Chapter 67
Neuroimaging Approaches for Elderly Studies

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ABSTRACT

Advances in the field of neuroimaging have allowed for the examination of the effects of age-related changes on cognitive capacity in elderly populations. Structural techniques are now routinely used to report cortical atrophic rates in aging and particularly within the context of the Alzheimer's disease, and may be integrated with functional techniques which examine the functional characteristics of the cortex at rest and during the performance of a task. Despite advancing age cognitive function remains highly plastic, allowing for interventions that aim to maintain or even remediate its capacity and the mechanisms by which structure and function are altered among seniors. Overall, information on the integrity of the cerebral structure and function aid in the early detection and treatment of the Alzheimer's disease as well as the evaluation and track of the disease's progression. In this chapter, neuroimaging methods are presented along with findings that are particularly relevant for the study of neuroplasticity in the aging brain.

INTRODUCTION

Growing older concerns a life-long interplay among cognitive, demographic, genetic, neuronal (structural and functional), and lifestyle factors which may in turn impose crucial changes to basic daily living activities of the elderly individuals (Cahn-Weiner and Malloy, 2000). Among the most important issues for lifelong health and development is the successful cognitive (healthy) aging which is characterized by effective reorganization of the brain function and structure (e.g. functional compensation). The cognitive reorganization that is related to aging constitutes the focus of multi-disciplinary and multi-modal

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approaches (epidemiology, cognitive psychology and neuroimaging) aiming to study the functional and structural underpinnings of cognitive abilities (e.g. memory, attention, emotion, language, action) that enable daily functions. The effects of aging in cognitive abilities is not straightforward: Some cognitive abilities begin to decline very early in life, some deteriorate with healthy aging but may exhibit different lifespan trajectories, and some remain stable or even improve with late-life (e.g. emotion). Thus, a primary step in elucidating the determinants of stable and impaired cognition requires knowledge on the interplay between associated neuronal structure and function not only among healthy elderly populations but also for those who are at risk for dementia and Alzheimer's disease (AD). AD is a neurodegenerative disease of four progressive stages (i.e. Mild Cognitive Impairment (MCI), Mild, Moderate and Severe AD). The diagnosis for AD is a difficult task since symptoms are often regarded as manifestations of healthy aging. AD is clinically diagnosed via screening tests, such as Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975), blood tests, spinal fluid, neurological examination. Definite diagnosis can only be accomplished with post-mortem detection of specific pathological lesions. A recent proposal to add distinctive and reliable neuroimaging biomarkers to the diagnostic criteria of AD (Dubois et al., 2007) has already demonstrated a powerful potential on finding methods so as to keep cognitive functions active and sharp or enhance their performance across the adult lifespan. A promising approach is to engage seniors into computerized interventions of appropriate to their capacity training schemes (Bamidis et al., 2014; Busse, Gil, Santarém, & Filho, 2009; Colcombe & Kramer, 2003; Tardif & Simard, 2011) which allow for the longitudinal evaluation and monitor of their cognitive status. Consequently, the enhanced understanding on neuroplasticity and the employment of neuroimaging biomarkers offer promising solutions in the existing clinical measures for the early detection or even prevention of the AD as well as the monitoring of the disease's progression.

The aim of this chapter is to present recent neuroimaging findings that unravel the functional and structural reorganization of the aging brain with an emphasis in the context of the AD. In this chapter, we review the efficacy of various types of image-based and brain signal techniques in the accurate and early diagnosis of the AD and their widespread impact on specific treatment strategies aiming to at slow down or even prevent neurodegeneration in the aging brain. Initially, the basic neuroimaging modalities, along with their strengths and limitations are briefly described, so that the reader develops the necessary background to understand the scientific meaning of the research results based on these techniques. Subsequently, the role of neuroimaging in the understanding of neuroplastic changes that relate to healthy or pathological aging is discussed. Then, the basic neuroimaging findings related to structural and functional imaging of aging and AD are presented along with a brief description of their current role in the clinical diagnosis of AD. Finally, the research results of the various types of neuroimaging modalities are integrated in a unified conclusion.

BACKGROUND ON NEUROIMAGING MODALITIES

Recent technological advances that allow the in-vivo study of brain structures and functions in human subjects have greatly contributed to a better understanding of the brain changes that occur due to aging and are likely to impact the cognitive function and neuronal activity. The non-invasive nature of most of these techniques (i.e. Electroencephalography – EEG; Magnetoencephalography – MEG; Magnetic Resonance Imaging – MRI; functional MRI – fMRI; Diffusion Tensor Imaging – DTI) constitutes them an invaluable tool in the study of the living brain in healthy as well as pathologic subjects. These methods