A model of aging effects on the visual system

Mots clés :

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Résumé du projet de recherche (Langue 1)

Demographic changes require that science focuses on the effects of natural aging on the human body and functions, to identify which factors can influence future health problems. All sensory modalities undergo age-related functional changes. In particular, visual perception, which mediates most of our interactions with the world, declines with age. A major cause for this are changes to the lens and an increased likelihood to develop optical or retinal pathologies. Additionally, the sensitivity of perceiving certain stimuli changes in disease-free aging, which can not be explained with optical factors. Effects range from increased threshold for very low and very high spatial frequencies to reduced motion sensitivity. The visual system is computationally complex and it is subject to intense study. However, the precise mechanisms underlying how visual information is transformed and interpreted neurally remain partially understood. More strikingly, while we know that there are age-related neuronal changes in the visual system (e.g., changes in calcium dynamics, in connectivity and plasticity, and in the cortical representation of receptive fields), there has not been an investigation on how these changes correspond to cellular and molecular changes in the aging retina and brain. From a theoretical viewpoint, models exist about how aging can detriment cognition (e.g., the noise hypothesis, inhibition hypothesis and speed and number of nerve fibres). However, there is no study of how age-dependent changes correspond to parameters in state-of-the-art neural models of the visual system. This doctoral project aims at bridging this gap. The objective is to create a neuromimetic model of visual processing that predicts contrast sensitivity for arbitrary visual stimuli. The final model will incorporate a minimal set of assumptions to replicate perceptual performance in terms of contrast sensitivity of human subjects and specifically the differences between young and old subjects. The model will transform visual input into retinal ganglion cell responses. Ganglion cell outputs will then be combined and processed in the visual cortex, and ultimately decoded to assess at which contrast the stimulus is perceivable.

Résumé du projet de recherche (Langue 2)

The mechanisms involved in perception of even very simple stimuli are already complex and each mechanism is specific to only a certain spatio-temporal range of stimuli. Therefore, the level of detail of the model should iteratively increase to correctly predict larger ranges of stimuli. This development has to be guided by biological plausibility and the psychophysical effects that are observed. For instance, the model will be grounded on known response characteristics at a certain stage (such as the retina), and on the invariances created after a certain processing step (such as the primary visual cortex, where the shape of orientation tuning curves are invariant to contrast at their steady state. The main scientific challenges of the model are two-fold: on the one hand, accounting for data from both psychophysical and neurobiological experiments across young and old subjects can provide insights into visual processing as well as the effects of aging on brain mechanisms in general. On the other hand, the model will inform about previously neglected stimulus spaces and will potentially lead to new directions for psychophysical experiments (to be performed in the host lab).