Research in Developmental Disabilities 68 (2017) 66–77

Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Thinking inside the box: Spatial frames of reference for drawing in Williams syndrome and typical development

Kerry D. Hudson, Emily K. Farran*

Department of Psychology and Human Development, UCL Institute of Education, University College London, UK

ARTICLE INFO

Number of reviews completed is 2

Keywords:
Drawing
Williams syndrome
Development
Spatial
Orientation
Processing style
Frames of reference
Oblique lines

ABSTRACT

Background: Successfully completing a drawing relies on the ability to accurately impose and manipulate spatial frames of reference for the object that is being drawn and for the drawing space. Typically developing (TD) children use cues such as the page boundary as a frame of reference to guide the orientation of drawn lines. Individuals with Williams syndrome (WS) typically produce incohesive drawings; this is proposed to reflect a local processing bias.

Aims: Across two studies, we provide the first investigation of the effect of using a frame of reference when drawing simple lines and shapes in WS and TD groups (matched for non-verbal ability).

Methods and procedures: Individuals with WS (N = 17 Experiment 1; N = 18 Experiment 2) and TD children matched by non-verbal ability drew single lines (Experiment One) and whole shapes (Experiment Two) within a neutral, incongruent or congruent frame. The angular deviation of the drawn line/shape, relative to the model line/shape, was measured.

Outcomes and results: Both groups were sensitive to spatial frames of reference when drawing single lines and whole shapes, imposed by a frame around the drawing space.

Conclusions and implications: A local processing bias in WS cannot explain poor drawing performance in WS.

What this paper adds

This is the first study to assess whether individuals with WS can effectively use spatial frames of reference when drawing, and in doing so acts as a direct test of the assertion that visuo-spatial cognition in WS is characterised by a local processing bias (Bellugi, Sabo, & Vaid, 1988). This study also investigates the influence of a frame of reference in TD children to a more fine-grained level than previous studies. Results suggest that the WS group, like the TD participants, were influenced by the surrounding orientation cues provided by the frame, and thus refutes the local processing bias hypothesis. The Drawing Orientation Task (DOT) and the whole-shape drawing task are suitable for use with clinical groups such as individuals with constructional apraxia or autism to investigate use of spatial frames of reference when drawing.

1. Introduction

In order to understand the relationship between elements within a visual scene it is necessary to impose systems for describing the relative positions and orientations of those elements or parts. Gestalt theories of visual perception described this as 'spatial frames of

* Corresponding author at: Department of Psychology and Human Development, UCL Institute of Education, University College London, 25 Woburn Square, London, WC1H 0AA, UK.
E-mail address: e.farran@ucl.ac.uk (E.K. Farran).

http://dx.doi.org/10.1016/j.ridd.2017.07.008
Received 1 November 2016; Received in revised form 25 April 2017; Accepted 12 July 2017

reference' which Rock (1992, p. 404) defined as "a unit or organization of units that collectively serve to define a coordinate system with respect to which certain properties of objects […] are gauged". Based on this definition, the object or parts within a visual scene can be used as a frame of reference for locating other objects or parts within the scene. Equally, a frame that surrounds an image can provide a useful frame of reference for locating the relative positions of the elements within the image.

The ability to use a spatial frame of reference is necessary for producing accurate copies when drawing; that is, drawing requires the individual to determine a coordinate system by which to encode the relations of parts of a visual scene and to use this to replicate elements of a model and their relative positions. The drawer must be able to transfer the spatial frame of reference from the model to the drawing space to guide copying. During the course of drawing, the spatial frame of reference for the copy must also be updated to reflect the elements that have been completed and those that are yet to be drawn.

In a drawing task, Naeli and Harris (1976) provided evidence to suggest that typically developing (TD) four and five year-olds can recognise the congruence of orientation of a model and a surrounding border (a frame of reference) to increase "goodness of copy" (defined as the presence of three lines in the correct orientation in a four line figure). Similarly, drawing squares on A4 paper facilitates drawing accuracy by reference to the page boundary as a frame of reference to guide line orientation (Broderick and Laszlo, 1987). It is hypothesised that the presence of a border or page edge might reduce planning demands by allowing participants to integrate the boundaries provided by the border into their spatial frame of reference. This frame of reference provides additional reference points to guide orientation, distance and changes in the direction of drawn lines. Across two studies, we investigate the effect of using a frame as a reference when drawing simple lines and shapes in both TD children and in individuals with Williams syndrome (WS), for whom drawing is a specific weakness (Bertrand, Mervis, & Eisenberg, 1997). To-date no studies have assessed whether individuals with WS can effectively use spatial frames of reference when drawing.

WS results from a deletion of approximately 28 contiguous genes on chromosome 7q11.23 (Nickerson, Greenberg, Keating, McCaskill, & Shaffer, 1995; Osborne, 2012; Tassabehji, 2003) with a prevalence of approximately one in 7,500 to one in 20,000 live births (Morris et al., 1988; Strømme, Bjømstad, & Ramstad, 2002). WS is typified by mild to moderate learning difficulties, and a disparity between relatively strong verbal ability and poor visuospatial skills (Ewart et al., 1993; Farran & Karmiloff-Smith, 2012; Ferrero et al., 2007; Mervis & John, 2008; Smoot, Zhang, Klaiman, Schultz, & Pober, 2005).

Errors in drawings made by individuals with WS resemble those made in early typical development; that is, drawings typically lack cohesion (Bellugi, Lichtenberger, Jones, Lai, & St. George, 2000; Bertrand et al., 1997; Georgopoulos, Georgopoulos, Kuz, & Landau, 2004). The incohesive drawings seen in WS have been used to support the hypothesis that visuo-spatial cognition in WS is characterised by a local processing bias (Bellugi et al., 1988) in which details of a visual scene are preferentially produced without integration of those parts into the correct global configuration. However, detailed analysis of drawing strategies in WS suggest that the drawings of individuals with WS become increasingly diverged from those of TD children, as the complexity of the to-be-drawn image increases (Hudson & Farran, 2011). Evidence suggests that a local processing bias is too simplistic an account to explain the characteristic drawing observed in WS. For example, replication of a model line drawing of a house is not biased towards replicating the local elements over the more global elements in WS, relative to TD controls (Hudson & Farran, 2013a).

Poor drawing in WS relates to reduced attention to the model image (Hudson & Farran, 2013a) and, for relatively complex images, a difficulty in reproducing the spatial relations between the parts of an image, coupled with atypical replication strategies (Farran & Dodd, 2015; Hudson & Farran, 2011, 2013b). Thus, although a difficulty in reproducing the spatial relations between the parts of an image nods towards the local processing bias hypothesis, this is intertwined with a number of other atypical characteristics in WS, and does not necessarily support the local processing bias hypothesis (e.g. impaired spatial relationship production could relate to impaired spatial category understanding; Farran & Jarrold, 2005; Laundau & Hoffman, 2005; Farran, Atkinson, & Broadbent, 2016). Here, by presenting a frame as a spatial frame of reference in drawing tasks, we will directly determine whether this influences participants' drawing accuracy. If individual with WS have a local processing bias, they should not be influenced by the frame.

Beyond the literature on drawing ability in WS, a deficit in the use of spatial frames of reference has been documented on spatial tasks from early in development in WS. Brown et al. (2003) demonstrated that infants with WS (mean age 29 months) were unable to use their body as a frame of reference when performing simple eye movements, which is an ability that emerges at three months in TD infants. In addition, individuals with WS have poor understanding of the configuration of objects in both a small-scale array (Nardini, Atkinson, Braddick, & Burgess, 2008) and a large-scale environment (Farran et al., 2015). This is also suggestive of an impaired ability to use or construct a spatial frame of reference in WS. In light of the evidence above which suggests a deficit in using of spatial frames of reference in WS, the current study assessed the spatial frames of reference provided by a frame. The frames can be used as a reference to provide cues to orientation when drawing single lines (Experiment One) and whole shapes (Experiment Two). These experiments investigated whether deficits in the use of spatial frames of reference are present in the drawing domain in WS and whether use of the orientation cues provided by these frames differs from a non-verbal matched TD control group.

2. Experiment One: the Drawing Orientation Task (DOT)

2.1. Introduction

The Drawing Orientation Task (DOT) is a novel drawing task inspired by the perceptual Rod and Frame Test (Witkin & Asch, 1948). In the original Rod and Frame Test participants are seated in a darkened room and attempt to vertically orientate a rod within a tilted frame. Participants typically place the rod at the same angle as the frame and so are unable to overcome the cues provided by the surrounding frame of reference (Daini, Wenderoth, & Smith, 2003; Li & Matin, 2005; Rock, 1992). This might represent a bias towards the nearest gravitational axis (vertical, horizontal or diagonal; Beh, Wenderoth, & Purcell, 1971). Participants with a global