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How the brain responds to reward is linked to socioeconomic background

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MIT neuroscientists have found that the brain's sensitivity to rewarding experiences—a critical factor in motivation and attention—can be shaped by socioeconomic conditions. Credit: Jose-Luis Olivares, MIT

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experiences—a critical factor in motivation and attention—can be shaped by socioeconomic conditions.

In a study of 12 to 14-year-olds whose socioeconomic status (SES) varied widely, the researchers found that children from lower SES backgrounds showed less sensitivity to reward than those from more affluent backgrounds.

Using functional magnetic resonance imaging (fMRI), the research team measured brain activity as the children played a guessing game in which they earned extra money for each correct guess. When participants from higher SES backgrounds guessed correctly, a part of the brain called the striatum, which is linked to reward, lit up much more than in children from lower SES backgrounds.

The brain imaging results also coincided with behavioral differences in how participants from lower and higher SES backgrounds responded to correct guesses. The findings suggest that lower SES circumstances may prompt the brain to adapt to the environment by dampening its response to rewards, which are often scarcer in low SES environments.

"If you're in a highly resourced environment, with many rewards available, your brain gets tuned in a certain way. If you're in an environment in which rewards are more scarce, then your brain accommodates the environment in which you live. Instead of being overresponsive to rewards, it seems like these brains, on average, are less responsive, because probably their environment has been less consistent in the availability of rewards," says John Gabrieli, the Grover Hermann Professor of Health Sciences and Technology, a professor of brain and cognitive sciences, and a member of MIT's McGovern Institute for Brain Research.

Gabrieli and Rachel Romeo, a former MIT postdoc who is now an

assistant professor in the Department of Human Development and Quantitative Methodology at the University of Maryland, are the senior authors of the study. MIT postdoc Alexandra Decker is the lead author of the paper, which appears today in the *Journal of Neuroscience*.

Reward response

Previous research has shown that children from lower SES backgrounds tend to perform worse on tests of attention and memory, and they are more likely to experience depression and anxiety. However, until now, few studies have looked at the possible association between SES and reward sensitivity.

In the new study, the researchers focused on a part of the brain called the striatum, which plays a significant role in reward response and decision-making. Studies in people and animal models have shown that this region becomes highly active during rewarding experiences.

To investigate potential links between reward sensitivity, the striatum, and socioeconomic status, the researchers recruited more than 100 adolescents from a range of SES backgrounds, as measured by household income and how much education their parents had received.

Each of the participants underwent fMRI scanning while they played a guessing game. The participants were shown a series of numbers between 1 and 9, and before each trial, they were asked to guess whether the next number would be greater than or less than 5. They were told that for each correct guess, they would earn an extra dollar, and for each incorrect guess, they would lose 50 cents.

Unbeknownst to the participants, the game was set up to control whether the guess would be correct or incorrect. This allowed the researchers to ensure that each participant had a similar experience, which included

periods of abundant rewards or few rewards. In the end, everyone ended up winning the same amount of money (in addition to a stipend that each participant received for participating in the study).

Previous work has shown that the brain appears to track the rate of rewards available. When rewards are abundant, people or animals tend to respond more quickly because they don't want to miss out on the many available rewards. The researchers saw that in this study as well: When participants were in a period when most of their responses were correct, they tended to respond more quickly.

"If your brain is telling you there's a really high chance that you're going to receive a reward in this environment, it's going to motivate you to collect rewards, because if you don't act, you're missing out on a lot of rewards," Decker says.

Brain scans showed that the degree of activation in the striatum appeared to track fluctuations in the rate of rewards across time, which the researchers think could act as a motivational signal that there are many rewards to collect. The striatum lit up more during periods in which rewards were abundant and less during periods in which rewards were scarce. However, this effect was less pronounced in the children from lower SES backgrounds, suggesting their brains were less attuned to fluctuations in the rate of reward over time.

The researchers also found that during periods of scarce rewards, participants tended to take longer to respond after a correct guess, another phenomenon that has been shown before. It's unknown exactly why this happens, but two possible explanations are that people are savoring their reward or that they are pausing to update the reward rate. However, once again, this effect was less pronounced in the children from lower SES backgrounds—that is, they did not pause as long after a correct guess during the scarce-reward periods.

"There was a reduced response to reward, which is really striking. It may be that if you're from a lower SES environment, you're not as hopeful that the next response will gain similar benefits, because you may have a less reliable environment for earning rewards," Gabrieli says. "It just points out the power of the environment. In these adolescents, it's shaping their psychological and brain response to reward opportunity."

Environmental effects

The fMRI scans performed during the study also revealed that children from lower SES backgrounds showed less activation in the striatum when they guessed correctly, suggesting that their brains have a dampened response to reward.

The researchers hypothesize that these differences in reward sensitivity may have evolved over time, in response to the children's environments.

"Socioeconomic status is associated with the degree to which you experience rewards over the course of your lifetime," Decker says. "So, it's possible that receiving a lot of rewards perhaps reinforces behaviors that make you receive more rewards, and somehow this tunes the brain to be more responsive to rewards. Whereas if you are in an environment where you receive fewer rewards, your brain might become, over time, less attuned to them."

The study also points out the value of recruiting study subjects from a range of SES backgrounds, which takes more effort but yields important results, the researchers say.

"Historically, many studies have involved the easiest people to recruit, who tend to be people who come from advantaged environments. If we don't make efforts to recruit diverse pools of participants, we almost always end up with children and adults who come from high-income,

high-education environments," Gabrieli says. "Until recently, we did not realize that principles of brain development vary in relation to the environment in which one grows up, and there was very little evidence about the influence of SES."

More information: Alexandra L. Decker et al, Striatal and Behavioral Responses to Reward Vary by Socioeconomic Status in Adolescents, *Journal of Neuroscience* (2024). DOI: 10.1523/JNEUROSCI.1633-23.2023

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