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Redundancy reduction in the ascending auditory system

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Abstract

Information processing by a sensory system is reflected in the changes in stimulus representation along its successive processing stages. A major issue in sensory representation is that of informational redundancy, caused by the fact that each point in the sensory epithelium is represented by a large number of neurons, both within and across auditory stations. We used information theoretic measures to quantify information content and stimulus-induced redundancy of neural responses in three subsequent auditory processing stations in the core auditory pathway: the inferior colliculus (IC), the medial geniculate body of the thalamus (MGB), and the primary auditory cortex (AI), using a set of natural sounds. We found large differences in the character of stimulus coding between AI and IC. Individual AI neurons conveyed half the information that IC neurons conveyed about the identity of the stimuli, but at the same time AI neurons were significantly less redundant than IC neurons. Redundancy in IC neurons is largely due to their frequency selectivity in that IC neurons with similar tuning tended to give similar responses to a given stimulus. At the same time the mutual information between the spectro-temporal content of short stimulus segments and neural responses was only one tenth as large in AI as in IC. AI neurons thus conveyed relatively large amount of information about complex stimuli even though they did not code well their spectro-temporal structure. Information about the spectro-temporal structure of sounds was also much less redundant in cortex than in IC. Properties of MGB neurons tended to be intermediate,

although more similar to AI than to IC. Redundancy reduction may therefore be a generic organization principle of neural systems, which allows for easier readout of the identity of a stimulus by using an array of AI neurons than by using an array of IC neurons.