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PRESS RELEASE

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THE AMYGDALA PREDICTS PARTNERS' ECONOMIC CHOICES

'Social learning' is crucial to building understanding. We learn from our own experiences and by observing others, especially those around us. We constantly process our perceptions about the intentions, actions, and experiences of our social partners. How does the brain use this information to guide and improve our own decisions?

Researchers at Cambridge University investigating the role of the amygdala have uncovered a new mechanism through which this brain structure plays a role in social learning. These findings may have implications for human conditions affecting social learning, such as social anxiety or autism.

Dr Fabian Grabenhorst, speaking at the FENS Forum of Neuroscience in a symposium he co-chaired on brain mechanisms for social cognition, presented data on amygdala simulation processes from his team's studies on observational learning in monkeys. Today (10 July) he described that while observing a social partner's reward-based economic choices, brain cells in the amygdala can simulate the partners' decision processes, and can predict behavioural choices as well.

The amygdala is a small but key region within the brain's limbic system, crucially involved in emotion, motivation, and reward. Known for its role in fear and aggression — including the 'fight-or-flight' response — the amygdala also helps identify faces and situations, and is considered by many scientists to be a key component of 'the social brain'. While amygdala dysfunction is associated with social cognitive deficits, as seen in autism, how individual amygdala neurons support complex social learning had so far been unclear.

Dr Grabenhorst, working in the team of Professor Wolfram Schultz at Cambridge University, examined how the amygdala itself might code information about social partners' economic choices. They measured electrical activity of single amygdala neurons as monkeys in a social setting observed each other engaging in a choice and reward task.

As one monkey observed the partner's choice, amygdala cells signaled expected 'reward values' of the partner's choice options, Dr Grabenhorst described. "The neurons' activity seemed to encode a comparison of which choice object had the higher 'economic' value," he said. "Rather than signalling cue values from one's own experience, these specific neurons seemed to learn values through social observational learning." Importantly, these object value signals appeared during observation, even before the recorded monkey himself experienced actual reward from that object, he noted.

Additionally, different but related amygdala neurons predicted which object the recorded monkey or partner monkey was about to choose. Some neurons specifically predicted the partner's choices, suggesting a specific 'simulated' choice signal rather than more generalised choice prediction, Dr Grabenhorst explained. These 'simulation neurons' appear to evaluate the partner's choices of objects and anticipate their upcoming choices, he said. "These neurons code the partner's predicted choice, and also exhibit vital decision-making signatures, namely value

comparisons, and value-to-choice conversions," he noted. "All this occurred within a few hundred milliseconds each time before the social partner made a choice," he said, which suggests these cells participate in decisionmaking.

Remarkably, these simulation neurons also seemed relevant for the recorded monkey's learning, Dr Grabenhorst reported. "When it was the monkey's own turn to choose, he made better choices if his amygdala neurons had more accurately anticipated the partner's decisions for the same objects. This indicates that simulating decisions of social partners may be important in observational learning."

The team's previous research found that amygdala cells encode an individual monkey's economic decision processes and predict the monkey's upcoming choices. This new research demonstrates that similar brain patterns emerge when one monkey observes a social partner — that amygdala neurons can learn reward values of choice objects purely from observing — even without the observer monkey making a decision. These neurons thus seem to simulate a decision process that predicts the likely choice of the social partner. Importantly, separate amygdala neurons processed the monkey's own decisions or the simulated partner's decisions.

The research by Dr Grabenhorst and his colleagues strengthens understanding of how the amygdala actively engages in forging our social lives, especially how one is influenced by others' economic choices. The new findings show that the amygdala's functions go far beyond basic emotion and reward processing, by demonstrating an active role for the amygdala in social behaviour through the simulation of the social partner's decisions.

Based on this research, Dr Grabenhorst and colleagues are currently building a biologically-inspired computer model (a complex set of equations) of the amygdala's decision circuits, to examine how the neurons interact with each other to compute a monkey's choices, or their social partner's simulated choices. "The model will also help us understand what could go wrong when amygdala decision circuits are dysfunctional." These types of complex cognitive processes are affected in neurodevelopmental disorders such as autism, affecting understanding of others' mental states and leading to poor social interactions, he noted. "We speculate that hyperactive amygdala simulation neurons could promote social anxiety by exaggerated spontaneous simulation of others' decisions. Conversely, absence or dysfunction of amygdala simulation neurons or their inputs could impoverish social cognition, as is symptomatic in autism."

If further studies confirm similar findings in the human brain, these amygdala neurons could turn out to play a role in human disease, Dr. Grabenhorst said. He believes the ongoing findings are a step forward in understanding what guides our social decisions, and how to address conditions affected by impaired social learning.

END

Symposia S39: *Neural mechanisms for social cognition in monkeys and humans*
Abstract Reference: F. Grabenhorst - *Amygdala neurons simulate economic decision processes of social partners*

Contact
FENS Press Office and all media enquiries:
Elaine Snell, Snell Communications Ltd, London UK *(English language)*
tel: +44 (0)207 738 0424 or mobile +44 (0)797 395 3794
email: Elaine@snell-communications.net

Barbara Ritzert, ProScience Communications, Pöcking, Germany *(German language)*
tel: +49 8157 9397-0 or mobile +49 151 12043311
email: ritzert@proscience-com.de

Dr Fabian Grabenhorst, Department of Physiology, Development and Neuroscience,
University of Cambridge, UK www.neuroscience.cam.ac.uk/directory/profile.php?FGrabenhorst

NOTES TO EDITORS

The 11th FENS Forum of Neuroscience, the largest basic neuroscience meeting in Europe, organised by FENS and hosted by the German Neuroscience Society will attract more than 7,000 international delegates. The Federation of European Neuroscience Societies (FENS) was founded in 1998. With 43 neuroscience member societies across 33 European countries, FENS as an organisation represents 24,000 European neuroscientists with a mission to advance European neuroscience education and research. https://forum2018.fens.org/

Further Reading (Grabenhorst)

Amygdala neurons evaluate the progress of self-defined economic choice sequences. F Grabenhorst, I Hernadi, W Schultz. *Elife.* 2016, 5. pii: e18731.
DOI: 10.7554/eLife.18731

Planning activity for internally generated reward goals in monkey amygdala neurons. F Grabenhorst, I Hernadi, W Schultz. *Nature Neuroscience.* 2015, 18(3):461-469.
DOI: 10.1038/nn.3925

Prediction of economic choice by primate amygdala neurons. F Grabenhorst, I Hernadi, W Schultz. *Proceedings of the National Academy of Sciences USA.* 2012, 109 (46) 18950-18955. **DOI: 10.1073/pnas.1212706109**