

Neuroplasticity is the brain ability to reorganize functionally or structurally throughout life. It is now well established that this relationship can change as an effect of experience and learning. Studies on sensory loss have provided unique insight into our understanding of how it may occur and how the environmental experience shapes the structure and function of the brain. In blind individuals, the occipital regions usually involved in visual processing are activated by sound and touch (Amedi et al., 2005; Merabet et al., 2008). Following deafness, the auditory cortex engages in a wide range of tasks in visual and tactile modality (Cardin et al., 2020; Heimler et al., 2015). This type of reorganisation is known as cross-modal plasticity, where parts of the brain that typically process information from a given modality adapt to process sensory information from other senses.

However, the mechanisms that govern cross-modal reorganization are not well understood. In the general population, sensory cortices show clear and consistent functional organization, with primary sensory cortices processing low-level perceptual input, and secondary cortices gradually processing more high-level sensory information. A central question in the studies on cross modal plasticity is to what extent the organization of sensory cortex persists even if the modality input switches.

In the case of deafness, some studies show that auditory cortices preserve their specific functions but change the processing modality (Benetti et al., 2017; Bola et al., 2017). The auditory cortex in deaf individuals may thus be involved in the processing of low-level visual or tactile stimuli and receive bottom-up input from other sensory structures. Other studies suggest that the organizational principle of the sensory cortices may change due to altered sensory experience. Auditory cortex in the deaf may acquire new higher-level functions and may become part of high-level networks receiving inputs from top-down projections (see Cardin et al., 2020 for the review).

The focus of this dissertation is to identify the place of the reorganized auditory cortex in the hierarchy of processes: from low level perceptual functions to high level, cognitive tasks. To what extent its place is preserved, and the auditory cortex processes similar functions while responding to different modalities? To what extent they acquire new higher-level functions? Is it possible to recognize different parts of the deaf's auditory cortex processing visual stimulus on different levels of hierarchy?

We tackled these questions using two complementary approaches to functional magnetic resonance studies.

The first experiment is based on previous research which demonstrated that the function of particular part of the auditory cortex may be preserved in deafness while the processing modality switches (Bola, Zimmermann et al., 2017). The new task-based fMRI experiment (Zimmermann, et al., 2021) was meant to define the extent of this effect. By comparing different stimulus types, modalities (tactile, visual) and types of functions we were able to identify parts of cross modal effect associated to lower-level perceptual factors and higher-level working memory processes.

The naturalistic fMRI experiment (under review) was designed to recognize the role of the auditory cortex in the deaf in the processing visual, naturalistic stimulus (silent movie). Using a rich naturalistic stimulus, we were able to capture the nature of auditory cortex repurposing across a range of different time scales and levels of perceptual and cognitive processes.

Two approaches shown here are complementary to each other and may together provide an insight into what the function of the recognized cortices is, and what place the repurposed cortex occupy in the hierarchy of cognitive processes.