



Assessment of visual processing in Alzheimer's Disease and Lewy Body Dementia using Fast Periodic Visual Stimulation.

Introduction

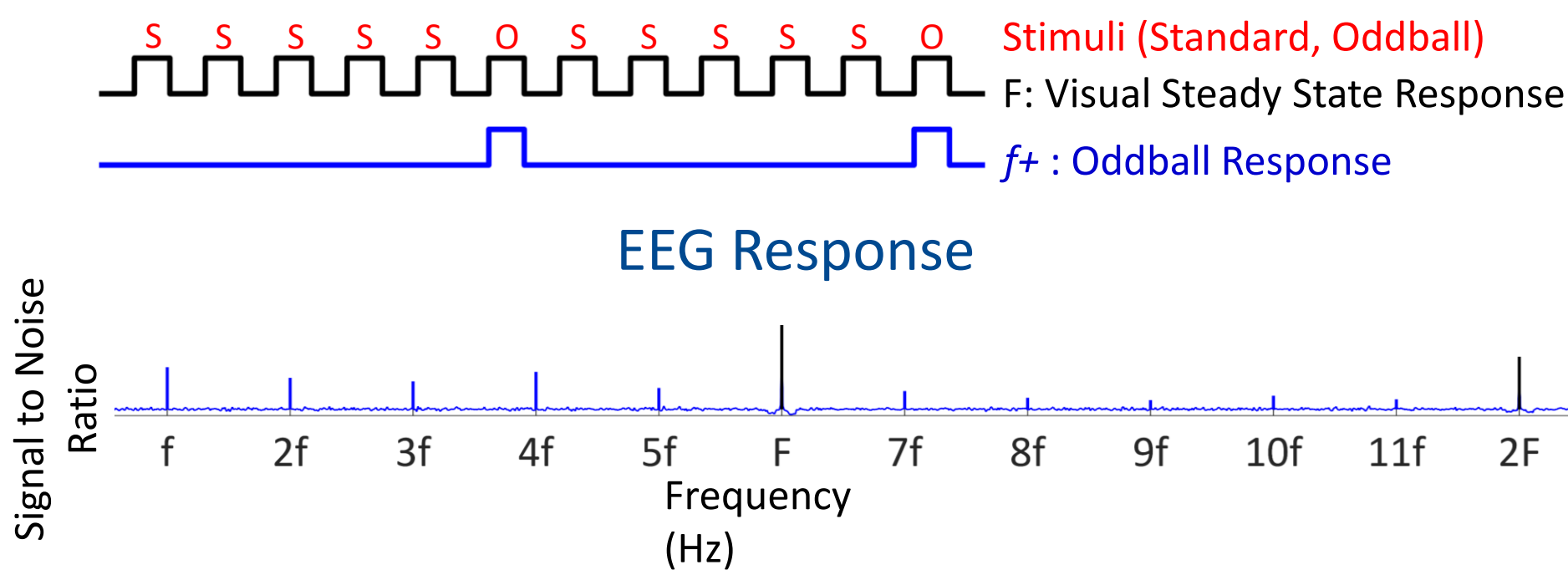
Neuropathological changes occur for up to 20 years before dementia diagnosis (1). For earlier diagnosis, biomarkers that differentiate between specific causes of dementia and healthy ageing must be developed. Critically, patients in the early stages of different dementia aetiologies present with specific patterns of cognitive impairment. Both Lewy body dementia (LBD) and Alzheimer's Disease (AD) affect visual processing, with more severe impairments seen in the former (2,3).

Fast periodic visual stimulation (FPVS) is an EEG technique, that involves sequentially presenting frequency-tagged standard and oddball stimuli. Oddballs systematically differ from standard stimuli, e.g., blue squares rather than black squares. If participants can differentiate between the two stimulus types, a steady-state neural response is elicited at the oddball presentation frequency and its harmonics.

This technique has been adapted to measure a range of cognitive functions in healthy populations (4,5) and recognition memory in AD (6) in under three minutes. However, it has not been used to assess visual processing in dementia.

Hence, this study aims to establish whether a novel battery of FPVS visual processing tasks can identify cognitive change and stratify healthy older adults, AD and LBD patients.

Stimulus Presentation



1 - Frisoni, G. B., Fox, N. C., Jack Jr, C. R., Scheltens, P., & Thompson, P. M. (2010). The clinical use of structural MRI in Alzheimer disease. *Nature Reviews Neurology*, 6(3), 67-77.
2 - Ota, K., Murayama, N., Kasanuki, K., Kondo, D., Fujishiro, H., Arai, H., Sato, K., & Iseki, E. (2015). Visuo-perceptual Assessments for Differentiating Dementia with Lewy Bodies and Alzheimer's Disease: Biopsy Corroborated and Other Neuropsychological Examinations. *Archives of Clinical Neuropsychology*, 30(3).
3 - Phillips, J. S., Da Re, F., Irwin, D. J., McMillan, C. T., Vashnavi, S. N., Xie, S. X., Lee, E. B., Cook, P. A., Gee, J. C., Shaw, L. M., Trojanowski, J. Q., Wolk, D. A., & Grossman, M. (2019). Longitudinal progression of grey matter atrophy in non-amnesic Alzheimer's disease. *Brain*, 142(6).
4 - de Heering, A., & Rossion, B. (2015). Rapid categorization of natural face images in the infant right hemisphere. *ELife*, 4.
5 - Lochy, A., Van Belle, G., & Rossion, B. (2015). A robust index of lexical representation in the left occipito-temporal cortex as evidenced by EEG responses to fast periodic visual stimulation. *Neuropsychologia*, 66, 28-33.
6 - Stothart, G., Smith, L. J., Milton, A., & Coulthard, E. (2021). A passive and objective measure of recognition memory in Alzheimer's disease using Fastball memory assessment. *Brain*, 144(9), 2812-2825.

Methods

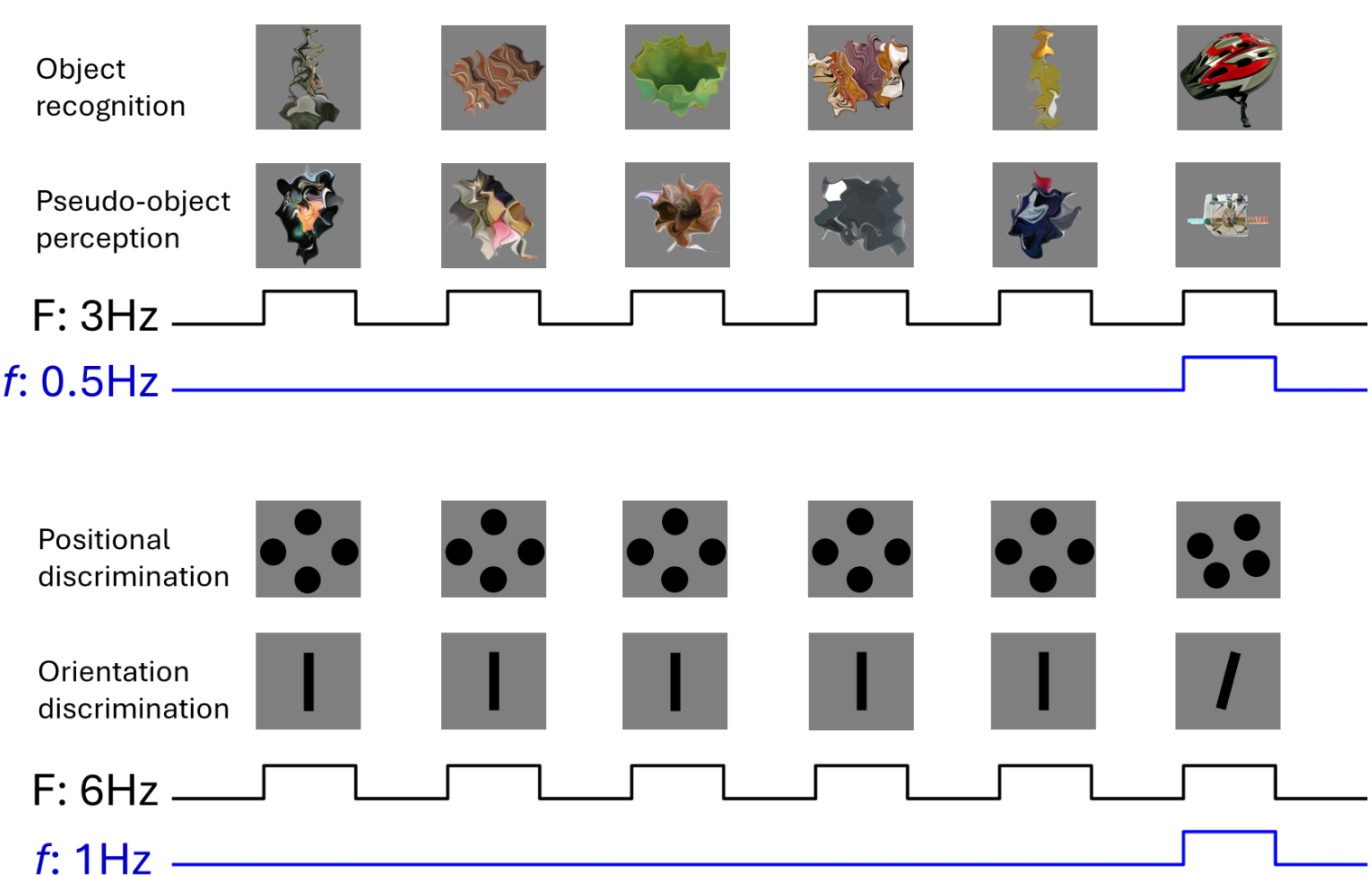
Participants

18 AD patients (mean age 75 +- 7, 10 females), 10 LBD patients (mean age 73 +- 6, 1 female), 40 healthy older adults (HOA (mean age 70 +- 6). Data collection is ongoing with a target sample size of 20 per patient group.

EEG home testing

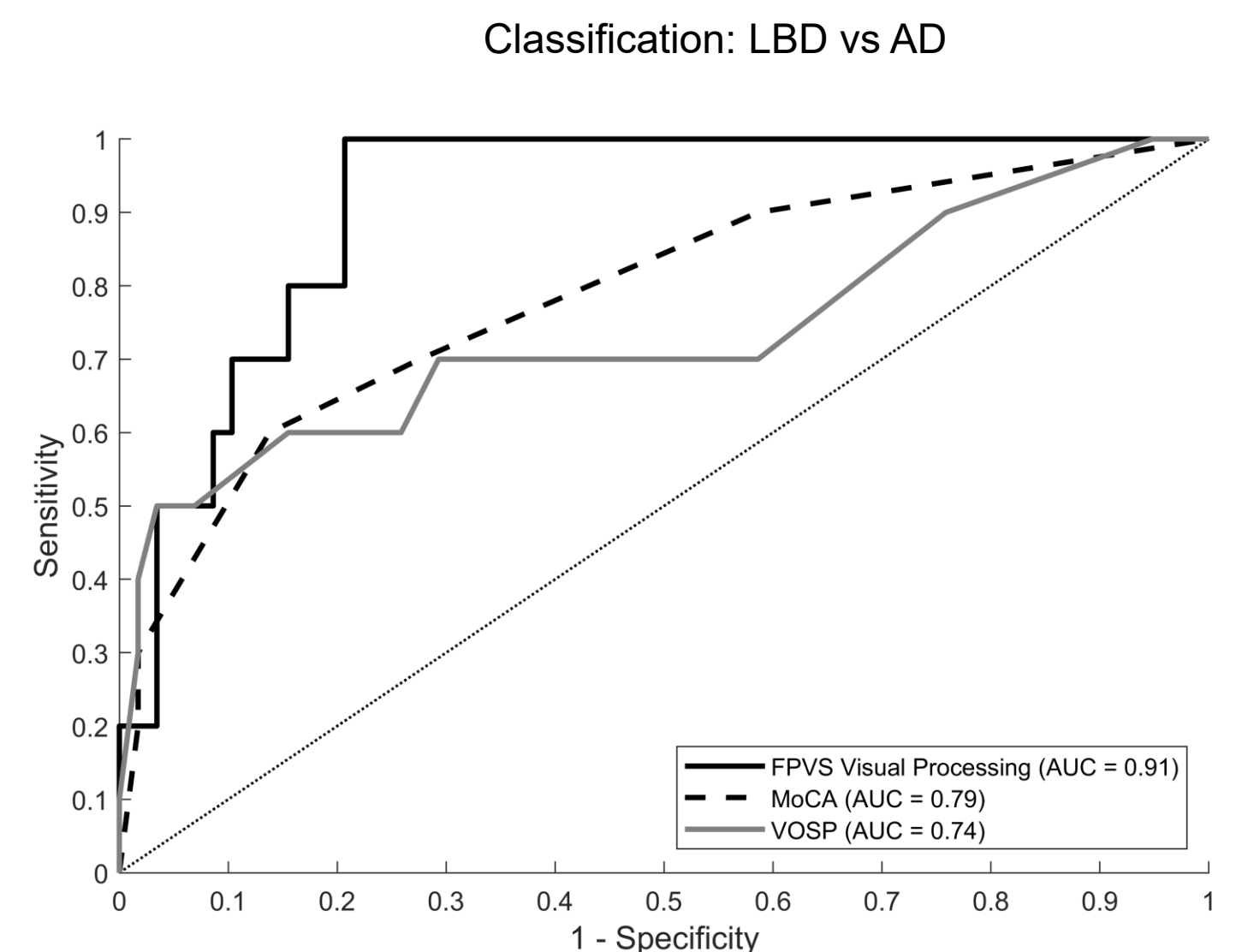
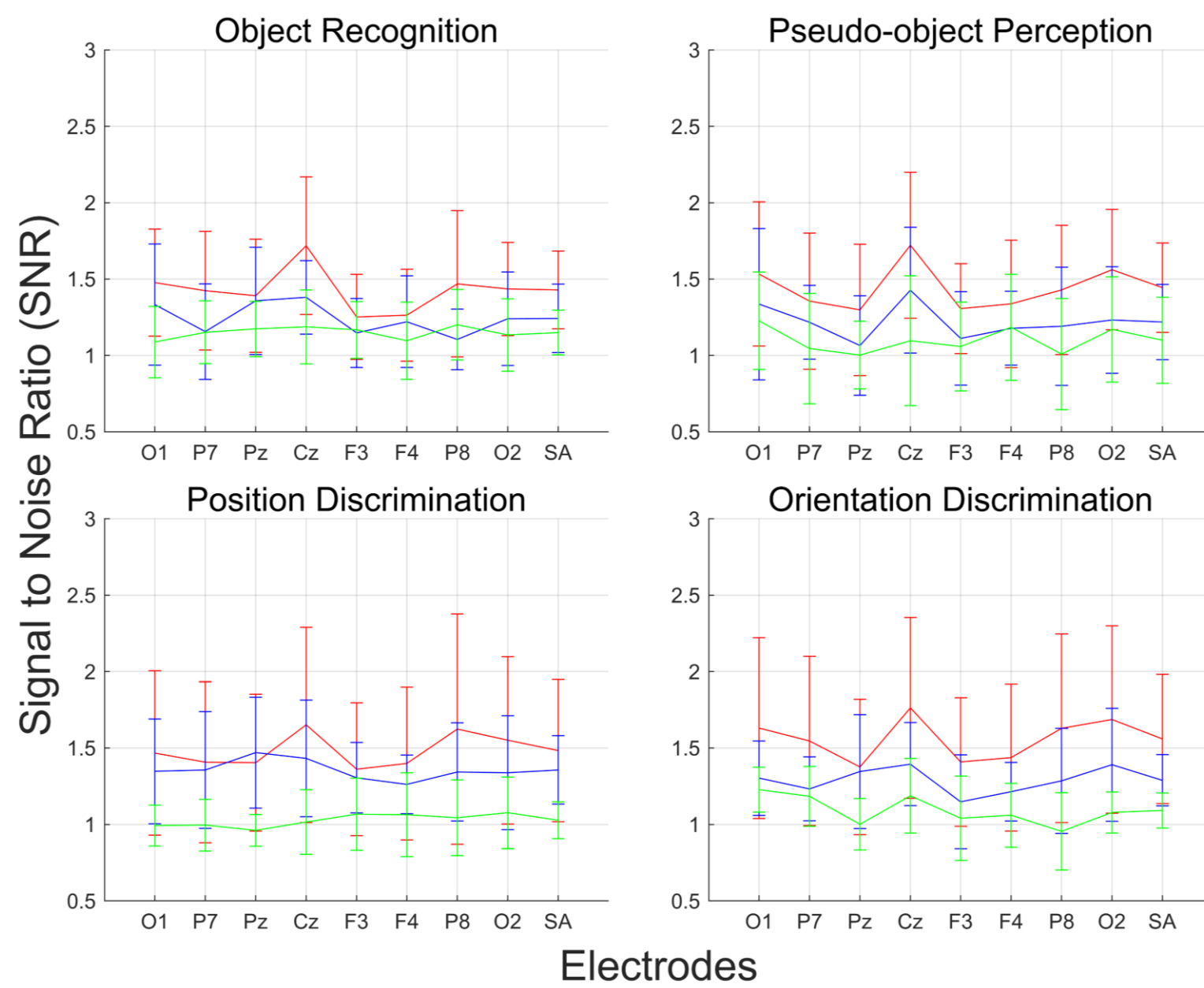
All participants completed FPVS tasks that implicitly and passively measured different forms of visuoperception: object recognition, pseudo-object perception, positional discrimination, and orientation discrimination, and a previously validated recognition memory task (6). They viewed a stimulus presentation sequence that lasted no longer than three minutes, per condition. Visuoperception was assessed behaviourally using the Freiburg Visual Acuity and Contrast Test, and the Visual Object and Space Perception Battery (VOSP). Global cognitive function was assessed using the Montreal Cognitive Assessment (MoCA).

8-channel (O1, P7, Pz, Cz, F3, F4, P8, O2) EEG recordings were sampled at 512Hz, using a Neuroelectronics ENOBIO portable EEG system. Per condition, entire stimulation epochs were fast Fourier transformed. Oddball responses were the mean signal-to-noise ratio (SNR) at the oddball presentation frequency and significant harmonics.



Results

Task	HOA	AD	LBD
DecVA	0.9 (0.2)	0.7 (0.2)	0.7 (0.2)
LogCS	1.6 (0.2)	1.4 (0.3)	1.3 (0.3)
MoCA Overall	27 (2)	21 (3)	21 (6)
MoCA Memory	3.6 (1.4)	0.7 (1.4)	1.5 (1.4)
MoCA Visuospatial	4.3 (0.9)	3.5 (1.2)	2.3 (1.7)
VOSP Position Discrimination	19.3 (2)	17.6 (4.4)	18.2 (2.3)
VOSP Number Location	9.5 (1)	7.3 (3.5)	6.3 (4.3)
VOSP Object Decision	17.1 (1.8)	15 (2.7)	14 (2.8)
Behavioural Line Orientation	93 (2.8)	90 (3.8)	81 (21)



Left: Neuropsychological assessment performance for each group. Values shown are mean (SD).

Middle: Electrode-wise and scalp-average (SA) oddball responses in each of the four FPVS visual processing tasks. Across tasks, implicit visuoperception was reduced in patients compared to HOAs, with more pronounced impairment observed in LBD than in AD. Per task, scalp-average oddball responses were as follows: Object Recognition: HOA > AD > LBD ($\eta^2 = .225$, $p < 0.001$); Pseudo-object Perception: HOA > AD > LBD ($\eta^2 = .215$, $p < 0.001$); Positional Discrimination: HOA > AD > LBD ($\eta^2 = .154$, $p = 0.004$); Orientation Discrimination: HOA > AD > LBD ($\eta^2 = .233$, $p < 0.001$).

Right: Classification of LBD patients from AD patients using FPVS visual processing responses compared to MoCA and VOSP scores.

Summary

FPVS measures different levels of visual processing in cognitive healthy older adults and is sensitive to impairment in AD and LBD. Furthermore, the technique can classify LBD patients from AD patients, thus potentially guiding differential diagnosis. The passive nature of FPVS is ideally suited to cognitive assessment in dementia.