Trends in Cognitive Sciences

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Letter

Developmental Origins of the Pathway for Social Perception

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Pitcher and Ungerleider [1] argue for a revision of the two visual pathway (dorsal and ventral) model by presenting evidence for the existence of a third visual pathway specialized for social perception. This pathway is located at the lateral surface of the brain, processes dynamic social information, and projects into the superior temporal sulcus. This letter further supports and critically extends this new account by highlighting an existing body of research that sheds light on the developmental emergence of this third pathway in the human brain during infancy.

In particular, prior neuroimaging work with human infants using functional near-infrared spectroscopy (fNIRS) shows that superior temporal cortical regions become specialized in dynamic social perception early in human ontogeny [2–4]. This early cortical specialization for social perception in the superior temporal cortex during infancy can be seen across cultures and demographics. Specifically, this cross-cultural research extends the original work conducted with European infants in the UK to rural Gambia and poor urban Bangladesh [5,6]. Furthermore, infants with a greater genetic risk for developing autism spectrum disorder (ASD) show reduced engagement of superior temporal cortex during social perception (Box 1).

With respect to the developmental emergence of this brain pathway, newborn infants have been shown to engage posterior superior temporal regions when viewing facial but not when viewing manual actions [4]. Importantly, this study also demonstrates that engagement of posterior superior temporal regions during social perception increases with infant age (in hours), thus, pointing to the role that early experience and face-to-face engagement may play in the specialization of this cortical system involved in social perception. The role of early experience is further supported by work showing that improved fine motor manual skills in 4–6-month-old infants are associated with the enhanced engagement of posterior superior temporal brain regions when viewing manual actions [7]. Moreover, the existing neuroimaging work with infants suggests that posterior superior temporal brain regions are also involved in infants' processing of eye gaze, body motion, and voices [8–10]. This is similar to what is known from adults and attests to the notion that beginning in infancy this brain system undergirds the perception of dynamic social information coming from a multitude of sources.

The evidence presented by Pitcher and Ungerleider [1] goes beyond showing that superior temporal brain regions preferentially respond to social stimuli by establishing additional functional properties: (i) differential sensitivity to dynamic when compared with static faces or bodies; (ii) responsiveness to an expanded visual field; and (iii) functional independence from activation in the ventral stream. Recent fNIRS work with 7-month-old infants provides support for the superior temporal cortex of infants being specifically engaged when processing dynamic social information [11]. In this study, the right superior temporal cortex of infants was engaged when viewing dynamic upright point-light walkers approaching but not when viewing inverted or nondynamic (rigid) point-light walkers. Additionally, infants in this study responded to point-light walkers that changed in size and moved from the periphery to the center of the screen, which likely required them to utilize information from an expanded visual field. Despite this progress, the functional independence from activation in the ventral stream and especially the fusiform gyrus remains to be directly assessed in infancy. Addressing this question will require the use of fMRI with infants [12], as fNIRS is limited in its utility of mapping responses from ventral parts of the human infant brain.

Another critical question to consider in future research is how, over the course of development, superior temporal brain regions involved in dynamic social perception become integrated with other brain regions into coordinated functional brain networks to serve more complex social–cognitive functions. With respect to this question, it is worth noting that infants have been shown to coactivate superior temporal and medial prefrontal cortical regions during face-to-face interactions [8], but functional brain network connectivity measures have not been directly assessed. Medial prefrontal cortex is considered a key brain region involved in higher-order social and cognitive processes linked to understanding one's own and others' mental and

Box 1. Social Perception in Neurodevelopmental Disorders

There is evidence indicating that reduced engagement of superior temporal cortex seen during social perception in infancy may be linked to neurodevelopmental disorders such as autism spectrum disorder (ASD) [13]. Specifically, infants aged 4–6 months with an increased genetic risk for ASD (defined as having an older sibling diagnosed with ASD) show less selective responses during social perception in superior temporal brain regions than infants with a low genetic risk. This suggests that early-developing individual variability in the third pathway for social perception exists, may be under genetic or epigenetic control, and might ultimately help with identifying and characterizing early risk factors and markers of atypical neurodevelopment linked to ASD. However, to date, it remains unknown whether reduced specialization for social perception seen in the infant superior temporal cortex reflects a biomarker or indeed predicts ASD phenotype and diagnosis later in childhood.

emotional states. It thus seems critical to directly examine the early development of functional connectivity of superior temporal brain regions with other brain regions, including the medial prefrontal cortex. This may allow us to understand how the emergence of such brain networks enables the more sophisticated processes required to navigate our complex social environment through learning from and coordinating behavior with others.

In summary, this letter advocates for a developmental cognitive neuroscience approach in furthering our understanding of the third visual pathway specialized for social perception. The reviewed research with human infants provides important developmental evidence for Pitcher and Ungerleider's [1] account, showing that the third visual pathway represents an early developing functional organizational feature of the human brain. This supports the notion that social cognition plays a major role in the development and evolution of the human brain. The developmental data presented here further strengthen the ground-breaking proposal for a third visual pathway specialized for social perception and emphasize the need to further characterize the developmental origins of this brain system and its implications for typical and atypical social cognitive development.

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