Research news response

Response: Sound analysis in auditory cortex – from temporal decomposition to perception

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We are grateful for Robert Zatorre's insightful endorsement [1] of our view regarding the significance of temporal decomposition of sensory signals in the auditory system [2]. Here, we would like to emphasize some of the points raised in Zatorre's excellent review that appear to be particularly specific for audition, as compared with vision. In the auditory domain, all sensory input is received in series, and it is the time dimension that is crucial for the construction of auditory scenes. Consider that a painting by Van Gogh or the face of a familiar person can be recognized within a few dozens of milliseconds, whereas a melody of Mozart or the voice of a loved one requires several seconds of listening before it can be recognized. A brief snapshot of a complex sound is often nothing but an incoherent burst of noise, whereas a visual snapshot of the same duration can easily produce a coherent percept of useful information.

As outlined by Zatorre, auditory neuroscience has historically taken a back seat to vision. However, recent lines of research have identified analogous visual and auditory functional streams in the processing of 'what' and 'where' information [3,4], and in the recognition of faces [5] and voices [6]. Researchers are also starting to delineate the polymodal interaction between these two systems as they relate to the perception of space and time. To name just two exciting temporal examples, recent work has examined the case in which time is a common dimension between audition and vision, being represented in processing of visual and auditory motion in the monkey and the human brain [7], and also how one sensory input (e.g. acoustic) can influence perceptual quality of another input (e.g. visual) in terms of cross-modal binding [8]. An exciting spatial example lies in unraveling the mechanisms by which auditory and visual space maps converge, so that visually acquired space maps can be recruited and used by the auditory system when visual information is not available (e.g. in darkness), both in animals [9] and humans [10]. However, we would like to emphasize that, although there are certainly analogies between hearing and seeing, which will be reflected in their respective neural substrates, these analogies are not likely to be absolute. In ecological terms, audition and vision subserve different specific operations that have evolved to solve different evolutionary problems. For example, navigational abilities such as traversing terrain, catching prey, guiding self-motion and perceiving looming objects are informed by both vision and audition. A specific advantage of the auditory system is that it can provide spatial information about sound sources that are occluded, out of the line of sight or in conditions such as darkness or fog that make viewing impossible. These abilities are particularly important for survival considering that an organism should be able to detect moving objects rapidly – particularly objects that are approaching. Although extensive research has been conducted on the neural principles underpinning visual looming [11], little is known about looming and the auditory system. Nevertheless, this gap is beginning to be filled by an emerging body of research examining information from auditory cortex unit recordings [12], psychophysical evaluations in animals [13] and humans [14], and functional brain imaging [15].

The ability of the auditory system to process temporal information is at least an order of magnitude greater than that of other sensory systems. At the level of the cochlea, phase-locked neural activity can reach frequency levels of up to several kilohertz; however, such phase locking is not observed at higher stages of the ascending auditory pathway. Thus, the temporal pattern of sound is recoded and represented using other, as yet incompletely understood, principles. In the ascending auditory pathway of the human brain, for instance, recent evidence suggests that one of these principles might be the conversion of temporal regularities into local neural activity levels [16]; however, the signal reconstruction principles remain to be delineated as they have been in animal thalamocortical circuits [17] and synaptic cortical networks [18]. On a higher level of processing, one of the key aspects of how the brain constructs coherent concepts of sequentially received sensory information lies in the understanding of auditory memory mechanisms, and it remains to be seen what role sensory memory traces play in assembling temporal information into an auditory experience. Functional magnetic-resonance imaging (fMRI) provides not only excellent spatial resolution, but also good temporal resolution. In

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combination with the new possibilities offered by non-inferential analysis techniques [19], fMRI appears to be an ideal method for exploring further the mechanisms that the brain uses to decipher the sequential code of auditory information. We suggest, in line with Zatorre, that transient and sustained neural response types appear to be fundamental principles for this operation; however, their functional significance awaits further study.

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Research Focus

Neurotrophins in myelination: a new role for a puzzling receptor

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Binding of neurotrophins to $p75^{NTR}$ was recently identified as a positive signal for myelination by Schwann cells. This new finding adds yet another distinct biological role to the growing list of functions of $p75^{NTR}$ in the nervous system and identifies a novel target for promoting remyelination in peripheral neuropathies or post-nerve-injury.

Myelin formation by oligodendrocytes in the CNS, and by Schwann cells in the PNS, is closely regulated by reciprocal signaling between the myelin-forming glial cells and their target axons [1]. The identity of these signals is largely unknown but membrane-bound, in addition to diffusible, factors are thought to be involved. Given this complexity, several immunological, metabolic or genetic disturbances can cause abnormal myelin formation or demyelination, resulting in reduction of the conduction velocities of action potentials. Demyelinating diseases comprise a significant fraction of neurological disorders, with the most common being multiple sclerosis in the CNS and peripheral neuropathies in the PNS. Compared with their central counterparts, peripheral nerves have a remarkable capacity to regenerate following injury. Therefore, the identification of factors that promote peripheral nerve remyelination could have direct therapeutic potential.

Neurotrophins and peripheral nerve myelination

Neurotrophins are a family of proteins that play a variety of vital functions in the development and maintenance of the vertebrate CNS and PNS. Two distinct classes of receptors mediate the effects of neurotrophins: the tropomyosin-related kinase (trk)

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