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Direct brain recordings reveal continuous encoding of structure in random stimuli

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How does the brain process randomness? Mounting evidence suggests it tries to make sense of any given sequence, generating sophisticated internal models that continuously draw on statistical structures in the unfolding sensory input to maintain a detailed representation of its environment. However, it is unknown how specifically this modelling applies to random sensory signals. Here, we investigate conditional statistics, through transitional probabilities, as an implicit structure encoding a random auditory stream. We evaluate this through a trial-by-trial analysis by applying information-theoretical principles to intracranial electroencephalography recordings. Based on high-frequency activity (75–145 Hz), we demonstrate how the brain continuously encodes conditional relations between random stimuli in a network outside of the auditory system following a hierarchical organization including temporal, frontal, and hippocampal regions. We further hypothesize that in lower frequency bands (alpha/beta), there might be a hierarchically inverse cascade of involved regions which originates in higher cortical areas and possibly encodes an event already prior to its onset. Linking the frameworks of statistical learning and predictive coding, our results illuminate an implicit process that might be crucial for the swift detection of patterns and unexpected events in the environment.

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