Research in Developmental Disabilities 34 (2013) 2133–2142

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

journal homepage:

Facilitating complex shape drawing in Williams syndrome and typical development

Kerry D. Hudson *, Emily K. Farran

Department of Psychology and Human Development, Institute of Education, UK

ARTICLE INFO

Article history:
Received 9 January 2013
Received in revised form 5 April 2013
Accepted 8 April 2013
Available online 1 May 2013

Keywords:
Drawing
Developmental disorders
Williams syndrome
Typical development
Perception
Graphic planning
Remediation

ABSTRACT

Individuals with Williams syndrome (WS) produce drawings that are disorganised, likely due to an inability to replicate numerous spatial relations between parts. This study attempted to circumvent these drawing deficits in WS when copying complex combinations of one, two and three shapes. Drawing decisions were reduced by introducing a number of facilitators, for example, by using distinct colours and including facilitatory cues on the response sheet. Overall, facilitation improved drawing in the WS group to a comparable level of accuracy as typically developing participants (matched for non-verbal ability). Drawing accuracy was greatest in both groups when planning demands (e.g. starting location, line lengths and changes in direction) were reduced by use of coloured figures and providing easily distinguished and clearly grouped facilitatory cues to form each shape. This study provides the first encouraging evidence to suggest that drawing of complex shapes in WS can be facilitated; individuals with WS might be receptive to remediation programmes for drawing and handwriting.

1. Introduction

The ability to produce a drawing is underpinned by a range of abilities, such as perception, spatial cognition and the execution of planned movements (Bonoti, Vlachos, & Metallidou, 2005). As a result, drawing is a marker of both cognitive and neurobiological maturation. Williams syndrome (WS) has often been associated with poor drawing ability (e.g. Bertrand, Mervis, & Eisenberg, 1997), although few studies have investigated this. WS is a rare genetic disorder that results from a hemizygous 1.6 Mb microdeletion of approximately 26 contiguous genes on chromosome 7q11.23 (Nickerson, Greenberg, Keating, McCaskill, & Shaffer,1995; Tassabehji, 2003) which affects one in 20,000 live births (Morris, Demsey, Leonad, Dilts, & Blackburn, 1988). Individuals with WS typically display mild to moderate learning difficulties (average IQ between 50 and 60) and an unusual cognitive profile comprising of relatively strong linguistic ability and poor visuo-spatial performance (Ewart et al., 1993; Ferrero et al., 2007; Mervis & John, 2008; Smoot, Zhang, Klaiman, Schultz, & Pober, 2005).

Mark-making ability is generally poor in WS; difficulties with handwriting are observed in 93% of individuals with WS (Semel & Rosner, 2003, p. 154). Throughout development, drawings made by individuals with WS are often seriously disorganised, lack detail and exhibit less mastery than typically developing (TD) individuals of the same mental (MA) or chronological (CA) age (Bertrand et al., 1997; Stiles, Capirci, & Volterra, 2000; Wang & Bellugi, 1993). Until recently, this

* Corresponding author at: Department of Psychology and Human Development, Institute of Education, University of London, 26 Woburn Square, London WC1H 0AA, UK. Tel.: +44 020 7612 6272; fax: +44 020 7612 6304.
E-mail addresses: k.hudson@ioe.ac.uk, kerrydhudson@gmail.com (K.D. Hudson).

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http://dx.doi.org/10.1016/j.ridd.2013.04.004

pattern of behaviour in WS had been explained by the local processing hypothesis which suggests that when copying an image, individuals with WS typically attempt to depict the details of the image but fail to replicate the overall spatial arrangement of these details (e.g. Bellugi, Sabo, & Vaid, 1988; Bellugi, Wang & Jernigan, 1994). Current understanding of visuo-spatial ability in WS accepts that a local-level bias does not characterise the visuo-spatial phenotype in WS as a whole (e.g. Farran, Jarrold, & Gathercole, 2001; Farran, Jarrold, & Gathercole, 2003, also see Deruelle, Rondan, Mancini, & Livet, 2006; Pani, Mervis, & Robinson, 1999).

Hudson and Farran (2011) refuted the local processing hypothesis in a drawing task and suggested that poor drawing performance in WS might be due to a reduced ability to understand the relations of parts and an increased sensitivity to the complexity of images, relative to TD controls. The net result of this in WS is a reduced ability to strategically replicate images, which is likely to also be affected by poor mental imagery (e.g. Farran et al., 2001). Despite clear graphomotor deficits there is a distinct lack of research to understand these difficulties in WS and the means to remediate problems. This study therefore focused on understanding how drawing can be facilitated by manipulating drawing demands and is the first of its type to focus exclusively on methods to facilitate drawing performance in WS and TD children.

The decisions that are made when attempting to accurately produce a drawing include kinematics such as force and pressure on a stylus, selecting starting and cessation points, depicting appropriate line lengths and directional changes (such as initial direction choice, turning points and the angle of directional change; Broderick & Laszlo, 1988). In the current study, we introduced facilitation methods designed to manipulate the graphomotor decisions that are made during drawing. These were: (1) a dot-joining measure (Guide dots); (2) edge markers for individual shapes; (3) half-completed shapes and (4) marks to indicate the typical starting location for each shape. The rationale for each of these conditions is described in turn below.

To successfully complete the current drawing task, participants must utilise perceptual grouping ability in order to visualise the elements as contiguous forms. Smith and Gilchrist (2005a) demonstrated a strong tendency of drawers to perceptually group edge markers of shapes (as in the Edge Marker condition used in the current experiment) by completion across the space between markers, even in instances when this was not requested. Dot-joining also requires perceptual grouping of elements and has been used to facilitate drawing of simple shapes in TD children (Broderick & Laszlo, 1988) and an individuals with WS (Stiles et al., 2000). These conditions encourage participants to group the given elements to create lines within the figure on the basis of perceptual grouping factors such as similarity, closure and proximity (Wertheimer, 1923). Edge markers and dot-joining marks also provide explicit guidance for starting and cessation points, directional changes and line lengths and so greatly reduce planning demands.

We know that the ability to perceptually group elements is present in WS (Farran, 2005; Grice et al., 2003; Wang, Doherty, Rourke, & Bellugi, 1995), therefore providing guiding features such as edge markers should aid drawing in a WS group by reducing planning demands and encouraging grouping of the given features into shapes. However, for participants to benefit from this kind of facilitation, the global form of the model must be processed and related to the guiding features provided by the response sheet. Should a local processing preference exist, participants with WS would have difficulty replicating figures using facilitation methods that rely on perceptual grouping, due to the need to appreciate the global features of the model and response sheet. Thus, this study also assessed the efficacy of the local processing bias in explaining drawing in WS.

Less emphasis on perceptual grouping ability was presented in a condition where participants were presented with a pre-drawn half of each shape. In this condition, participants were subject to reduced planning demands as starting and cessation points were provided and participants only has to determine a change in angle once. Provision of half a shape to guide drawing has previously been investigated in constructional apraxia (CAp; Smith & Gilchrist, 2005b), which is an acquired deficit in localising elements of visual space, and in TD children (Broderick & Laszlo, 1988). In both of these groups drawing of squares with and without a pre-drawn half of the square educed no significant differences in the angular deviation of drawn lines. Conversely, drawing diamonds using pre-drawn half-shapes led to greater angular deviation of drawings than when no facilitation was provided; this suggests a specific difficultly with replication of oblique lines even when graphic planning demands were reduced. This type of facilitation has not been investigated in WS; the current study aims to determine if individuals with WS benefit from being given half-drawn shapes to guide drawing, by recognising that production of a mirror image of the half-shape is required.

For each of the conditions discussed above, in addition to using standard black line drawings, colour was added as a further form of facilitation. We hypothesised that this would increase the distinction across the elements of the image and could be used as a platform for verbalisation strategies. Nakamura et al. (2001) and Nakamura, Kaneoke, Watanabe, and Kakigi (2002) demonstrated that in a small group of individuals with WS (although no control participants) the use of a coloured dot matrix (each dot was a different colour) in a dot-joining task compensated for poor spatial localisation ability relative to a single-coloured matrix. Participants were able to draw figures on the coloured matrix that could not recognisably be drawn on a single-coloured matrix. However, using a similar task, Farran and Dodd (submitted) demonstrated that the facilitation effect of colour observed in a WS group, although present, was weaker than that observed in non-verbal ability matched TD children. Despite this, these studies suggest that colour can be used by individuals with WS as a means of increasing drawing accuracy. This might potentially be due to reduction of graphic planning demands and increased salience of individual elements. Additionally, the use of colour permits verbalisation of the elements of the matrix. This enables individuals to use language, a relative strength in WS (Jarrold, Baddeley, & Hewes, 1998), to improve their drawing accuracy.