Auditory sensory processing

Auditory sensory processing refers to the way the auditory system receives, interprets, and organizes sound information. This complex process involves various structures in the ear and the central nervous system, ultimately leading to the perception of sounds and the ability to make sense of auditory stimuli.

Key components

Sound Detection: The process begins with the detection of sound waves by the ears. The outer ear collects sound and directs it to the ear canal, where it reaches the eardrum. The vibrations of the eardrum are transmitted to the middle ear, where the three small bones (ossicles) amplify the sound.

Transduction: In the inner ear, hair cells within the cochlea convert the mechanical vibrations of sound into electrical signals. These signals are then transmitted to the auditory nerve.

Auditory Nerve Transmission: The auditory nerve carries the electrical signals from the inner ear to the brainstem. This nerve transmission is crucial for relaying auditory information to the central nervous system.

Auditory Processing in the Brain: The auditory signals are then processed in various regions of the brain, including the auditory cortex. The brain interprets the frequency, intensity, and timing of the sound, allowing us to perceive qualities such as pitch, volume, and rhythm.

Sound Localization: The auditory system helps in determining the direction and location of sounds in space. This is achieved through the comparison of the arrival times and intensity of sounds at each ear.

Auditory Discrimination: Auditory processing involves the ability to distinguish between different sounds, including speech sounds. This discrimination is essential for understanding spoken language and recognizing environmental sounds.

Challenges in auditory sensory processing can result in difficulties in various aspects, including:

Auditory Hypersensitivity: Increased sensitivity to sounds, leading to discomfort or distress in response to typical environmental sounds.

Auditory Hyposensitivity: Decreased sensitivity to sounds, resulting in difficulty detecting or processing certain auditory stimuli.

Auditory Processing Disorders (APD): These are conditions where there are difficulties in processing auditory information, particularly in challenging listening situations. Individuals with APD may struggle with tasks such as following directions, understanding speech in noise, and recognizing subtle differences in sounds.

Occupational therapists, audiologists, and other professionals may work with individuals experiencing challenges in auditory sensory processing to develop strategies and interventions that improve their ability to process and respond to auditory stimuli effectively.

Auditory sensory processing is assumed to occur in a hierarchical structure including the primary auditory cortex (A1), superior temporal gyrus, and frontal areas. These areas are postulated to generate predictions for incoming stimuli, creating an internal model of the surrounding environment. Previous studies on mismatch negativity have indicated the involvement of the superior temporal gyrus in this processing, whereas reports have been mixed regarding the contribution of the frontal cortex. Fujitani et al. designed a novel auditory paradigm, the "cascade roving" paradigm, which incorporated complex structures (cascade sequences) into a roving paradigm. They analyzed electrocorticography data from six patients with refractory epilepsy who passively listened to this novel auditory paradigm and detected responses to deviants mainly in the superior temporal gyrus and inferior frontal gyrus. Notably, the inferior frontal gyrus exhibited broader distribution and sustained duration of deviant-elicited responses, seemingly differing in spatiotemporal characteristics from the prediction error responses observed in the superior temporal gyrus, compared with conventional oddball paradigms performed on the same participants. Moreover, they observed that the deviant responses were enhanced through stimulus repetition in the high-gamma range mainly in the superior temporal gyrus. These features of the novel paradigm may aid in our understanding of auditory predictive coding [1).].

1)

Fujitani S, Kunii N, Nagata K, Takasago M, Shimada S, Tada M, Kirihara K, Komatsu M, Uka T, Kasai K, Saito N. Auditory prediction and prediction error responses evoked through a novel cascade roving paradigm: a human ECoG study. Cereb Cortex. 2024 Jan 5:bhad508. doi: 10.1093/cercor/bhad508. Epub ahead of print. PMID: 38183184.