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Pupillary responses as non-invasive biomarkers of cognitive decline in aging

Early detection of cognitive decline is a key issue for improving preventive strategies and maintaining autonomy in an ageing population. Locus Coeruleus plays a central role in supporting cognitive functions, and its dysfunction has been linked to age-related cognitive decline. Task-evoked pupillary responses provide a non-invasive index of this system's integrity, as they reflect mental effort and cognitive resource allocation. Pupil dilation typically increases with cognitive demand but decreases when resources are depleted or engagement diminishes, reflecting cognitive disengagement. To examine whether pupillary dynamics may serve as an early marker of cognitive decline, healthy younger and older adults completed an auditory working memory task under low, moderate, and high cognitive load while pupil size was continuously recorded. The data showed accuracy declined similarly across both groups as cognitive load increased. However, a clear divergence emerged under higher demands: younger adults showed flexible, load-dependent pupillary modulation, whereas older adults exhibited significantly reduced pupillary reactivity under moderate and high loads. This reduced dilation was associated with age and Stroop interference scores, indicating a link with executive inhibitory control. Overall, these findings suggest that attenuated pupillary responses in cognitively healthy older adults may reflect early functional alterations in the locus coeruleus–noradrenergic system before overt behavioural deficits emerge. Pupillary reactivity may therefore represent a sensitive, non-invasive biomarker of cognitive integrity.

Keywords: Aging, cognitive load, working memory, pupillometry, prevention

Biography

After a career in geriatric services focused on the screening of cognitive disorders and in clinical research, I turned towards prevention in 2018 with the creation of the Centre de Prévention Santé Longévité at the Institut Pasteur de Lille. My passion for research led me to pursue a PhD in psychology. My work focuses on potential non-invasive biomarkers of cognitive aging and cognitive decline, particularly pupillary responses. I am especially interested in the mechanisms underlying cognitive aging, with a focus on attention, executive functioning, and in the locus coeruleus–noradrenergic system as a key pathway involved in age-related cognitive changes.