Neural Correlates of Visual Perceptual Organization (PO) in an EEG Oddball Paradigm

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Introduction

- This EEG study aims to explore neural correlates of perceptual organization (PO) to assist with the diagnosis of schizophrenia (SZ) spectrum disorders, as impaired PO is well-documented in patients.
- We propose to study PO in a visual oddball study by adapting Color vs. Motion stimuli from Kurylo et al. (2018) to analyze neural responses among healthy controls.
- Data from this study will support building a baseline comparison model when we adapt this procedure to clinical populations in the future.
- This study will investigate the Mismatch Negativity (MMN) ERP, which is elicited when a series of similar stimuli are followed by unexpected stimuli (Luck, 2005).
- In a similar EEG oddball paradigm, Farkas et al. (2015) found that individuals with SZ showed a smaller MMN response compared to healthy controls.

Visual Processing System

- There are two main visual pathways in the brain:
  (1) Magnocellular/M-pathway
  (2) Parvocellular/P-pathway
- Both project information from the eyes to the **lateral geniculate nucleus**, which projects to the **primary visual cortex**.

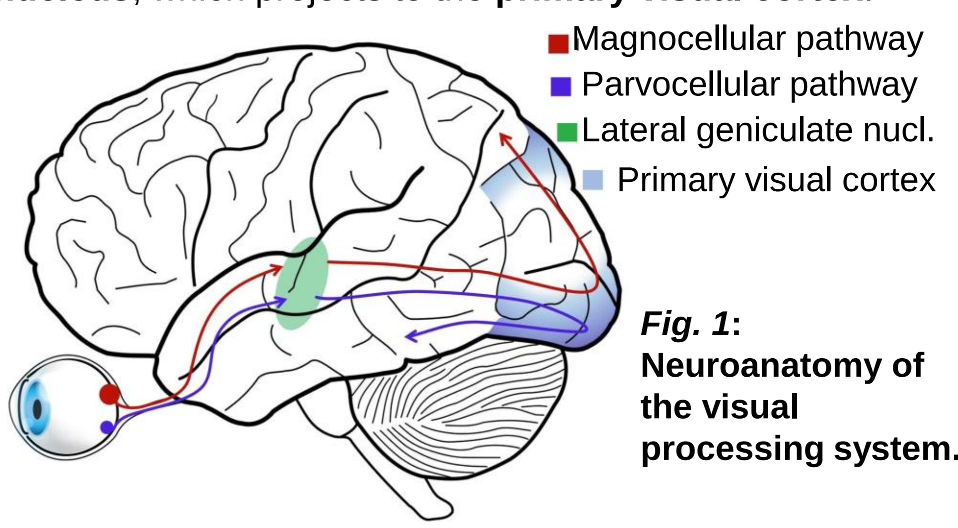


***Fig. 1*: Neuroanatomy of the visual processing system.**

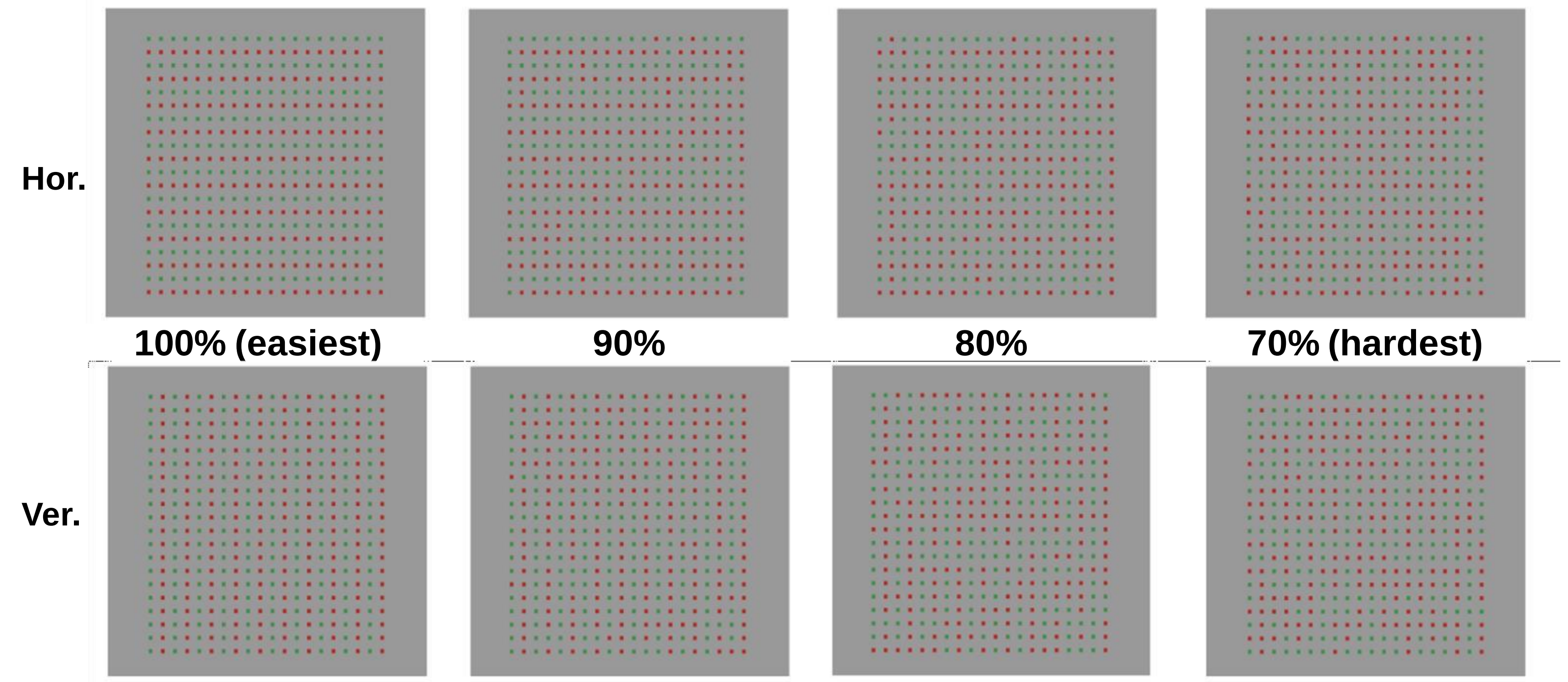
- The **M-**pathway travels primarily to the **dorsal** area, extending to the **parietal cortex**; Affiliated with motion detection and spatial reasoning.
- The **P-**pathway travels primarily to the **ventral** area, extending to the **inferotemporal cortex;** Affiliated with perception of color, fine details and object recognition.

Hypotheses

1. We anticipate that the **color** stimuli will be processed by the **P-**pathway and the **motion** stimuli will be processed by the **M-pathway**. MMN activity should be greater in these respective regions for the two stimulus types.
2. The stimuli coherence level should scale with perceptibility of vertical/horizontal orientation (see "Stimuli"). Thus, the orientation change in the oddball paradigm should be most detectable in the 100% condition and least detectable in the 70% condition.
   - We previously found that coherence level scales directly with participants' performance on the PO task (accuracy and reaction time), as well as saccadic activity and pupillary measures (Gordon et al., 2020).

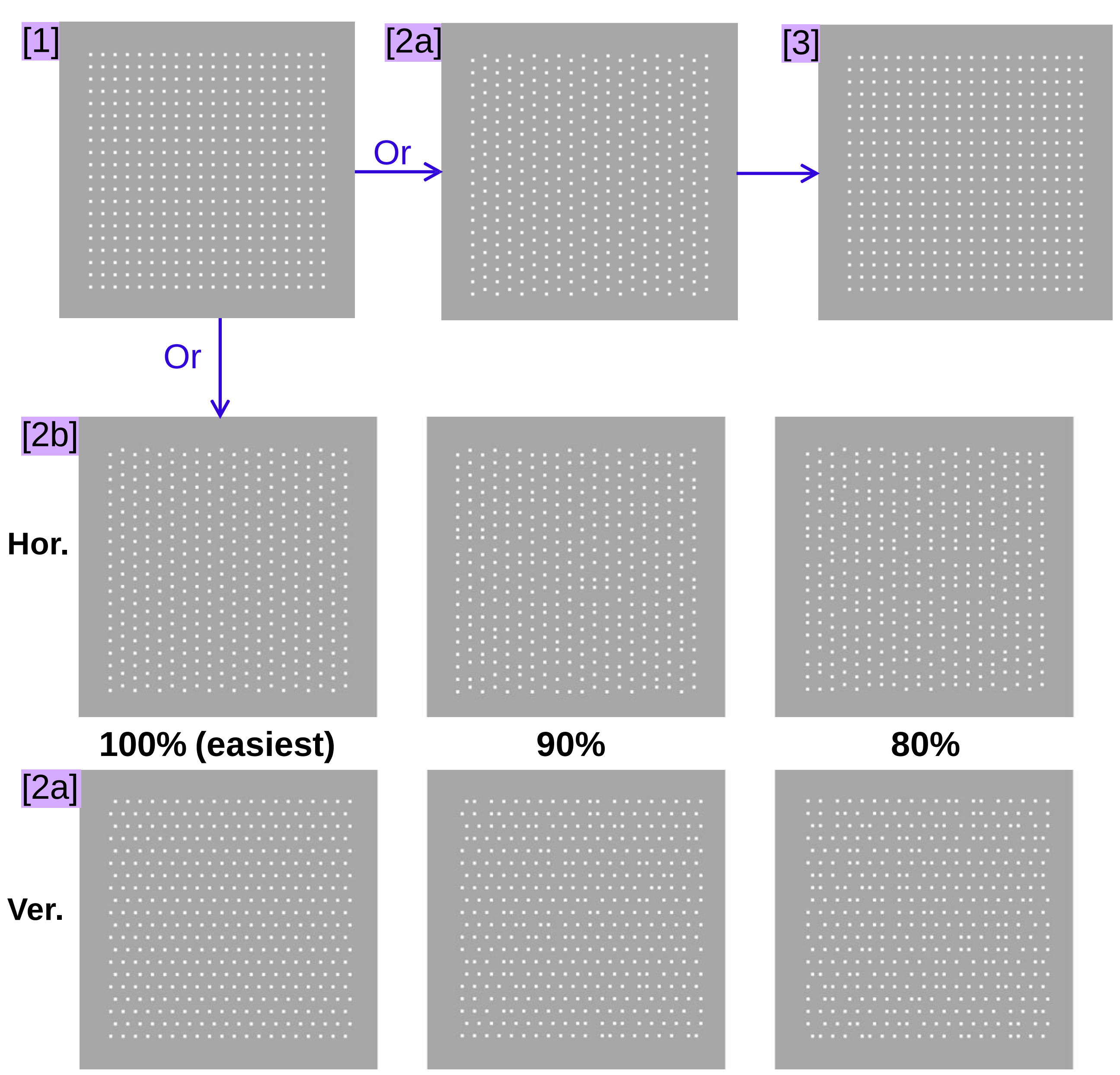
Stimuli: Color (P-pathway Stimuli)

Color Stimuli: Images can be perceived as either **Horizontal** or **Vertical**, and the organization levels will vary from 100% (easiest to perceive) to 70% (hardest).



Stimuli: Motion (M-pathway Stimuli)

Motion Stimuli: Participants will see 200ms animations displayed over **three frames**, where:
1 The 1st frame is at baseline;
2 The 2nd frame is where pairs of dots appear to *move* closer to one another, either:
[2a] **Vertically** or [2b] **Horizontally**; and the organization levels will vary from 100% - 70%.
[3] The 3rd frame is where the dots return to their original position.



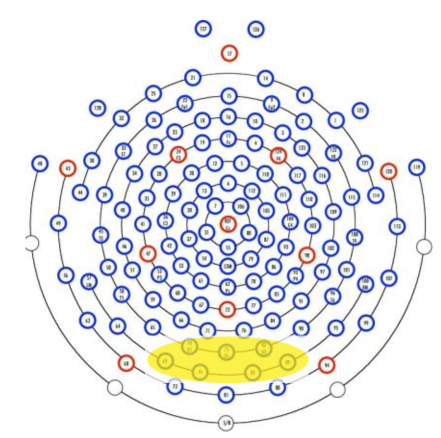


Fig. 2: Layout of sensor net's electrodes.

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Methods

1. Healthy adults (n=20) will undergo an adapted EEG paradigm of the PO task by Kurylo et al. (2018), where the task taps into visual PO of form and texture under varying degrees of noise.
2. Stimuli consist of 20 x 20 dot arrays of elements that indicate general organization (Horizontal or Vertical orientation) at four levels: 100%, 90%, 80%, 70% (Percentages indicate the proportion of elements that conform to the dominant orientation).
3. Trials consist of a display sequence comprising 3-5 stimuli of the same orientation, followed by a stimulus of the opposite orientation, which should trigger the MMN deflection.
4. A 128-channel EGI Geodesic Sensor Net will measure the MMN's amplitude (and potentially other ERPs of sig.) within epochs of interest for peaks, while latency will be measured from stimulus onset to the MMN's maximum amplitude.
5. Participants will passively view stimuli, and to sustain their attention, will be asked to press a key whenever an emoticon appears on-screen (☺).
6. Recording sites selected for statistical analysis will be focused on locations over the occipital area, where MMN activity will be calculated based on topography represented by an electrode montage, including electrodes 69, 70, 74, 75, 82, 83, 89 (highlighted in yellow in Fig. 2).
7. This montage will be used to identify peak latencies and calculate adaptive mean amplitudes for the MMN at 150-200 ms.
8. Individual files will be grand-averaged together to produce neural waveforms by condition (Color vs. Motion).

Expected Results

- We predict that the Color stimuli will stimulate the P-/ventral pathway (posterior parietal cortex), while the Motion stimuli will stimulate the M-/dorsal pathway (inferotemporal cortex).
- We anticipate connections between poorer performance on the PO task, reduced MMN responses, and decreased activity in the M-/dorsal pathway.
- In terms of future anticipated results when comparing EEG data from healthy controls against patients with SZ spectrum disorder, we expect to see that when the stimulus' orientation changes, patients will have smaller MMN responses, with healthy controls having the largest MMN amplitudes.

References

Kurylo, D. D., Waxman, R., Silverstein, S. M., Weinstein, B., Kader, J., & Michalopoulos, I. (2018). Remediation of perceptual organisation in schizophrenia. *Cognitive Neuropsychiatry, 23*(5), 267-283.
Davis, J. (2020). Magnocellular and parvocellular pathways [Online image]. University of Minnesota. https://pressbooks.umn.edu/sensationandperception/chapter/magnocellular-and-parvocellular-pathways/
Gordon, P., Kurylo, D. D., *et al.* (2020). "Saccadic and Pupillary Response as Biobehavioral Markers in a Perceptual Organization Task," in *Cognitive Neuroscience Society (CNS) 2020 Virtual Conference*.
Luck, S. J. (2005). "Chapter 1. An Introduction to Event-Related Potentials and Their Neural Origins," in *An introduction to the event-related potential technique*, 1st ed., Cambridge, MA: MIT Press, pp. 1–16.
Farkas, K., *et al.* (2015). Elementary sensory deficits in schizophrenia indexed by impaired visual mismatch negativity. *Schizophr. Res.*, 166 (1-3),p. 164–170.