What you want vs. how you get it: New neuroconomics study

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New research reveals how we make decisions. Birds choosing between berry bushes and investors trading stocks are faced with the same fundamental challenge - making optimal choices in an environment featuring varying costs and benefits.

A neuroeconomics study from the Montreal Neurological Institute and Hospital – The Neuro, McGill University, shows that the brain employs two separate regions and two distinct processes in valuing 'stimuli' i.e. 'goods' (for example, berry bushes), as opposed to valuing the 'actions,' needed to obtain the desired option (for example flight paths to the berry bushes). The findings, published in the most recent issue of the *Journal of Neuroscience* and funded by the Canadian Institutes of Health Research, are vital not only for improving knowledge of brain function, but also for treating and understanding the effects of frontal lobe damage, which can be a feature of common neurological conditions ranging from stroke to traumatic brain injury to dementia.

Decision making - selecting the most valuable option, typically by taking an action - requires value comparisons, but there has been debate about how these comparisons occur in the brain: is value linked to the object itself , or to the action required to get that object. Are choices made between the things we want, or between the actions we take? The dominant model of decision making proposes that value comparisons occur in series, with stimulus value information feeding into actions (the body's motor system). "So, in this study we wanted to understand how the brain uses value information to make decisions between different

actions, and between different objects," said the study's lead investigator Dr. Lesley Fellows, neurologist and researcher at The Neuro. "The surprising and novel finding is that in fact these two mechanisms of choice are independent of one another. There are distinct processes in the brain by which value information guides decisions, depending on whether the choice is between objects or between actions." Dr. Fellows often sees patients with damage to the frontal lobe, where decision making areas of the brain are located. "This finding gives me more insight into what is happening in the brain of my patients, and may lead to new treatments and new ways to care for them and manage their symptoms."

"Despite the ubiquity and importance of decision making, we have had, until now, a limited understanding of its basis in the brain," said Fellows. "Psychologists, economists, and ecologists have studied decision making for decades, but it has only recently become a focus for neuroscientists. For clinicians, this relative neglect is surprising; neurologists and psychiatrists have long identified poor judgment as a core feature of conditions ranging from dementia to drug addiction." The bad decisions made by such patients can lead to disastrous encounters with society and the legal system, and are an important source of distress and disability for patients and their families. "This area of study represents a paradigm shift in our perspective on frontal lobe disorders. We have known for a long time that patients with frontal lobe damage have trouble getting organized and planning to reach goals but with this new research we are now seeing that frontal injury can make it hard for patients to choose their preferred goal to begin with, or to keep track of what they want. This may explain the erratic, impulsive or inappropriate choices they sometimes make."

The study examined action-value and stimulus-value learning in patients with frontal lobe damage. "Iinvestigating a damaged area of the brain provides particularly solid evidence to prove if that area is necessary for

a particular function," said Dr. Fellows. Two groups of patients with damage to different parts of the frontal lobes played games where they learned to choose either between two actions (twisting movements of a joystick) or between objects (decks of cards). They won or lost play money depending on their choices, gradually learning which choices were better. In people with damage to the orbitofrontal cortex their ability to sustain the correct choice of stimulus (the better deck of cards) was disrupted but they chose normally between different actions. On the other hand, people with damage in a separate frontal lobe region known as the dorsal anterior cingulate cortex (dACC) had the opposite deficit. They weren't as good at choosing between two actions with different values, but they could choose between objects as well as participants without brain injury. These results indicate that the orbitofrontal cortex plays an important role in linking stimuli to their subjective, relative values, and the dorsal anterior cingulate cortex plays a similar role in the selection of an action based on value. It seems the brain has at least partly separate systems for deciding between actions and objects.

"As a clinician, my patients inform the research I conduct, and as a researcher, my work informs me on ways to better treat and manage patients, as well as gain new insights into brain function." Studies of patients with frontal lobe injury that trace the neural pathways of decision making, show that cognitive neuroscience tools can be applied to understand this complex behaviour, and provide new perspectives on illnesses marked by frontal lobe dysfunction.

Dr. Fellows is the Interim Chair of the Department of Neurology and Neurosurgery, McGill University and a neurologist at The Neuro. She is a Chercheur-Boursier of the Fonds de recherche en santé du Quebec and has been the recipient of numerous awards throughout her career including a Rhodes Scholarship. She is a recognized expert in the field of cognitive neuroscience, with investigations that focus on the brain basis of decision making. She is also interested in the role of the frontal

lobes in the regulation of emotion, the expression of personality traits, and the representation of past and future information.

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