on their terms. With the emergence of walking between 9-11 months, children become more interested in distal objects (Karasik, Tamis-LeMonda, & Adolph, 2011), pay less attention to their mothers (Fogel, Dedo, & McEwen, 1992) and rarely lift their heads to look out for others' faces, "because they are too busy playing with toys and running around the room" (Adolph & Hoch, 2019). With upright posture the visual input changes from faces to hands (Fausey, Jayaraman, & Smith, 2016) and pointing emerges out of reaching actions by the age of 12 months (O'Madagain, Kachel, & Strickland, 2019). Parents adjust their engagement to children's emerging abilities (Brand, Shallcross, Sabatos, & Massie, 2007) and provide more learning opportunities to walking children (Kretch et al., 2022).

Looking at the early species-specific environment might help us understand why and how humans, but not other species, develop such a sophisticated understanding of others. The foundations of human social skills may not be exclusively cognitive but emerge from a unique ontogenetic environment that constrains infants' ability to explore their environment on their own. Infants' prolonged dependence on caregivers places them in a niche in which it makes sense to predict others' actions just as well as one's own. 'Others' are integrated into the own body like a tool is integrated by sophisticated users (cf. Gibson, 1986). It is this particular and peculiar environment that provides the foundations of human communication (Pickering & Garrod, 2004, 2014) and social learning (Sebanz, Bekkering, & Knoblich, 2006; Sebanz & Knoblich, 2009).

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