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The neural basis of rapid visual recognition: Neural decoding and Granger causality analysis of connectivity

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Abstract

A visual paradigm that has been extensively used to study visual cognition is the rapid categorization paradigm (Thorpe et al., 1996). While much is known about its psychophysical basis, its neural underpinnings still remain to be understood. Here we recorded intracranial field potentials (IFPs) from the occipital and temporal lobes of human patients implanted with subdural electrodes while they were engaged in a rapid animal categorization task.

Using multivariate pattern analysis techniques, we quantified at millisecond precision the amount of visual category information conveyed by IFPs. Our analysis, which suggests that abstract category information can be read-out at a level close to behavioral performance (typically within the 70–80% accuracy range), includes the estimated flow of visual information and a lower bound of the read-out latencies. Additional results using spectral properties of the signal suggest a substantial amount of task relevant information in the delta phase and alpha amplitude that is seen selectively in the regions along the ventral stream. By quantifying the information content using the neural decoding, we investigated the relationship between electrode selectivity to category and behavioral measures in a correlation analysis.

We also employed Granger causality as a measure of connectivity during the task. This measure combined with multivariate autoregressive models was used to explain the causal interactions between the recording sites by means of revealing how a past state of a brain region informs the current state of another. Partial causality and spectral causality measures were also used over successive time windows during the task. Linking causal flow along the ventral stream to the neural information content in recording sites, we outline a comprehensive analysis of the connectivity in relation to the visual categorization and the dynamics of re-entrant signals in the low to intermediate parts of the visual system.

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