Brain circuit differences reflect divisions in social status

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Barbary macaques. Credit: Wikipedia/Flickr/Karyn Sig

Life at opposite ends of primate social hierarchies is linked to specific brain networks, a new Oxford University study has shown.

The importance of social rank is something we all learn at an early age.

In non-human primates, social dominance influences access to food and mates. In humans, social hierarchies influence our performance everywhere from school to the workplace and have a direct influence on our well-being and mental health. Life on the lowest rung can be stressful, but life at the top also requires careful acts of balancing and coalition forming. However, we know very little about the relationship between these social ranks and brain function.

The new research, conducted at the University of Oxford, reveals differences between individual primate's brains which depend on the their social status. The more dominant you are, the bigger some brain regions are. If your social position is more subordinate, other brain regions are bigger. Additionally, the way the brain regions interact with each other is also associated with social status. The pattern of results suggests that successful behaviour at each end of the social scale makes specialised demands of the brain.

The research, led by Dr MaryAnn Noonan of the Decision and Action Laboratory at the University of Oxford, determined the position of 25 macaque monkeys in their social hierarchy and then analysed non-invasive scans of their brains that had been collected as part of other ongoing University research programs. The findings, publishing September 2 in the open access journal *PLOS Biology*, show that brain regions in one neural circuit are larger in more dominant animals. The regions composing this circuit are the amygdala, raphe nucleus and hypothalamus. Previous research has shown that the amygdala is involved in learning, and processing social and emotional information. The raphe nucleus and hypothalamus are involved in controlling neurotransmitters and neurohormones, such as serotonin and oxytocin. The MRI scans also revealed that another circuit of brain regions, which collectively can be called the striatum, were found to be larger in more subordinate animals. The striatum is known to play a complex but important role in learning the value of our choices and actions.

The study also reports that the brain's activity, not just its structure, varies with position in the social hierarchy. The researchers found that the strength with which activity in some of these areas was coupled together was also related to social status. Collectively, these results mean that social status is not only reflected in the brain's hardware, it is also related to differences in the brain's software, or communication patterns.

Finally, the size of another set of brain regions correlated not only with social status but also with the size of the animal's social group. The macaque groups ranged in size between one and seven. The research showed that grey matter in regions involved in social cognition, such as the mid-superior temporal sulcus and rostral prefrontal cortex, correlated with both group size and social status. Previous research has shown that these regions are important for a variety of social behaviours, such as interpreting facial expressions or physical gestures, understanding the intentions of others and predicting their behaviour.

"This finding may reflect the fact that social status in macaques depends not only on the outcome of competitive social interactions but on social bonds formed that promote coalitions," says Matthew Rushworth, the head of the Decision and Action Laboratory in Oxford. "The correlation with social group size and social status suggests this set of brain regions may coordinate behaviour that bridges these two social variables".

The results suggest that just as animals assign value to environmental stimuli they may also assign values to themselves – 'self-values'. Social rank is likely to be an important determinant of such self-values. We already know that some of the brain regions identified in the current study track the value of objects in our environment and so may also play a key role in monitoring longer-term values associated with an individual's status.

The reasons behind the identified brain differences remain unclear,

particularly whether they are present at birth or result from social differences. Dr Noonan said: "One possibility is that the demands of a life in a particular social position use certain brain regions more frequently and as a result those areas expand to step up to the task. Alternatively, it is possible that people born with brains organised in a particular way tend towards certain social positions. In all likelihood, both of these mechanisms will work together to produce behaviour appropriate for the social context".

Social status also changes over time and in different contexts. Dr Noonan added: "While we might be top-dog in one circle of friends, at work we might be more of a social climber. The fluidity of our social position and how our brains adapt our behavior to succeed in each context is the next exciting direction for this area of research."

More information: The paper, A neural circuit covarying with social hierarchy in macaques, is due to be published in the journal *PLOS Biology* on September 2, 2014.

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