Editorial: Frontiers in Synaptic Plasticity: Dendritic Spines, Circuitries and Behavior

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The Editorial on the Research Topic

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More than a century ago, in 1906, the Nobel Prize in Physiology or Medicine was awarded to Camillo Golgi and Santiago Ramón y Cajal “in recognition of their work on the structure of the nervous system.” Using the Golgi technique, Cajal discovered and described dendritic spines, which, since then, have received considerable attention. Dendritic spines are the major targets of excitatory synapses within the brain. Their disparate morphologies appear to reflect cellular processes involved in neuronal and synaptic plasticity. Dendritic spines reach high levels of complexity in humans (1). Neuronal and synaptic plasticity are manifested by changes in structure (e.g., dendritic spine shape, size, density, and connectivity) and activity (e.g., long-term potentiation) leading to dynamic changes in circuitries for neuronal processing. Furthermore, some of these changes in the brain can translate into altered behavior and even can contribute to psychiatric disorders. Animal models have been key to the study of affective and social behaviors, as well as neurological and psychiatric disorders. They provide insight into mechanisms underlying basic to complex neural functions and disturbances in behavior. However, there is a paucity of compilations correlating alterations in synaptic structure with various physiological and behavioral paradigms. This Research Topic is a forum for the exchange of data and novel hypotheses about synaptic and brain plasticity. It comprises 10 articles with 3 original research articles, 3 reviews, 2 hypothesis and theory papers, 1 opinion, and 1 general commentary elaborated by 39 authors from various countries. These contributions present state-of-the-art approaches to the study of dendritic spines, circuitries, and behavior from animal models, including rodents and primates, to humans. The research strategies used range from classic techniques to cutting-edge technologies, including imaging techniques, electrophysiology, and experimental-based hypothetical approaches.

Tønnesen and Nägerl provide up-to-date STED microscopy data on structure and function relationships of dendritic spines. These data include the spine head volume and local postsynaptic density associated with the neck diameter and its variable resistance. In conjunction, they modulate the spine electrical compartmentalization or the influence on dendritic voltage and synaptic plasticity. These data are crucial in evaluating the impact of spine geometry on neuronal function and dynamic synaptic processing and enduring changes in neural circuits.

Hansberg-Pastor et al. describe the broad and complex actions of estradiol and progesterone on the regulation of protein components of the cytoskeleton of neurons and astrocytes that ultimately affect cellular morphology, function, and connections, including dendritic spine growth. These properties correlate with region-specific features in the brain of females. This modulation begins early in
development and persists along the life span, notably during the
estrous cycle, suggesting a continuous plastic transformation of
dendritic spines, synapses, and neural networks.

Bittencourt et al. demonstrate that synapses and circuitries can
undergo post-lesion reorganization, as is the case for mossy fiber
sprouting and its debatable relationship with epileptogenesis.
Here, ultrastructural data reveal the number and type of asym-
matic contacts involving spine and shaft synapses and the likely
restorative connectivity of the dentate gyrus molecular layer of
rats with induced chronic seizures.

Vargas-Barroso et al. report cytological, whole-cell patch-
clamp electrophysiological and connectional data indicating an
anatomical and functional interaction between the accessory and
the main olfactory bulb in rats. These findings are relevant for
the animal’s perception of complex chemosensory clues from the
environment and the neural circuits implicated in the display of
various social behaviors.

Calcagnotto addresses the role of interneurons in synaptic
plasticity and the ways in which cellular replacement approaches
can rescue defects in local circuit activity and synaptic plasticity.
Strategies that alter interneuronal networks, including those that
control inhibitory interneurons and the use of precursor cell
grafts, may have the potential to restore synaptic plasticity and
brain oscillations.

Zimmermann-Peruzatto et al. provide a comprehensive
review of the relationship between vasopressin receptors and
specific brain circuits. Alterations in vasopressinergic pathways
may lead to changes in synaptic plasticity and parental and sexual
behaviors.

de Sousa et al. link important data about the secretion and
modulatory actions of hormones to developmental ages in young
primates. They show that sex differences, cortisol levels, acute or
chronic social isolation, and coping strategies are important for
the development of neural circuitries and learning in male and
female monkeys, an approach that can serve as a model for the
study of emotional and behavioral disorders.

Gottfried et al. propose that neuroimmune responses are
central to translating the effect of environmental risk factors and
genetic and epigenetic changes to deficits in brain function and
behavior in autism spectrum disorder (ASD). They present an
immunological sequence of events leading to neuroinflamma-
tion, neuronal-gial responses, and brain connectivity dysfunction
that may be involved in ASD pathogenesis.

Siniscalco highlights the impact of aberrations in neuroimmune
responses in ASD, as proposed by Gottfried et al., citing the role of
pro-inflammatory cytokines in disruption of the immunological
interface between the peripheral immune system and central
nervous system, leading to deleterious neuronal and behavioral
consequences.

Pandey’s group (Kyzar et al.) provides evidence for the effects
of disturbances in epigenetic programming during adolescence
due to repeated exposure to binge levels of alcohol. Alcohol expo-
sure during adolescence leads to alterations in epigenetic, neu-
rotropic, and neuroimmune pathways in the brain, manifested
by widespread and persistent changes in synaptic remodeling
and neurogenesis in strategic brain areas. Rodent and human
data link alcohol exposure, impaired dendritic spines, and neural
circuitry to long-lasting behavioral consequences in the adult.

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