Signal detection theory can be used to objectively measure cognitive fatigue

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Dr. Wylie, the director of the Rocco Ortenzio Neuroimaging Center at Kessler Foundation, conducts research in cognitive fatigue in healthy individuals and populations with multiple sclerosis, brain injury, and Gulf War illness. Credit: Kessler Foundation/Jody Banks

A team of New Jersey researchers has shown that changes in perceptual

certainty and response bias, two central metrics of signal detection theory (SDT), correlate with changes in cognitive fatigue. They also show that SDT measures change as a function of changes in brain activation. This finding was reported in *Frontiers in Psychology* on January 15, 2021, in the open access article "Using Signal Detection Theory to Better Understand Cognitive Fatigue."

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Cognitive fatigue is a common experience that affects the healthy population as well as individuals with brain injury or neurodegenerative disease. A large body of research shows that subjective feelings of cognitive fatigue do not correlate with performance—that is, a person may experience cognitive fatigue and yet objective measures of their performance, such as their response time or level of accuracy, do not necessarily worsen. As a result, researchers have long lacked an objective behavioral measure that covaries with the subjective experience of fatigue.

While previous research has indicated that one metric of SDT, perceptual certainty, may change as a function of fatigue, it remains unclear whether perceptual certainty covaries with fatigue. Moreover, there has been no research investigating the effect of fatigue on the second key SDT metric, response bias, which is the amount of evidence one requires before releasing a response. Understanding if and how cognitive fatigue covaries with both SDT metrics is essential to the development of effective interventions for people with this condition.

The study was conducted at the Rocco Ortenzio Neuroimaging Center at Kessler Foundation, a specialized facility dedicated solely to rehabilitation research. To investigate cognitive fatigue using SDT, the

investigators induced cognitive fatigue in 39 healthy volunteers while acquiring both structural and functional magnetic resonance imaging (fMRI) data. They assessed subjects' cognitive fatigue using a visual analogue scale of fatigue (VAS-F) at baseline and after each of the eight runs of the tasks. This enabled the team to assess whether perceptual certainty and response bias covary with cognitive fatigue, and whether similar patterns of brain activation underlie cognitive fatigue and SDT measures.

Researchers found that both SDT metrics were correlated with changes in cognitive fatigue. As fatigue increased, subjects became more conservative in their response bias and their perceptual certainty declined. This study is the first to show that changes in cognitive fatigue are correlated with changes in perceptual certainty.

Furthermore, the research team found that activation in the striatum of the basal ganglia—an area of the brain Kessler researchers have previously identified as sensitive to changes in cognitive fatigue—was also related to response bias and perceptual certainty.

"Our results show that cognitive fatigue is related to changes in subjects' response bias and perceptual certainty," said lead author Dr. Wylie, director of the Ortenzio Center. "We theorize that as cognitive fatigue increases, subjects make more errors because their perceptual sensitivity declines and they compensate for this by adopting a more conservative response bias," he emphasized. "Our work demonstrates the relevance of SDT measures in the understanding of fatigue and provides researchers with a new set of tools with which to better understand the nature and consequences of cognitive fatigue."

More information: Glenn R. Wylie et al, Using Signal Detection Theory to Better Understand Cognitive Fatigue, *Frontiers in Psychology* (2021). DOI: 10.3389/fpsyg.2020.579188

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