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Spatial Frequency Implications for Global and Local Processing in Autistic Children

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Introduction

Visual Perception (VP)

- VP requires integration of both **global** and **local** sensory input
- **Local interference:** local details prioritized over global input
- **Overall project aim: decrease** local interference in **Autism Spectrum Disorder (ASD)** by using a filter to *highlight global features*

Research Question

- Does **spatial frequency (SF)**, a measure of *contrast*, affect the filter's functionality and an individual's likelihood of *fixating* on *normative* areas?

Methods

Participants and Test Procedures

- N=10, Ages 9 -18 , ASD diagnosis
- Conducted two sessions over two days
- Randomly presented 50 filtered and unfiltered images on Day 1 and another version on Day 2

Data Collection

- Head-mounted eye gaze device to track *fixations*
- Assistants scored each video on whether the participant hit a **hotspot** (areas where normative individuals looked the most)

Statistical Analyses

- Used the **OpenCV** image processing package in Python to isolate each image's hotspots, draw **contours** around them and create *rectangles* around each
- Used a formula to calculate the **SF** of each image (filtered and unfiltered) and hotspot
- Created a dataframe of all SF results
- Performed **paired sample t-tests** to examine differences in SF by *hotspot vs. entire image* and *filtered vs. unfiltered image*

Spatial Frequency Forumla

In a **M x N** image where **M = number of rows** and **N = number of columns**, row and column frequencies are:

$$\text{Row\_Freq} = \sqrt{\frac{1}{MN}\sum_{j=0}^{M-1}\sum_{k=1}^{N-1}[F(j,k)-F(j,k-1)]^2}$$

$$\text{Column\_Freq} = \sqrt{\frac{1}{MN}\sum_{k=0}^{N-1}\sum_{j=1}^{M-1}[F(j,k)-F(j-1,k)]^2}$$

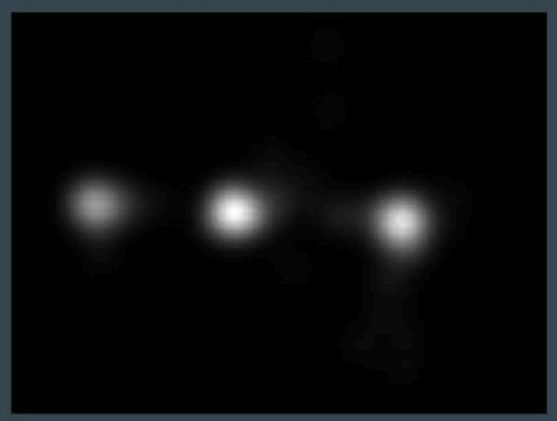
The **total spatial frequency** is then:

$$= \sqrt{(\text{Row\_Freq})^2 + (\text{Column\_Freq})^2}.$$

Main finding: There was **a statistically significant** difference between the **spatial frequency** for the *entire image* and the *average spatial frequency* for the **normative visual fixations areas.**

Raw, unfiltered image

Filtered image



Heat map of hotspots where normative individuals fixated

Results

Main Finding

- **Paired t-test** indicated that the difference between the *entire image's SF* and the *average hotspot SF* was **statistically significant**

SF of Entire Image vs. Hotspots for Filtered Images

- *Mean: whole image: 144756.193, hotspot: 15540.080*
- *T-test: t-statistic* = -63.135, *p-value* < 0.001

SF of Entire Image vs. Hotspots for Raw Images

- *Mean: whole image: 172865.634, hotspot: 15579.260*
- *T-test: t-statistic* = 77.919, *p-value* < 0.001

SF of Entire Image in Filtered vs. Unfiltered Images

- *Mean (SD): Raw:* 172865.634, 13823.480; *Filtered:* 144756.193, 13957.312
- *T-test: t-statistic* = 14.864, *p-value* <0.001

SF of Hotspots in Filtered vs. Unfiltered Images

- *T-test: t-statistic* = 0.631, *p-value* = 0.531

Discussion

Implications

- The **SF** of an image and its hotspots **affect** the filter as it is designed

Weaknesses

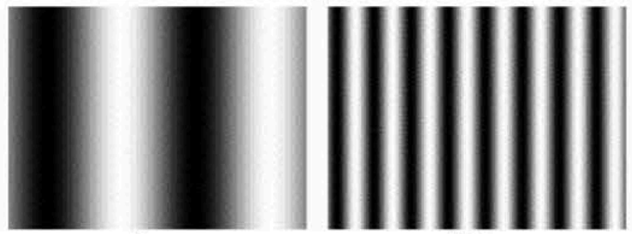
- The use of the head-mounted tracker did not allow for fixations to be automatically recorded by eye-tracking software

Future Work

- Investigate the role of SF in participants encountering hotspots
- This research lays the groundwork for potentially improving the filter to create a significant **decrease** in *local interference*
- Once COVID restrictions allow and a screen-mounted eye gaze device is available, the team plans to test more participants

Extra Tables & Figures

High vs. low spatial frequencies



Low High

Formula used to calculate SF of entire image and hotspots

```
def spatial_freq(image_rect):
    #M = rows, N = columns
    M,N = image_rect.shape
    #Calculating row frequency
    row_sum = 0
    for j in range(0,M-1):
        for k in range(1,N-1):
            row_sum = row_sum +
            (image_rect[j,k] - image_rect[j,k - 1])**2
    row_freq = math.sqrt((1/M*N)*row_sum)
    #Calculating column frequency
    col_sum = 0
    for k in range(0,N-1):
        for j in range(0,M-1):
            col_sum = col_sum +
            (image_rect[j,k] - image_rect[j-1,k])**2
    col_freq = math.sqrt((1/M*N)*col_sum)
    #Calculating final spatial freq
    SF = math.sqrt(row_freq**2 + col_freq**2)
    return(SF)
```