



## Item and error analysis on Raven's Coloured Progressive Matrices in Williams Syndrome<sup>☆</sup>

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### ABSTRACT

Raven's Coloured Progressive Matrices (RCPM) is a standardised test that is commonly used to obtain a non-verbal reasoning score for children. As the RCPM involves the matching of a target to a pattern it is also considered to be a visuo-spatial perception task. RCPM is therefore frequently used in studies in Williams Syndrome (WS), in order to match WS participants to a control group or as a single measure to predict performance on a test-condition in developmental trajectory analyses. However, little is known about the performance of participants with WS on the RCPM. The current study compared the type of errors and the difficulty of each item for 53 participants with WS to 53 typically developing children who were individually matched on the total raw score for RCPM. Results showed that the participants with WS made the same proportion of error types and that the proportion of error types changed similarly to those of typically developing controls over development. Furthermore, the differential item difficulty between the two groups was highly similar. It is therefore argued that, although participants with WS are delayed on RCPM, their performance is not atypical which suggests that RCPM performance is supported by typical mechanisms. The RCPM is therefore a useful tool to match WS to control groups or to construct developmental trajectories.

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## 1. Introduction

Williams Syndrome (WS) is a rare developmental disorder with a prevalence of approximately 1 in 20 000 live births (Morris, Demsey, Leonard, Dilts, & Blackburn, 1988) and is caused by the hemizygous deletion of 28 genes on chromosome 7 (Donnai & Karmiloff-Smith, 2000; Tassabehji, 2003). WS is characterised by a fractionated cognitive profile with relatively good face-processing and language abilities in contrast to poor performance on tasks such as drawing, visuo-spatial abilities, memory and number processing in the context of an overall general intelligence score within the mild to moderately impaired range (Martens, Wilson, & Reutens, 2008; Mervis et al., 2000). Furthermore, studies investigating the cognitive processes underlying behavioural outcomes have shown that individuals with WS use different strategies compared to controls. For example, studies examining face processing abilities in WS have found that people with WS tend to look more at individual features compared to controls (Annaz, Karmiloff-Smith, Johnson, & Thomas, 2009; Deruelle, Mancine, Livet, Cassé-

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Perrot, & de Schonen, 1999; Karmiloff-Smith et al., 2004). This local bias has also been claimed to explain the weaker visuo-spatial abilities reported in people with WS (Abreu, French, Annaz, Thomas, & de Schonen, 2005; Mervis et al., 2000). Yet, other studies have shown that the bias to process elements locally rather than globally is only present in the drawing abilities but not in visual perception or identification of patterns tasks (see Farran & Jarrold, 2003; Farran, Jarrold, & Gathercole, 2003 for a discussion).

Due to the fact that overall cognitive development is impaired in individuals with WS, studies (e.g. Farran, Jarrold, & Gathercole, 2001; Riby & Hancock, 2009) have often matched participants with WS to control groups based upon performance levels on a specific task, such as Raven's Coloured Progressive Matrices (RCPM; Raven, Court, & Raven, 1990). RCPM is a standardised test which, although described as a measure of fluid intelligence (Woliver & Sacks, 1986), involves visual matching of a target to a pattern and is thus a measure of specific visuo-spatial ability (Gunn & Jarrold, 2004). Previous studies investigating RCPM scores in children with WS have found that performance scores are well below what is expected for their chronological age. For example, Brock, Jarrold, Farran, Laws, and Riby (2007) found that for 17 out of 41 children with WS between the ages of 6 and 17 years old, no mental age (MA) equivalent score could be calculated and that they obtained raw scores lower than 15 points on the RCPM. The remaining 24 participants had a mean MA of 7 years and 5 months (SD 1.5) while their mean chronological age (CA) was 12 years old (SD = 3.1) (Brock et al., 2007). However, little is known about how the performance of individuals with WS compares to typically developing (TD) controls on individual RCPM items and how their performance can be characterised i.e., delayed, atypical or both. First of all, an analysis of the types of errors made by participants with WS can provide useful information about the processing strategies employed during task completion. For example, the type of errors made by participants with WS can inform us whether they show a bias to process local elements rather than the entire pattern. Secondly, it is possible for individuals with a developmental disorder to obtain the same raw score or mental age equivalent score without passing necessarily the same items as the level of difficulty of each item might be different across groups (Facon & Nuchadee, 2010). Thus, it is unclear whether the level of difficulty of RCPM items is the same among individuals with WS and typical controls. Without such knowledge it is difficult to draw any conclusions from comparison studies in WS which have matched groups based upon RCPM performance or from studies which have used performance on a single MA measure to predict performance on a test-condition and make comparisons to the TD-group (see Thomas et al., 2009 for a discussion). The current study aimed therefore to investigate whether the types of errors made by a large group of participants with WS differed from TD controls matched for the overall number of errors made, and how error patterns changed with increasing CA in both groups. This would provide further information whether the underlying processes used by participants with WS are typical or atypical. Lastly, this study investigated the functioning of individual items of RCPM in participants with WS and TD controls and examined whether the same items caused difficulties in both groups.

## 2. Methods

### 2.1. Participants

Fifty-three participants with Williams Syndrome between the ages of 5;0 and 41;04 years old (mean = 18;03, SD = 9;10) completed the RCPM test. Performance of participants with WS was individually matched to that of TD children, based upon the total raw score plus or minus 1. This ensured that different types of error patterns would not be confounded by different levels of performance ability between the two groups. This matching approach resulted in both groups having very similar mean raw scores and standard deviations (WS: mean: 19.34, SD = 4.91; TD: mean: 19.68, SD = 5.08). A one-way ANOVA with group as between factor showed that there was no significant difference for overall performance on the RCPM between the two groups ( $F(1,105) = 0.122, p = 0.727$ ). The TD children had an average chronological age of 5 years and 8 months (SD = 1;03 range: 3;04–9;04 years). Participant and parental consent was obtained for all participants and they were all informed that they could withdraw from the study at any time.

### 2.2. Materials and methods

Raven's Coloured Progressive Matrices (Raven et al., 1990) is a standardised test which includes 36 items which are divided into three sub-tests of 12 items each. In each item the participant is presented with a coloured pattern of which one part is missing and the participant is asked to select the missing part out of six options. In each sub-test the items are ordered in increasing difficulty. There is no set time limit to complete items and all participants were encouraged to complete all 36 items. Testing took place on a one-to-one basis in a quiet room either at the participant's home or school and was carried out according to the Manual's instructions.

### 2.3. Data analyses

#### 2.3.1. Error type analysis

In accordance with Raven et al. (1990), each error was coded using one of the following four categories: (1) Difference, (2) Inadequate Individuation, (3) Repetition of the Pattern, and (4) Incomplete Correlation. 'Difference' errors are types of errors in which the participant selects an option that either has no pattern of any kind or has no direct relation to the target pattern.

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