RubaVision: Innovative Research Software for Cortical Visual Impairment Rehabilitation

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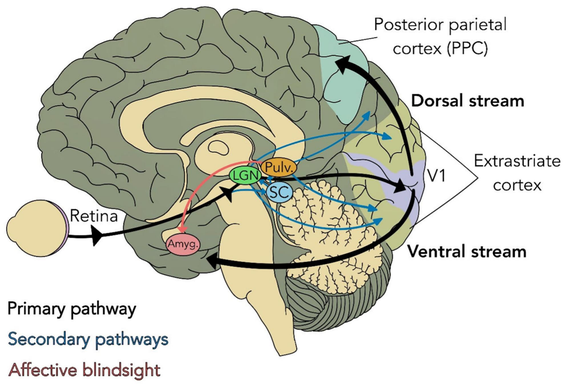
There is no accepted rehabilitation for vision loss in cortical visual impairment

- Cortical visual impairment (CVI) caused by damage to the primary visual cortex results in partial or complete blindness, light sensitivity, and reduced visual acuity
- Recovery is limited to spontaneous resolution of symptoms and behavioral compensation for visual deficits; there is no accepted rehabilitation for CVI
- Visual restoration therapy (VRT) is a treatment for CVI that aims to repair visual deficits by presenting visual stimuli within the damaged field
- Currently available VRT platforms (e.g., NovaVision) are expensive, technically challenging for patients to use, and have controversial efficacy
- We present RubaVision, an open-source research software for CVI rehabilitation

Activation of blindsight through parallel visual pathways may promote vision restoration

- Most conscious vision is processed using the primary visual pathway, which includes the primary visual cortex (striate cortex) that is damaged in CVI
- Neural plasticity in the striate cortex has been proposed to mediate visual cortical rehabilitation, and the incidence of blindsight in patients with CVI represents an additional potential therapeutic target

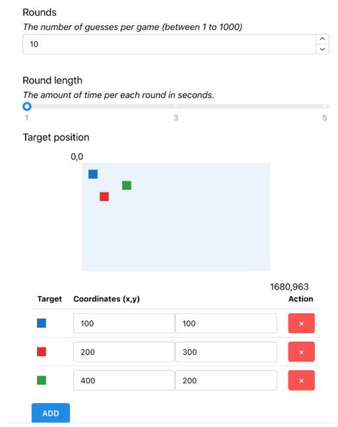


Visual pathways (Adapted from Danckert, Striemer, & Rossetti; 2021)

- Blindsight is a phenomenon by which individuals with CVI are able to discern visual stimuli within their blind visual fields without consciously seeing the stimuli
- Blindsight is mediated by alternative visual pathways that bypass the primary visual cortex in the context of object motion, orientation, color, and emotion
  - Motion blindsight has been attributed to a pathway including the dorsal LGN (dLGN), the superior colliculus/pulvinar systems, and extrastriate cortex (areas V4, V5). Discrimination of motion in VRT has been shown to improve visual processing (detection of luminance increments, contrast sensitivity).
  - In affective blindsight, emotional stimuli are processed in a pathway that includes the amygdala and temporal cortex
  - Discrimination of color, orientation, and other properties can be achieved through extrastriate pathways terminating in the V4 visual cortex
- Stimuli with modifiable qualities may evoke plasticity through secondary pathways implemented in blindsight including the lateral geniculate nucleus (LGN), superior colliculus, visual area V4, and the amygdala

RubaVision is an open-source, innovative software to promote research into visual restoration therapy

a.



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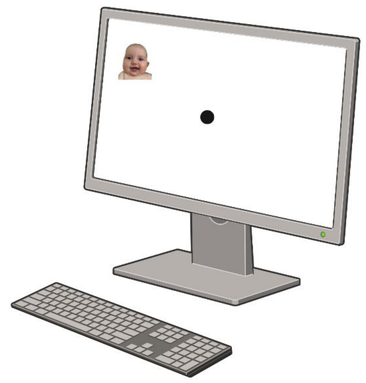

c.

a, RubaVision settings can be modified, including the length of round, time for response, and the location and type of stimuli presented. **b**, Users respond to visual stimuli by pressing keys. **c,** Responses are recorded and the results (correct and incorrect responses) are displayed after each round and can be downloaded

- RubaVision is freely available and playable in the web browser (rubavision.netlify.app)
- RubaVision has 4 different training modes: motion (left vs right), emotion (happy vs sad), color (red, green, yellow), and shapes (circle, triangle, square)
- Round length can range from 1-1000 stimuli and duration of stimuli can last from 1-5 seconds
- Users respond to stimuli with corresponding keys (e.g., 1 = circle, 2 = square, 3 = triangle)
- Audio cues follow user responses to reinforce correct (chime) or incorrect selections (buzz)
- Correct and incorrect selections for each coordinate can be saved for evaluation over time

Conclusions and future directions

- More research is needed into the efficacy of VRT for rehabilitation in CVI
- RubaVision is free software that researchers can modify and use in trials to assess VRT
- RubaVision is a pioneering leap forward in CVI rehabilitation research and brain resilience
- Quality improvement will include the development of standardized parameters (i.e. distance from computer, recommended screen size) at which to play RubaVision for reproducibility
- Future capabilities include developing a perimetry map for each stimulus mode so that users can track changes in performance over time

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