Youth is not wasted on the young: Late-in-life sight restoration in congenitally blind children leads to the emergence of some visual constructional skills but not others

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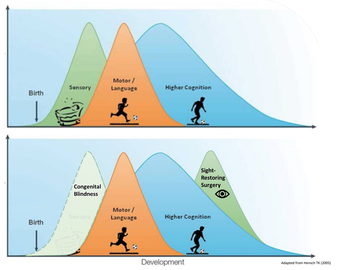
Background

Do visuospatial construction skills require early visual experience?

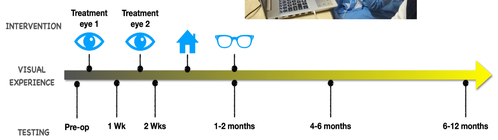
- Visuospatial Construction (VC): the ability to spatially organize individual elements into a whole pattern.
- VC acquisition is multimodal, relying on visuospatial processing, motor planning, and executive functioning
- Provides a useful window into aspects of visual representation and the crosstalk between perceptual and motor systems.
- VC assessments include graphomotor (e.g. drawing to command, copying) and assembly (e.g. block & pattern reproduction) tasks.
- In typical development, vision emerges in first year, then motor, and VC begins in toddlerhood.
- Will VC still emerge if onset of vision is delayed until after other sensory systems have matured**?**



HOW WILL VISUAL CONSTRUCTION BE IMPACTED IF WE "TURN OFF" VISION AT BIRTH AND ALLOW OTHER SENSORY SYSTEMS TO MATURE NORMALLY?

WHAT IF WE THEN "TURN VISION BACK ON" LATER IN LIFE?

Project Prakash – a model for visual learning



'Project Prakash' *- a unique model for isolating the roles of visual status (e.g. acuity) from visual experience for learning visual function and representation late in life*

A humanitarian and scientific endeavor to treat children (ages 7-22yo) born blind due to bilateral cataracts, while exploring their unique brain development following this extended visual deprivation.

Methods – Reconstructing M&M patterns

Paradigm:

- Task – organize a set of M&M's into a particular 2D pattern
- Conditions – Matching vs. Reproduction
- Increasing difficulty – 3, 4, and 6 dot patterns of uniquely colored M&M's followed by 6 dot patterns of all black M&M's
- Longitudinal data pre- & post- treatment

Measured metrics:

- Final performance – goodness of produced pattern
- Strategy – process of laying out pattern
- Visual information collection – Eye tracking

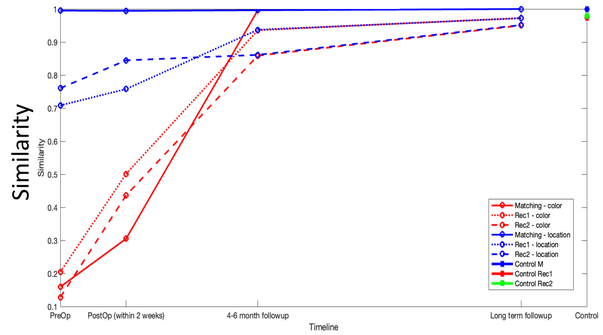
Matching

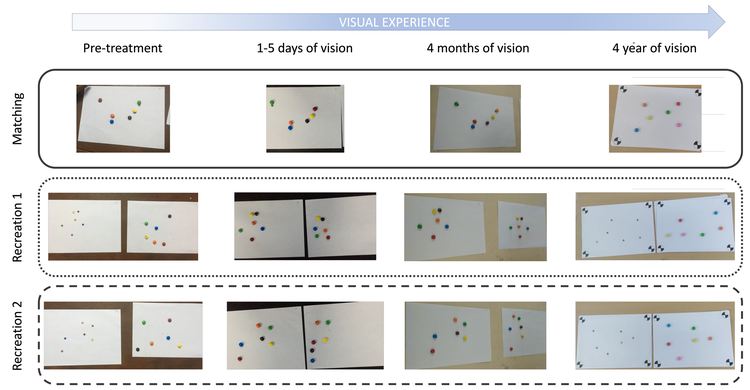
Reproduction

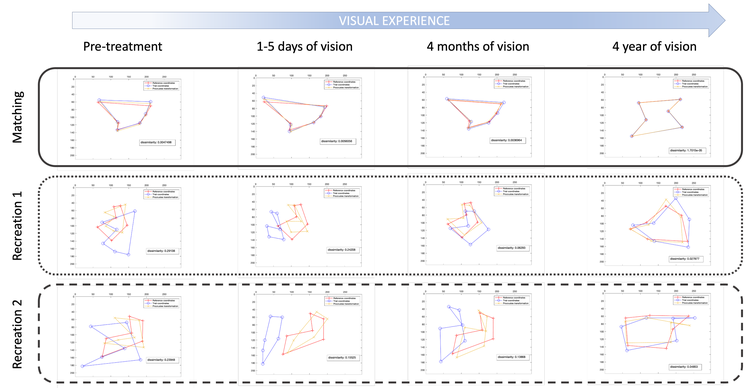
Results

- Even young controls perform both Matching and Reproduction perfectly regardless of task complexity.
- For Matching, newly sighted children position M&M's perfectly → requires minimal vision and no visual experience.
- However, they mix colors even for matching, regardless of their ability to see and identify colors → use of color information is delayed until gain visual experience
- For Reproduction, newly sighted have dramatic improvements within hours to days of vision onset, but improvements are in grouping some elements together, not capturing relative relations between elements not overall shape of pattern → latter characteristics may require further visual experience.
- Extensive experience is required to fine tune additional pattern characteristics such as relative location of elements, overall shape and orientation.

Procrustes Analysis

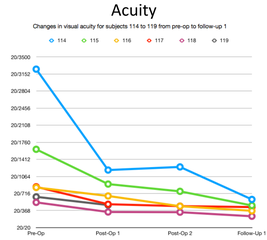






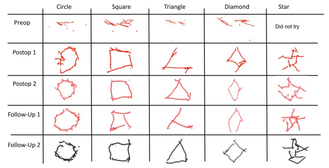
Relation to other tasks

Acuity



"Draw a face"

Connect the Dots



- Improvement in basic grouping of M&M correspond to acuity changes.
- Relative positioning of elements continued to be impaired, requiring extensive visual experience
- In comparison, improvements on the drawing follow a more gradual progression but errors still mirror the sustained form distortions observed in the assembly task.
- Connect the dots shows over-segmented representation, perhaps explaining difficulties in representing relations between pattern elements.

Conclusion & Open Questions

Overall, vision onset seems sufficient to allow reconstruction of a generally coherent pattern, but the lack of early visual experience results in the continued use of localized pairwise error correction as a primary strategy, resulting in pattern deformations that the children seem unaware of, despite the rich visual experience they have gained in the years since treatment.

- What aspects of representational similarity is Procrustes not capturing?
- Are there better algorithms to quantify change in performance?
- How do developmental changes and persistent impairments compare to developmental progression in typical visual development?
- What do gaze patterns tell us?

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