# A Computational Platform for Visuospatial Assessment

Woo Zong Han[1], Zikun Wang[1], Alicja Mahr[1], Derek Roberts[1], Kiran Jagaroo[2], Daniel Oh[1], and Vinoth Jagaroo[3,4]

[1]*Boston University Center for Computing & Data Sciences, 665 Commonwealth Ave, Boston, MA 02215*
[2]*University of Massachusetts-Boston, Department of Engineering, 100 Morrissey Blvd, Boston, MA 02125*
[3]*Boston University Chobanian & Avedisian School of Medicine, Behavioral Neuroscience Program, 80 East Concord Street, Boston, MA 02118;* [4]*Emerson College, 120 Boylston Street, Boston MA 02116*

Presenting: *W.Z. Han* <*wzhan@bu.edu*> Z. Wang <zikunw@bu.edu> A. Mahr <alicja@bu.edu> V. Jagaroo <jagaroo@bu.edu>

Approaches to visuospatial assessment in neuropsychology remain largely analogue, paper-and-pencil type tests that are far outmoded in the digital era. They are also incongruent with the complexities of cognition and underlying neural systems, and are especially ill-suited to assessing complex disorders of high-level vision such spatial neglect and visual agnosia. There is pressing need for computational methods in neuropsychological assessment. We describe the design and development of a proof-of-concept grid-based, scalable, informatics-driven platform for the dynamic assessment of disorders of spatial processing. Inspired by a problem in behavioral neuroscience, the project involves computer science, computer engineering, and data science.

**Introduction:** There is stark mismatch between legacy neuropsychological assessment instruments and the complexity of neural systems underlying cognition. Neuropsychological instruments need urgent re-invention. With regard to the visuospatial functional domain, the development of a computational, informatics-driven platform can serve the assessment of disorders of high-level vision that manifest in object-centered or scene-centered contexts, e.g., visual agnosia and spatial neglect. We describe the development of a proof-of-concept model. Theoretical impetus for the platform stemmed initially from the spatiotopic representational (cognitive neuroscience) model of hemispatial neglect, centered on Brodmann's area 7 – that representational neglect is a function of spatiotopic compression or extinction, and that the relationship can be mathematically described.

**Methods:** A technology stack platform was built using *Electron*, an open source development framework for cross-platform desktop applications. Core design of the platform rests on a grid configuration -- an array of cells of a computer screen. Cells record the coordinates of content displayed on the grid. The grid is scalable to different screen sizes. The system uses a dual-screen computer setup: The clinician's (control) screen and the patient's (viewer) screen. Grid information is sent to two renderer processes through Inter Process Communication (IPC) handlers with synchronous communication – for the clinician screen and patient screen renderings. This allows for the viewing of the same stimulus on the clinician and patient screens while limiting the control parameters/control menu to the clinician's screen. The basic mathematics for grid-based mapping involves *Manhattan Distance* -- applying coordinate translations with 0,0 (center grid cell) as the reference point. *Prisma*, the object-relational mapping tool, was used to create the database structure and to apply a migration strategy to a MySQLite file.

**Results (a functional architecture):** Development of a core software platform (described above) was achieved, with functionality successfully applied to two visuospatial tests used in neuropsychological assessment -- Letter Cancellation and the a few stimuli from the Boston Visuospatial Battery (BVT). The following functions were programmed and tested: The clinician selects either the letter cancellation task or an image adapted from the BVT. Selected test is displayed on the grid matrix. Patient uses a mouse, stylus or touchpad to draw over/trace image (direct copy or recall trials). Based on neglect gradient extracted by the software, the clinician can incrementally move the image and have the patient retrace image. The process is repeated until no neglect is recorded – to quantify line or gradient of neglect. Grid lines on patient's screen can be shown, made opaque, or hidden.

**Conclusion/Discussion:** Over an 8-month development period, a core functional architecture of a computational platform for visuospatial assessment was developed as proof-of-concept. Functionality was tuned to spatial neglect. With further development, we aim to (a) broaden functionality to visual agnosia; (b) incorporate simple eye-tracking into the platform; and (c) with beta version development and datasets, we hope to apply machine learning *Ensemble Methods* – to combine several predictive models and data dimensions (supervised ML) for high quality predictions of patients' visuospatial prognosis. A web-based "freemium" version is planned for data collection.