

USING IMMERSIVE VR TO EXPLORE INDIVIDUAL DIFFERENCES IN VISUAL PROCESSING STYLES

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INTRODUCTION

Autism Spectrum Disorder (ASD) and Attention-Deficit Hyperactivity Disorder (ADHD) are neurodevelopmental conditions often characterised by a **local bias in visual processing and difficulties with executive functions** (Simmons & Todorova, 2018). These difficulties have previously been experimentally assessed using the **Rey-Osterrieth Complex Figure (ROCF)** task, an extensively used neuropsychological tool in which drawings of a complex figure (first copied and then re-drawn from memory) are analysed. Several theories have been proposed to explain and challenge the local visual bias in ASD, including, but not limited to, **Weak Central Coherence (WCC)** and **Enhanced Perceptual Function (EPF)**. Building on our previous pilot work (Savickaite, McDonnell and Simmons, INSAR, 2020) we investigated visual processing and executive function patterns in a novel **Virtual Reality (VR)** version of the ROCF task.

The aim of this study was to analyse drawing performance in a VR environment using a combination of personality questionnaires and screen captures of participants' viewpoints.

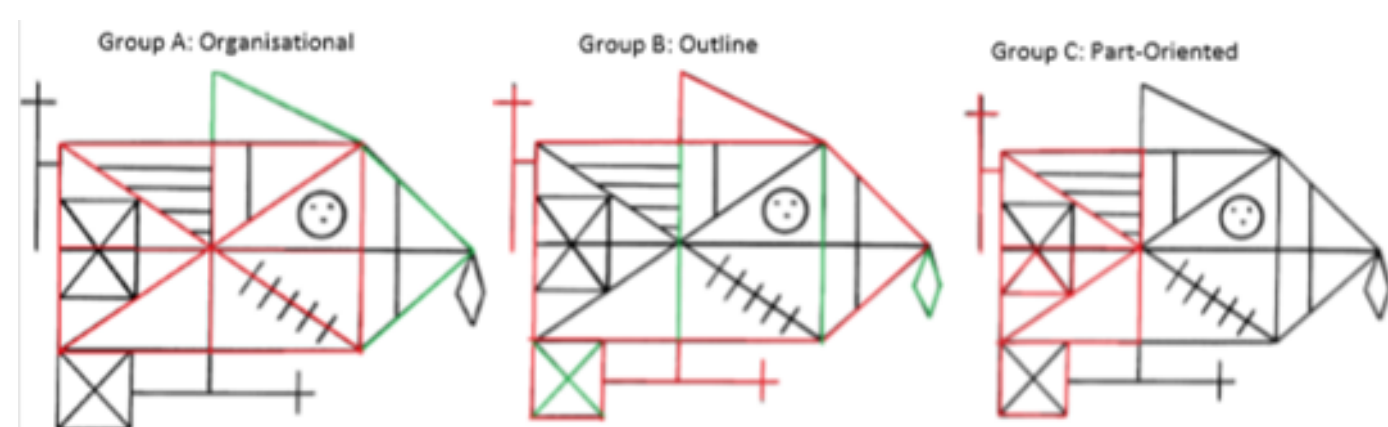


FIGURE 1. THREE PATTERNS WERE OBSERVED IN VIDEOS AND USED IN FURTHER ANALYSIS: A. ORGANISATIONAL, B. OUTLINE, C. PART ORIENTED. RED LINES INDICATE ELEMENTS DRAWN FIRST AND GREEN SHOWS ELEMENTS, WHICH WERE OCCASIONALLY DRAWN BEFORE THE RED ELEMENTS.

METHODS

92 (39 male, 53 female) neurotypical participants (average age 22.5) filled in AQ (Baron-Cohen et al, 2001), ASRS (Kessler et al, 2005) and SQ (Baron-Cohen et al, 2003) questionnaires and then a standard ROCF task (i.e. Copy, Immediate Recall and Delayed Recall) was completed in Virtual Reality. AQ (Autism Quotient) is a questionnaire devised to assess autistic traits in the general population. It has been found to be a good tool for investigating the continuum of autistic expression. ASRS (Adult ADHD Self- Report Questionnaire) assesses ADHD traits in the neurotypical population and SQ (Systemising Quotient) examines individuals' tendency to systemise.

Organisational (Hamby et al, 1993) and perceptual (Booth, 2006) scoring systems were used to quantify emerging visual processing and executive function patterns. These patterns were quantitatively compared to "ideal" stereotypical sequences by calculating the inner product (Figures 1 & 3). Essentially this measured how similar the participant's drawing sequence was to these ideal patterns (see Figure 1) and these were also visualised (Figure 2).

Participants were tested using Nvidia GTX 1080 PC (Windows 10) with HTC Vive VR kit. The experiment was run through three-dimensional drawing tool - TiltBrush (Google, 2016). It is a novel approach to the standard pen and paper ROCF task, and allows a detailed visualisation of drawings in three-dimensions (Figure 2).

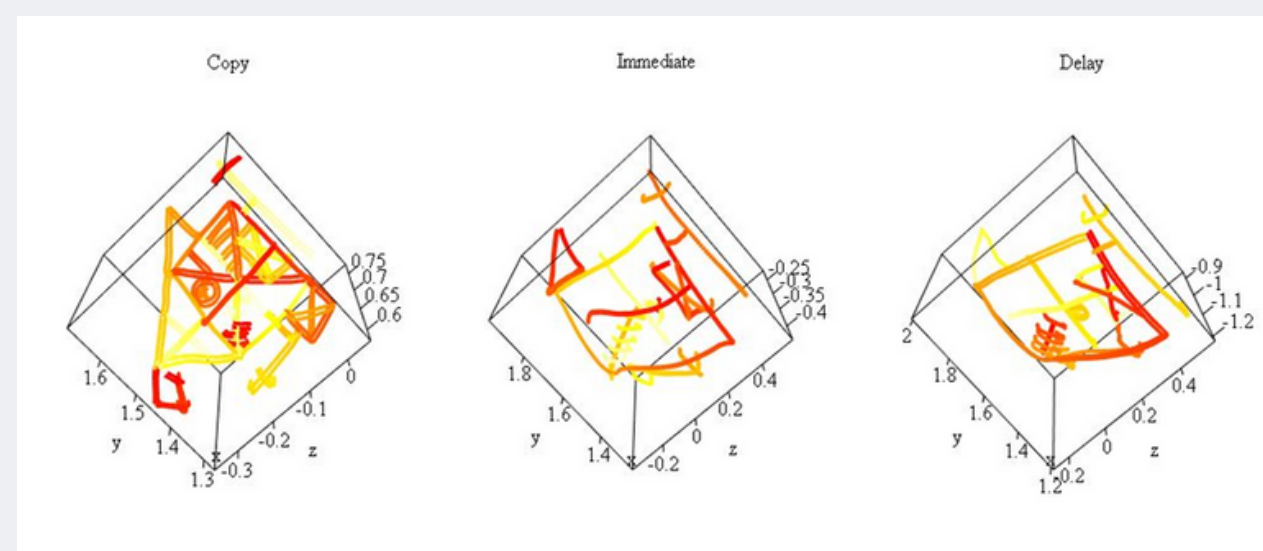


FIGURE 2. THREE-DIMENSIONAL PLOTS OF ONE OF THE PARTICIPANT'S DATA FOR ALL THREE CONDITIONS OF THE ROCF TASK: COPY, IMMEDIATE AND DELAYED RECALL. COLOURS INDICATE TIME: EARLIEST ELEMENTS IN YELLOW AND THE ELEMENTS COMPLETED LAST IN RED.

RESULTS

Although significant differences were not found in the drawing tendencies of participants with differing levels of autistic and ADHD traits, **drawings scoring higher on the organisational scale were systematically linked with higher perceptual scores**. Drawings were visualised in 3D plots (Figure 2). Matrices illustrating the order of figure completion were compared between the experimental conditions (Figure 3).

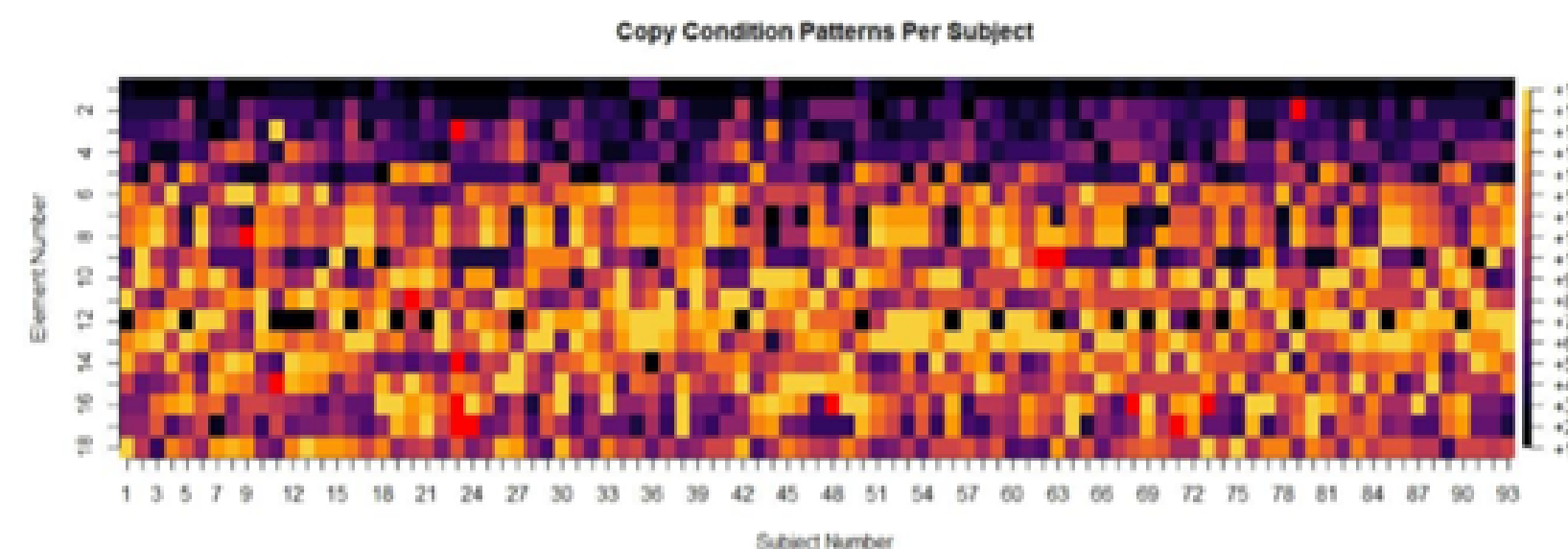


FIGURE 3. EXAMPLE MATRIX PLOT OF THE ORDER IN WHICH 18 ELEMENTS FROM THE PERCEPTUAL SCORING SYSTEM WERE DRAWN. COLOUR CHANGES INDICATE TIME, WITH DARKER INDICATING EARLY AND LIGHTER INDICATING LATE (SEE LEGEND).

DISCUSSION

Our study offered several innovative ways of visualising and evaluating VR data: **matrix plots of drawing sequences and data-driven pattern identification approaches**. This new approach supported other empirical findings from our lab that the attention-to-detail subscale of the AQ is a predictor of performance in the ROCF task. The organisational level is thought to correlate with executive function abilities, but, surprisingly, we did not identify significant performance differences in neurotypical participants with differing levels of autistic, ADHD and Systemizing traits. However, modification of the task and recruitment of diagnosed autistic participants are the next steps in identifying what the visual processing and executive function patterns we have identified really mean.

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