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COGNITIVE NEUROSCIENCE

COMMENTARY
The P300 as a build-to-threshold variable (Commentary on Twomey *et al.*)

EJN FEATURED ARTICLE

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For more than half a century, cognitive neuroscientists have used event-related potentials (ERPs) to explore the neural dynamics underlying perception, cognition, and behaviour; and in the great pantheon of ERPs identified, perhaps no other has been more debated than the P300. The functional significance of this reliable and robust positive centro-parietal deflection occurring approximately 300–400 ms post-stimulus has been the subject of intense speculation. Theories have variously argued that the P300 indexes the updating of the contents of working memory, the revision of expectations about a current task, or the updating of task-relevant information in anticipation of subsequent events. Although these theories are supported by compelling evidence, they fall short of linking the dynamics of neural activity measured to the underlying computational mechanism. In this Issue of EJN, Twomey *et al.* (2015) offer evidence for an exciting new theory of the P300 that remedies this shortcoming.

Computational models propose that decisions are optimised through repeated sampling and integration. Momentary sensory inputs are integrated by summation until a threshold level is met, at which point a response is initiated. In non-human primates, a wealth of evidence suggests that this process is mediated by gradually increasing neuronal firing rates in cortical neurons, a signal that scales with information quality and terminates at response initiation. However, evidence for a comparable signal in the human brain has remained elusive. Here, Twomey *et al.* (2015) start to bridge this gap by examining the relationship between the dynamics of the P300 build-up and predictions from evidence integration models. Across three experiments, they asked participants to respond to rare 'target' stimuli among frequent 'standards', by using a version of the oddball paradigm in which the P300 is reliably observed. When they computed ERPs locked to stimulation, the leading edge of the P300 built up with a rate that reflected the quality of evidence (discriminability of targets from the standard). ERPs locked to response were found to reach a common plateau at the apex of the P300, irrespective of whether response times were long or short. These results clearly mirror the two key hallmarks of the information integration signal as found in non-human primates, and suggest that the human correlate of neural evidence accumulation has been under our noses all of this time – in the form of the much-scrutinized P300.

ERPs offer insights into the timing of discrete states in the information processing pipeline, but the reasons for their specific shape or sign of deflection are often obscure. What is particularly compelling about the work of Twomey *et al.* is that, unlike past work, it links the ERP directly to a well-validated computational framework for understanding choices, in which the slope and termination point of integration correspond to specific model parameters. Indeed, it helps us to understand why the P300 is larger in response to surprising, motivationally salient or attended stimuli, because these are all situations in which the slope of information integration should be steeper. Moreover, their results raise the possibility that other well-known late positive potentials (such as the parietal old/new effect, or feedback-related potentials) may similarly reflect the growing integration signal that accompanies choices. One outstanding challenge for the authors is to explain how their build-to-threshold account can accommodate all of the situations in which the P300 is observed, including those in which no overt response is required. Nevertheless, the authors offer key new insights into a longstanding neural phenomenon, and open important avenues for future research.

Reference

Twomey, D.M., Murphy, P.R., Kelly, S.P & O'Connell, R.G. (2015) The classic P300 encodes a build-to-threshold decision variable. *Eur. J. Neurosci.*, **42**, 1636–1643.

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