Biology and Pathology

Central Nervous System

Neuroplasticity
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Learning Objectives:

- Convince the audience how in vivo imaging tools could increase our understanding of neuroplasticity.
- Teach the audience which imaging tools visualize which phenomena/aspects of neuroplasticity.

The brain's ability to act and react in ever-changing ways is known as neuroplasticity. This special characteristic allows the brain to constantly modify the pathways for neural communication throughout life, thereby aiding the processes of learning, memory, adaptation through experience and adjusting to a new environment. While plasticity enables the brain to recover from injuries (such as stroke or brain trauma) or overcome cognitive disabilities it can also disable the normal functioning of the brain as it can lead to abnormal wiring of certain brain circuits leading to disorders such as epilepsy, schizophrenia and autism spectrum disorders.

The term neuroplasticity clearly captures a wide diversity of phenomena at the neuronal level ranging from activity dependent changes in synaptic physiology (e.g., Long Term Potentiation and Long Term Depression) to morphological changes which include pine formation, dendrite branching, axonal outgrowth and even generation of new neurons, finally resulting in neuronal circuitry modulations. Recent evidence indicates that genetic but also epigenetic mechanisms may serve as a contributing mechanism in memory formation and storage as well as neuronal plasticity. Understanding these mechanisms may be relevant for healthy brain plasticity but also more generally in the control of a variety of clinical conditions such as Alzheimer's disease, depression, anxiety, schizophrenia, just to mention a few.

Some of the most dramatic examples of plasticity in brain structure and function have been identified in the neural structures that control vocal production in songbirds. The brain of songbirds (oscines) displays an unusual plasticity both during ontogeny and, for most species, across seasons. This plasticity directly relates to the acquisition and expression of songs and thus provides a novel and useful model for understanding the neural plasticity and relationships between perception, cognition, behavior, and the underlying cellular and molecular processes in the nervous system. For all these reasons song birds have become THE best model for studying neuroplasticity. In this lecture we will demonstrate how different aspects and diverse phenomena of neuroplasticity such as dendrite branching, axonal outgrowth, generation of new neurons and the resulting modified neuronal circuitry can be assessed or monitored in time using different in vivo imaging techniques. The capabilities of these imaging tools (mainly MRI and BLI) will be demonstrated in songbird studies as an unusually auspicious model of neuroplasticity and cognition/ learning/memory but also in mice and rat models for different neuropathologies. The MRI focus will be on manganese enhanced (ME) MRI, Diffusion sensitive MRI (DTI and DKI), Resting state functional (rsf)MRI and functional (f)MRI but also on BLI using LV transfection of neurogenic niches in the adult brain. This should convince the audience how in vivo imaging tools could

increase our understanding of neuroplasticity in the first place but also how it could contribute in monitoring the loss but also the recovery of connections because of trauma or disease.