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COGNITIVE NEUROSCIENCE

Adapting to cognitive load

The dorsal anterior cingulate cortex (dACC) is thought to be involved in regulating the cognitive control of goal-directed behaviour. Exactly how it does this, however, has been unclear, in part owing to a paucity of human neurophysiological studies. Now, Eskandar and colleagues show that the dACC estimates expected cognitive load, allowing optimization of future behavioural responses.

To assess dACC function, participants performed a multi-source interference task before and after they underwent cingulotomy for treatment-refractory obsessive–compulsive disorder. In this task, participants are presented with a cue comprising three numbers and have to identify, by pressing one of three buttons, the unique number (the 'target') from two other, identical numbers (the 'distractors'). By changing the position of the target and the identities of the distractors, different levels of cognitive interference can be introduced into the trials.

In non-interference trials, the location of the target was congruent with its button box position and distractors were not included (they were set at zero), generating cues such as '100'. In low-interference trials, the location of the target was incongruent with its position on the button box (for example, '010') or distractors were included (for example, '122'). Finally, in high-interference trials, both of these aspects of the cue were varied. Activity in the dACC during the task was measured through the use of functional MRI (fMRI) and single-neuron recordings.

Before surgery, the fMRI signal in the dACC was higher during high-interference trials than during non-interference trials. Also, reaction times increased as the degree of cognitive interference increased. Both findings were in line with previous studies and hence validated the study of this patient population.

Microelectrode recordings revealed that 41% of dACC neurons showed a maximal firing rate after cue presentation, and that the firing rate of these cue-responsive neurons increased with rising cognitive interference. Interestingly, if a trial included cognitive interference, the neuronal firing rate during the subsequent trial increased more quickly following cue presentation, and the magnitudes of the neuronal signals were greater. These findings suggest that dACC activity encodes contextual information about the present and the recent past.

The authors also assessed the effect of past experience on behaviour: reaction times were longer in non-interference trials when the previous trial involved cognitive interference but were shorter in high-interference trials when the previous trials involved low or high interference. Thus, previous cognitive interference induced behavioural adaptation in this task.

Interestingly, after surgery, the participants' reaction times in the task were still dependent on current cognitive load, but the modulation of reaction times by cognitive interference in previous trials was abolished.

This study provides invaluable human data supporting a role for the dACC in regulating ongoing behavioural adaptation to varying cognitive load. Activity in this region seems to delay behavioural responses, possibly to promote accuracy, in the face of varying cognitive load, but seems to promote performance efficiency by increasing the speed of responses when the cognitive load is stable.

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ORIGINAL RESEARCH PAPER Sheth, S. A. *et al.* Human dorsal anterior cingulate cortex neurons mediate ongoing behavioural adaptation. *Nature* 24 Jun 2012 (doi:10.1038/nature11239)
FURTHER READING Shackman, A. J. *et al.* The integration of negative affect, pain and cognitive control in the cingulate cortex. *Nature Rev. Neurosci.* **12**, 154–167 (2011)