MedicalXpress

Maturation of visual pathways spotlights early effects of social status on social development: Macaques study

June 21 2023, by Lisa Newbern

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Emory University and Marcus Autism Center researchers recently learned how eye contact with others when we are very young is related to

brain growth. This research has the potential to identify early brain and behavioral markers of conditions associated with social disability, such as autism spectrum disorders.

In the long term, this work can inform the development of diagnostic tools and timelines for early intervention to better support child and family outcomes.

Making eye contact in the first six months of a baby's life plays a critical role in the formation of infant-caregiver bonds. Despite the importance of social and neural development during infancy, not much is known about the brain pathways that support infant attention to the eyes of other people. Researchers at the Emory National Primate Research Center (EPC) and their colleagues at the Marcus Autism Center have been determined to change that.

The research team recently learned how eye contact behaviors develop in infant rhesus macaques and how these behaviors shape brain growth. The team's research shows that infant monkeys that spend more time looking at the eyes of other animals have stronger connectivity among the visual areas in the brain. In addition, the researchers found social status has an impact on this development, with animals of lower social status building these connections on an accelerated timetable.

The research, which has the potential to inform early neurobehavioral markers of later social disability and, therefore, ultimately support earlier identification and intervention, was published in *Developmental Cognitive Neuroscience*.

Looking into eyes is a critical social skill

"For both humans and macaques, learning to engage with the eyes of others during infancy is a critical social skill in typical

neurodevelopment," says senior author Mar Sanchez. "Attention to the eyes emerges differently in many neurodevelopmental disorders, including autism spectrum disorders and Williams syndrome. Therefore, investigating the brain regions and environmental factors that underlie and shape this critical behavior can help us understand how it emerges and how it provides the foundation for continued social development in rhesus macaques, which are a well-established model for studying human neurodevelopment because of similarity in brain structure to humans."

Sanchez is the division chief and core scientist in the Developmental and Cognitive Neuroscience Division of the EPC and a professor in the Department of Psychiatry and Behavioral Sciences, Emory School of Medicine. Other Emory team members represent the Department of Pediatrics in the School of Medicine, Department of Psychology and Neuroscience Program.

In this study, the research team showed male infant macaques videos of other macaques and used eye-tracking tools to measure how much time they spent looking at the eyes of the animals in the videos. The researchers also collected resting-state functional MRI (rs-fMRI) scans of the brain in the same animals to analyze connectivity within key areas of the occipital and temporal cortices, areas of the brain involved in visual perception and social processing.

Study data will be a critical resource for researchers

The research team began collecting data when the animals were about two weeks old and then continued at weekly and monthly intervals (for the eye-tracking and rs-fMRI data collection, respectively) for up to six months.

"This is the first study to show the association between attention to the eyes and development of connectivity in visual brain areas using data

collected at multiple timepoints from the same animals," says Sanchez.

The research team, which also includes collaborators representing Children's Healthcare of Atlanta, National Institute of Mental Health, University of North Carolina and University of Minnesota, used the data to create a unique neurobehavioral dataset that will inform their future studies and provide a unique resource to other researchers.

The researchers first used this unique longitudinal dataset to determine how connections between the occipital and temporal cortices in the visual pathway changed over time. They found the most change in these connectivity patterns happened in the first three months of life for infant macaques, which is comparable to the first year of life for infant humans.

Then, they looked at how the strengthening and weakening of brain connectivity from zero to six months was related to changes in the amount of infant eye contact during the same timeframe. Infants with stronger connections between the brain areas involved in processing what we see, the primary visual areas, looked more to the eyes of other monkeys earlier than infants with weaker connections between the primary visual areas.

Social status makes a difference

Importantly, the researchers determined that the relationship between brain maturation and eye contact depended upon whether the infant came from a high-social status or low-social status family.

Because rhesus macaques live in large, family-based social communities, their behaviors have parallels to social development in people. For example, the social structures in which individuals and animals are ranked by social status provide details about how social factors may

impact neural development.

When the research team examined how social status affected development of the visual pathways and infant eye contact, they found infants from low-ranking families had a stronger relationship between maturation in the visual pathways and eye contact versus high-ranking infants. This difference may indicate the brains of low-ranking infants are adapted to help them identify faces and expressions earlier in life to better navigate social interactions with other monkeys.

"We were intrigued by the influence of status on the development of the social brain even in the earliest postnatal months," says Aiden Ford, first author and a Ph.D. candidate in neuroscience at Emory. "This research offers unique insight into group and individual-level dynamics in brain and behavior development. It may help us uncover how early exposure to adversity may accelerate biological, brain and social development."

Forthcoming studies from this research group will focus on mapping the development of social behaviors and social brain regions in infant macaques, with a particular focus on the amygdala, as well as continuing to investigate the effects of infant social status.

More information: Aiden Ford et al, Functional maturation in visual pathways predicts attention to the eyes in infant rhesus macaques: Effects of social status, *Developmental Cognitive Neuroscience* (2023). DOI: 10.1016/j.dcn.2023.101213

Provided by Emory University