COMPREHENSION OF SPATIAL LANGUAGE TERMS IN WILLIAMS SYNDROME: EVIDENCE FOR AN INTERACTION BETWEEN DOMAINS OF STRENGTH AND WEAKNESS

Caroline E. Phillips[1], **Christopher Jarrold**[1], **Alan D. Baddeley**[1], **Julia Grant**[2] **and Annette Karmiloff-Smith**[2]

([1]Centre for the Study of Memory and Learning, Department of Experimental Psychology, University of Bristol; [2]Neurocognitive Development Unit Institute of Child Health, London)

Abstract

Individuals with Williams syndrome show an unusual neuropsychological profile, with relatively strong language abilities and impoverished visual and spatial abilities. Two studies are reported that examine the interaction between these two domains in Williams syndrome by assessing individuals' comprehension of spoken language with a spatial component. In a first study, the Test for Reception of Grammar (Bishop, 1983) was given to 32 individuals with Williams syndrome and to controls matched individually for total number of errors on the task. Individuals with Williams syndrome had particular problems when asked to comprehend sentences containing spatial prepositions, making significantly more errors on these items than control groups. A second study examined in more detail comprehension of sentences with spatial and non-spatial components, comparing the performance of 15 individuals with Williams syndrome and control groups matched for vocabulary ability. Individuals with Williams syndrome again showed impaired comprehension of spoken spatial terms. In contrast, they were unimpaired in comprehending utterances without a spatial component, with the exception of descriptions testing comprehension of non-spatial comparatives (lighter than and darker than). These results suggest that the spatial difficulties experienced by individuals with Williams syndrome may constrain language comprehension in certain circumstances. They also shed light on the ways in which spatial cognition may interact with language comprehension more generally.

Key words: Williams syndrome, language, spatial ability

Introduction

Williams syndrome is a congenital neurodevelopmental disorder first identified by Williams and colleagues (Williams et al., 1961). It is a relatively rare disorder with an incidence estimated at about 1 in 20,000 births (Morris and Mervis, 1999). It is genetic in origin and is believed to be caused by hemizygous submicroscopic deletion of contiguous genes on the long arm of chromosome 7 (Ewart et al., 1993; Frankiskakis et al., 1996; Korenberg et al., 2000; Tassebehji et al., 1999). In addition to characteristic physical symptoms (see Morris and Mervis, 1999), Williams syndrome is associated with an unusual cognitive profile. Although individuals typically have mild to moderate mental retardation (Jones and Smith, 1975; Udwin et al., 1986, 1987), evidence suggests that nonverbal skills in Williams syndrome are seriously impaired in comparison to relatively unimpaired language abilities (Bennet et al., 1978; Crisco et al., 1988; Mervis and Bertrand, 1995; Udwin and Yule, 1991). This phenotypic pattern is now seen as being characteristic of the condition. For example, Rossen et al. (1996) argued that the Williams syndrome phenotype can be characterised as: "a unique profile of nested dissociations of higher cortical functioning. Most prominently, a disparity between preserved linguistic abilities and gravely impoverished non-linguistic functioning" (p. 367).

Impairments in visuo-spatial construction have been demonstrated on a number of tasks. Individuals with Williams syndrome have poor drawing and copying skills, and tend to lack cohesion and overall global organisation in drawing (Bellugi et al., 1994; Farran and Jarrold, 2003; Pani et al., 1999). Their spatial deficits are most clearly seen on block design tasks, where the majority of individuals have difficulties with even the simplest four block patterns (e.g., Bellugi et al., 1988, 1994; Farran et al., 2001; Mervis et al., 1999). Indeed Mervis et al. (1999) argue that poorer performance on the block design (pattern construction) subtest of the Differential Ability Scales, relative to all other subtests of the battery, is a clear marker of the phenotypic profile of Williams syndrome.

In contrast to these impairments, researchers have suggested that the linguistic capabilities of people with Williams syndrome are surprisingly unimpaired. Bellugi and collegues (Bellugi et al., 1990, 1992, 1994, 1996, 1999; Bellugi and Wang, 1998; Rossen et al., 1996; Thal et al., 1989; Wang and Bellugi, 1993, 1994) have carried out a considerable amount of research designed to investigate the cognitive profile of the Williams syndrome phenotype. In a number of these studies they compared adolescents with Williams syndrome to adolescents with Down syndrome matched for age and IQ. While both groups showed a marked impairment in general cognitive abilities, the individuals with Williams syndrome performed at a superior level on language measures. In particular, Bellugi and colleagues argue that there is a special resilience of syntactic development among individuals with Williams syndrome (Bellugi et al., 1988, 1990, 1992, 1994; Reilly et al., 1990). They found that participants with Williams syndrome were able to manipulate, process, and comprehend a variety of complex grammatical structures, and the language they produced was said to be both grammatically complex and 'syntactically impeccable'. In contrast, participants with Down syndrome performed poorly on these tasks; their language was less complex, less varied in construction, and was rarely without errors or omissions in both morphology and syntax. This dissociation in Williams syndrome, between aspects of individuals' linguistic abilities and their performance on other more general tests of cognitive ability, has been used as support for language-particular functional subsystems (e.g., Levy, 1996; Pinker, 1994). For example, Flavell et al. (1993) discuss the findings from studies of Williams syndrome under a heading "Independence of Language and Intelligence".

Other research into the linguistic abilities of individuals with Williams syndrome has yielded more mixed results however, with a number of researchers finding that aspects of these individuals' grammatical abilities are considerably delayed (e.g., Capirci et al., 1996; Karmiloff-Smith et al., 1997a, b; Thal et al., 1989; Thomas et al., 2001; Volterra et al., 1996). For example, Karmiloff-Smith et al. (1997a) found that participants with Williams syndrome showed comprehension problems on a number of grammatical structures, particularly embedded sentences, which typically developing children appear to find relatively easy. In addition to this, analysis of expressive language from French-speaking individuals with Williams syndrome showed they had difficulties mastering grammatical gender rules and with production of determiner-noun-adjective phrases. This led the authors to conclude that morphosyntax is not unimpaired in Williams syndrome, and that children with Williams syndrome may learn language in a qualitatively different way from typically developing individuals. Researchers have attempted to account for these inconsistencies in findings in a number of different ways. As noted, studies that have compared the language abilities of individuals with Williams syndrome to individuals with other learning difficulties such as Down Syndrome tend to find superior linguistic functioning for the Williams syndrome group. However, this might equally reflect language difficulties which are specific to the comparison group (see Klein and Mervis, 1999). Alternatively, it has been suggested that the use of formal tests in language assessments may underestimate individuals' natural language ability (Cromer, 1994; Morris et al., 1988, Rossen et al., 1996; Zukowski, 2001).

Further work is clearly needed in this area in order to characterise fully what may turn out to be a more complicated profile than was originally believed. Increasingly, researchers agree that these individuals' linguistic skills are not uniformly spared; and, in common with their abilities in visual cognition which show an uneven profile of peaks and valleys across sub-domains, language abilities may also show a profile of relative strengths and weaknesses. Furthermore, the notion that verbal and nonverbal systems develop independently has been challenged by studies that fail to find a significant dissociation between these two domains in all individuals (see Jarrold et al., 1998, 2001; Paterson et al., 1999). These inconsistencies, and the uneven profiles of strengths within domains, seem to point to systems that do not function independently, and that may be involved in a complex process of interactions. While some authors have suggested that strengths in language may help individuals with spatial tasks (e.g., Bellugi et al., 1988, have noted how people with Williams syndrome frequently talk their way through drawing tasks, as if to use their verbal strengths to mediate visuo-spatial performance), few have considered whether spatial deficits influence performance on language tasks. The aim of the current research is to investigate the interaction between linguistic and non-linguistic functioning in Williams syndrome, and to explore the possibility that deficits within the spatial domain may impinge on performance on tasks that might otherwise be thought of as relatively pure tests of language comprehension.

STUDY 1

The aim of this first study was to use the Test of Reception of Grammar (TROG, Bishop, 1983) to explore the proposal that the difficulties in visual and spatial processing experienced by individuals with Williams syndrome may impinge on their performance on a task that is generally assumed to tap language abilities. The TROG is a standardised measure designed to test grammatical comprehension. In the task, the participant is presented with four pictures and is required to choose the one that matches a spoken word, phrase, or sentence. The TROG aims to test a number of different grammatical constructions ranging from simple nouns to more complicated embedded sentences (see appendix 1 for more details). Most studies have converted participants' raw scores on this test (number of blocks for which the participant answers all 4 items correctly) to mental age values to examine whether grammar is spared or delayed relative to age and other abilities in Williams syndrome.

Bellugi et al. (1990) summarised the performance of six individuals with Williams syndrome on the block of passive constructions taken from the TROG, showing that these individuals understood these passive structures, which in contrast proved problematic for their comparison sample of individuals with Down syndrome. However, Bellugi et al. (1988) note that the age equivalent score derived from the whole TROG for three of these individuals was comparable to their general 'mental age levels', rather than being chronological age appropriate. Similar results were reported by Mervis et al. (1999), who gave the TROG to 77 individuals with Williams syndrome. Mervis and colleagues found that, while 56% of this sample performed within normal limits (a standard score of 70 or above), on average mental age equivalent scores derived from the task were not age appropriate. By comparison, a slightly smaller proportion (42%) of a larger but related sample of individuals obtained standard scores of 70 or over on the Peabody Picture Vocabulary Test (PPVT; Dunn and Dunn, 1981). In the same vein, Karmiloff-Smith et al. (1997a) found that a group of 20 individuals with Williams syndrome performed at a lower level on the TROG than would be expected for their chronological age. However, in this sample TROG mental age equivalent scores were lower than those obtained for receptive vocabulary as assessed by the British equivalent of the PPVT (British Picture Vocabulary Scale; Dunn et al., 1982). Similarly Volterra et al. (1996) found that a group of young individuals with Williams syndrome were more impaired, relative to typically developing controls, on an Italian version of the TROG than on a translation of the PPVT.

None of these previous studies have directly examined the possibility that spatial items within the TROG might be adversely affecting individuals' overall performance. There are three blocks within the TROG that could be considered to possess a spatial component. These are: block K, which tests the understanding of longer, bigger, taller than; block M, which tests the understanding of in and on; and block P, which assesses understanding of above and below (see appendix 1 for details of all 20 blocks that make up the TROG). Clearly, if individuals with Williams syndrome have difficulty with the comprehension of spatial terms, as a result of their general spatial difficulties, then they should find these three blocks of the TROG particularly difficult. Clahsen and Almazan (1998) presented preliminary evidence to suggest that this may be the case in their study of the grammatical abilities of four individuals with Williams syndrome. Although not the main focus of their study, Clahsen and Almazan comment in passing on the TROG performance of these individuals, and note that they showed particular problems with "prepositions (confusing above and below), conjunctions (neither and nor) and comparative adjectives" (p. 175). As all the comparative adjectives in the TROG are spatial in nature (block K), this corresponds to noted difficulties on two of the three blocks with a spatial component identified above.

This issue of the comprehension of utterances with and without a spatial component in Williams syndrome was examined directly in the current study. To this end, the performance on the TROG of a group of 32 individuals with Williams syndrome was compared to that shown by two control groups; a group of children with moderate learning difficulties, and a group of typically developing children. An important design strength of this study is that these controls were matched individually to the Williams syndrome participants for total score on the TROG. This ensures that the groups are equated for overall level of performance, and is consequently a particularly stringent way of matching.

Method

Participants

Thirty-two individuals with the Williams syndrome phenotype took part in this study. The group consisted of 13 males and 19 females whose chronological ages ranged from 8 years 3 months to 38 years 1 month, with a mean age of 256.4 months (sd = 96.6). All individuals had been recruited through the Williams Syndrome Foundation of the United Kingdom, and had a positive clinical evaluation of Williams syndrome. Seventeen of these individuals had taken part in research programmes involving the first three authors, and lived in the South West of England. The remaining fifteen individuals were participants in research projects involving the fourth and fifth authors, and lived in and around London. Nine of the total group of individuals with Williams syndrome had received 'fluorescence in situ hybridisation' (FISH) tests to assess deletion of the elastin gene on chromosome 7. This genetic information is currently used as a marker in diagnosis, as over 90% of individuals with Williams syndrome test positive for this deletion (Lowery et al., 1995; Nickerson et al., 1995), although it is worth noting that the elastin gene itself is unlikely to be related to the cognitive phenotype of the condition (see Korenberg et al., 2000). All nine tests were positive confirming elastin deletion. No individual in the sample had a received a FISH test with a negative result, but clearly a number of individuals had received their diagnosis prior to the development of a test for elastin deletion[1].

[1] The results from this study are based on an analysis of the whole sample of individuals with Williams syndrome, however, analyses of the subgroup of only those individuals with a positive FISH test revealed entirely comparable results. Similarly a comparison of the two subsamples of individuals with Williams syndrome recruited from different geographical areas showed that these subgroups performed comparably. Details of these analyses are available from the authors on request.

All participants with Williams syndrome were given standardised tests of verbal and nonverbal ability. Verbal ability was measured in terms of vocabulary comprehension scores on the long form of the British Picture Vocabulary Scale (BPVS; Dunn et al., 1982); non-verbal abilities were assessed by Raven's Coloured Progressive Matrices (RCPM, Raven, 1986). The mean vocabulary mental age (VMA) equivalent score for the sample on the BPVS was 122.4 months (sd = 33.0, range 69 to 202 months). The average RCPM score was 18.12 out of a maximum of 36 (sd = 4.77, range 13 to 30). Although the RCPM is not designed to provide precise mental age equivalent scores, this value corresponds approximately to the 50% level of performance for individuals aged 82.2 months (sd = 17.5). A direct comparison of individuals' vocabulary and RCPM mental age equivalent scores confirmed a significant advantage for vocabulary scores ($t = 6.69$, $df = 31$, $p < .001$, paired t-test), in line with the Williams syndrome cognitive phenotype.

The performance of the Williams syndrome group was compared to that of two control groups. These were 32 typically developing (TD) children from a mainstream school, and 32 children with moderate learning difficulties (MLD) orgeneralized mental retardation, recruited from a school for children with special educational needs. The TD group consisted of 23 boys and 9 girls and their ages ranged from 6 years 8 months to 9 years 8 months with a mean age of 85.5 months (sd = 13.0). The MLD group consisted of 19 boys and 13 girls and their ages ranged from 8 years 9 months to 16 years 8 months with a mean age of 165.7 months (sd = 27.4). These individuals were selected on the basis of their overall level of performance on the TROG test (see below), to ensure that each individual in the Williams syndrome group was matched to two controls, one TD, one MLD, for total score on the task.

Procedure

Participants were given the Test for Reception of Grammar (TROG, Bishop, 1983). On each item of the test the participant is shown four pictures depicting similar scenes, and is simply asked to point to the one that corresponded to the word, phrase or sentence read by the examiner. The TROG consists of 80 items which are divided into blocks of four (20 blocks, A to T). Items include various tests of morphosyntax such as singular/plural personal pronouns, masculine/feminine personal pronouns, singular/plural inflections, comparatives, reversible passives etc. (see appendix 1).

Pilot work indicated that the 9 initial blocks of the TROG (blocks A to I) were too easy for individuals of this general level of ability, producing very few, if any, errors. Consequently, in this study individuals were only presented with the later 11 blocks of the test (J to T), and were matched for total score on these 44 test items. Importantly, this range of blocks includes the target spatial blocks, K, M and P. In contrast to the normal procedure for employing the TROG, all individuals received all items in all of these blocks, regardless of their level of performance throughout the test.

Results

Figure 1 plots the mean correct score, out of a maximum of 4, for each group on the 12 blocks of the TROG assessed here[2]. A two factor ANOVA analysis was conducted on these data, with the factors of group (independent measure, 3 levels) and block (repeated measures, 11 levels). This confirmed that, as a result of the matching procedure, the groups were almost perfectly equated for overall score [$F(2, 93) = 0.002$, $p = .998$]. There was, however, a significant main effect of block [$F(10, 930) = 84.13$, $p < .001$], due to the difficulty of the task increasing in the later blocks; and the group by block interaction was also significant [$F(20, 930) = 3.31$, $p < .001$]. Consequently, although the three groups were extremely closely matched for the total number of errors that they made on the test, they clearly made these errors on different blocks.

The source of the interaction was explored in two ways. First, a post-hoc analysis of simple effects was conducted to determine the magnitude of the effect of group on each of the separate blocks of the task. Second, a series of Scheffé tests were conducted to explore the nature of these group effects. These contrasted the performance of the Williams syndrome group with the combined performance of the two control groups to provide a conservative test of whether the Williams syndrome group's performance differed significantly from that of controls. F values for these effects and comparisons are shown in Table I, and indicate that the groups differ significantly in performance on blocks K, M, P and S. Individuals with Williams syndrome made significantly more errors than the combined controls on the spatial blocks K, M, and P; and significantly fewer errors on block S (see Figure 1).

A final analysis examined the extent to which age and measures of developmental level predicted performance among individuals with Williams syndrome. Individuals' total score on blocks J to T of the task was almost entirely unrelated to age (Pearson's $r = .00$, $df = 30$, $p = .99$), but was reliably related to both VMA ($r = .47$., $df = 30$, $p < .01$) and RCPM score ($r = .44$, $df = 30$,

[2] Error bars for this, and subsequent figures are +/- one standard error in the mean.

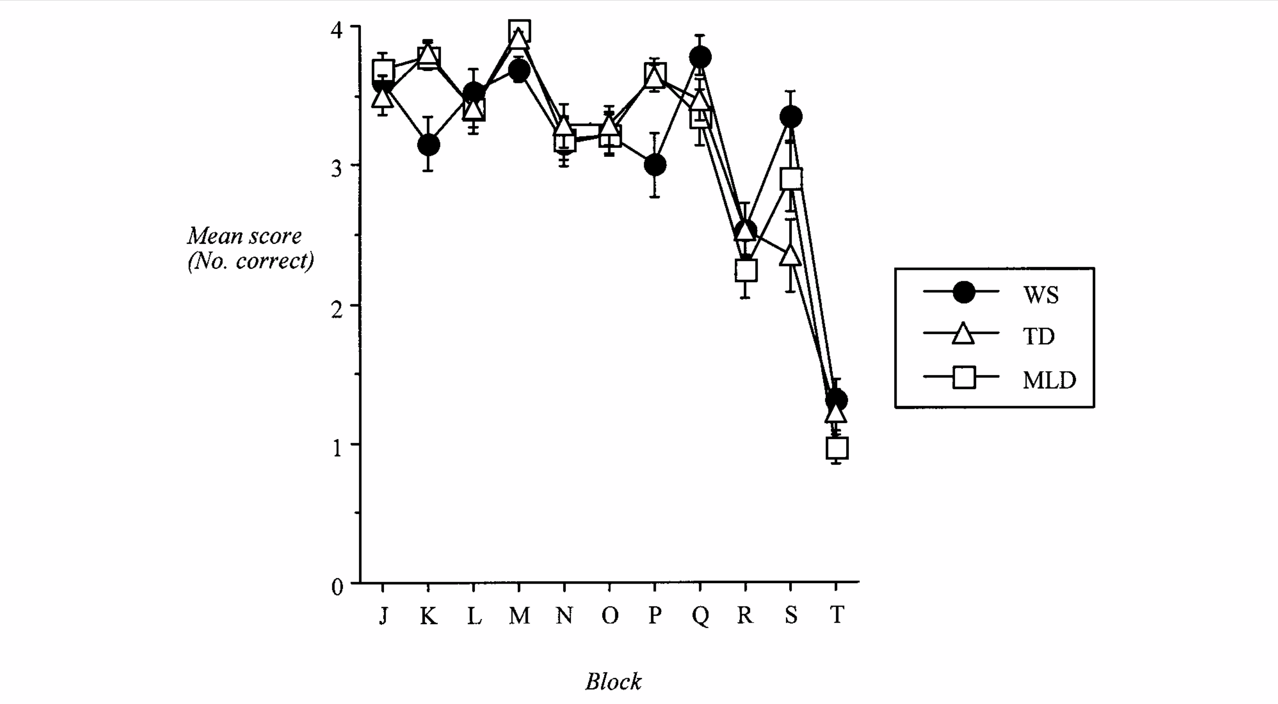

Fig. 1 – *Mean Score for Each Group on the 11 Blocks of the Task.*

TABLE I
Simple Main Effects and Scheffé Tests for Blocks J to T

	Simple main effect of group		Scheffé test (Williams syndrome vs. combined controls)	
Block	F (2, 93)	p	F (2, 93)	p*
J	0.46	.63	< 0.001	> 99
K	7.76	< .001	15.49	< .01
L	0.21	.81	0.41	.82
M	5.17	< .01	9.87	< .01
N	0.16	.85	0.16	.92
O	0.06	.94	0.03	.99
P	5.61	< .001	11.20	< .01
Q	1.87	.16	3.46	.18
R	0.69	.51	0.34	.84
S	4.76	.01	6.52	.04
T	1.48	.23	1.49	.48

* Note: p values for Scheffé tests with 3 groups are based on critical values of the F distribution which are double those that normally apply.

p = .01). A 'spatial' score derived from aggregate performance on blocks L, M and P was similarly not reliably related to age among individuals with Williams syndrome (r = – .17, df = 30, p = .37). The correlation between this measure and VMA approached significance (r = .30, df = 30, p = .10), while the correlation with RCPM score was significant (r = .44, df = 30, p = .01).

Discussion

The results from this initial study show that the individuals with Williams syndrome assessed here do have particular difficulty in comprehending the sentences presented in blocks; K, M, and P of the TROG. These individuals made more errors on these items that contain a spatial component than both typically developing children and children with moderate learning difficulties, who in comparison find these blocks relatively easy. In contrast, individuals with Williams syndrome performed as well as controls on the other blocks of the task, with the exception of block S where they showed superior performance. Although this might be seen as evidence of a relative strength in Williams syndrome on comprehension of negation (block S tests neither/nor, see appendix 1), individuals with Williams syndrome did not outperform controls on the other blocks testing comprehension of negation (blocks O and Q, see appendix 1). The absence of a group effect on these blocks may, of course, be due to ceiling effects in performance on these items, which as Figure 1 shows are slightly easier than those assessed in block S. The question of superiority in comprehension of negation will be returned to in the discussion of Study 2. However, it is worth noting that the matching procedure employed in the current study makes it inevitable that individuals with Williams syndrome will outperform controls on some blocks if they are impaired on others.

These results therefore confirm the indication of problems on blocks of the TROG with a spatial component that emerged from Clahsen and Almazan's (1998) anecdotal comments. As noted, these authors highlighted problems on blocks K and P. They did not pick up on any problems on block M, but the current data show that the group effect on this block is slightly smaller than that seen for blocks K and P and might therefore not be seen in small samples (see Table I). This may well be due to the fact that the absolute level of performance on block M is relatively high and close to ceiling, even among individuals with Williams syndrome (see Figure 1). Given that Clahsen and Almazan did not include controls in their examination of TROG performance, it is possible that an apparently high level of performance on this block did not appear anomalous in their sample. This may also account for why they noted problems with comprehension of neither and nor (block S), as this is one of the harder blocks where individuals do show lower levels of absolute performance (although it is certainly not the most difficult block). The current data show, however, that when compared to controls, this level of performance on neither/nor items is no poorer than one would normally expect, and if anything is superior to that seen in controls.

The clear results that emerge from this study therefore strongly suggest that individuals with Williams syndrome, who have particular problems on visuo-spatial tasks, also have difficulties with language with a spatial aspect. This effect was seen despite the large range in age of the individuals with Williams syndrome assessed here, which itself in part reflects the difficulties in recruiting a reasonable sample of individuals given the relative scarcity of the condition. In fact the analysis of predictors of performance in this group showed that age was unrelated to either total score on these blocks of the TROG or an aggregate spatial score from blocks L, M, and P. Instead, and perhaps unsurprisingly, these measures of performance were related to indices of verbal and non-verbal intelligence, which in Williams syndrome are not necessarily collinear with chronological age. Levels of intelligence in this group vary over a considerably smaller range than does age, although the variance in ability is still considerable.

Given this, the suggestion that individuals with Williams syndrome experience a particular problem in the comprehension of language with a spatial component certainly warrants further investigation. In addition, the TROG was designed specifically as an assessment of grammatical ability, not of comprehension of spatial and non-spatial terms specifically, and it only contains 3 blocks with an obvious spatial aspect. Consequently, a second study was designed to examine the comprehension of spatial and non-spatial terms in Williams syndrome in more detail. This involved designing a task, based loosely on the TROG, which included many more items with a spatial component. The findings from this first study also raise other important issues. First, when the TROG is used in assessment of grammar, individuals are typically only presented with a subset of the test blocks; testing stops when they fail a number of consecutive blocks. Given the problems seen here on blocks K, M and P, it is possible that previous assessments of grammatical competence in Williams syndrome which have used the TROG in this way may have potentially underestimated individuals' ability to comprehend grammatical constructs without a spatial aspect. This cannot be confirmed on the basis of the results of study 1, but was a further question addressed by the second study reported here. Second, the inclusion of more constructions involving negation allowed a more thorough test of whether comprehension of negative structures is a particular strength in Williams syndrome.

Study 2

Method

Participants

Fifteen individuals with the Williams syndrome phenotype, participated in this second study. All of these individuals had taken part in previous research projects associated with the first three authors, and lived in the South West of England. Eleven of these individuals had taken part in Study 1, but no individual was included or excluded from this second study on the basis of their performance in Study 1. The group consisted of 6 males and 9 females. Three of these participants had received positive 'fluorescence in situ hybridisation' (FISH) tests confirming deletion of the elastin gene on chromosome 7.

The performance of these individuals was compared with that shown by two control groups: 15 typically developing children from a mainstream school; and 15 children with moderate learning difficulties recruited from a school for children with special educational needs. Each individual with Williams syndrome was individually matched to one child in each of the two control groups, on the basis of VMA as assessed by the long form of the BPVS. In addition, individuals' non-verbal abilities were assessed by the RCPM. Because of the large range of ages within the Williams syndrome sample, it was not practical to match MLD controls for both VMA and chronological age. However, any differences in vocabulary IQ

TABLE II
Participant Details for Study 2

	Chronological age (months)		Vocabulary mental age (months)		RCPM score		RCPM approximate mental age (months)	
Group	Mean	*sd*	Mean	*sd*	Mean	*sd*	Mean	*sd*
WS	227.73	92.50	119.40	45.48	16.47	3.29	73.00	15.90
TD	95.40	15.84	103.87	24.12	22.60	6.43	96.20	28.16
MLD	158.87	29.88	110.07	28.82	22.67	6.82	95.10	27.20

between groups were controlled for statistically in the analyses presented below.

Summary details for chronological ages, mental age equivalent scores for the BPVS, and raw scores and approximate mental age equivalent values for the RCPM are given in Table II. Chronological ages of individuals with Williams syndrome were spread over a somewhat smaller range than in Study 1 (from 9 years 9 months to 31 years 3 months) although VMA was spread over a similar range (from 67 to 222 months). One-way ANOVA analyses indicated that there was no significant difference in VMA across the three groups [F (2, 42) = 0.79, p = .46]. There was, however, a significant group difference in RCPM raw scores [F (2, 42) = 5.78, p < .001], due to lower scores among the Williams syndrome group. In addition, the groups differed significantly in chronological age [F (2, 42) = 20.32, p < .001]; the TD group were younger than the MLD group who in turn were younger than the group of individuals with Williams syndrome (p < .05, Newman-Keuls tests). Analyses comparing mental age equivalent scores for the BPVS and the RCPM within each group confirmed that the Williams syndrome group showed significantly higher vocabulary than RCPM ages (t = 4.24, df = 14, p < .001) as would be expected given the average cognitive phenotype. The control groups showed no significant discrepancy between BPVS and RCPM ages (t = 1.93, df = 14, p = .07, MLD group; t = 1.52, df = 14, p = .15, TD group).

Procedure

For this study the 'Test For Receptive Understanding of Spatial Terms' (TRUST) was developed. This was based loosely on the format of the TROG, but contained many more items either with or without a spatial component. The spatial terms employed in the TROG – in, on, above, below and longer/bigger – were again assessed, but in this case with more trials testing each of these categories separately. In addition, comprehension of the terms behind, in front and shorter/smaller was also assessed to create 8 categories of spatial terms. Four non-spatial terms or constructions were taken from the TROG – reversible passives, X but not Y, not only X but also Y, neither X nor Y. These are the constructions tested in blocks L, O, Q and S of the TROG, and were selected for use here on the basis of being at least as difficult for typically developing individuals as the spatial terms from the TROG. The latter three of these non-spatial constructions are employed in the TROG with X and Y as the subjects of the statement on 50% of trials (e.g., 'the box but not the chair is red', 'not only the girl but also the cat is sitting') and as verb phrases on the other trials (e.g., 'the girl has not only food but also a drink', 'the pencil is neither long nor red'). In the TRUST, these two forms were distinguished from one another and tested as separate non-spatial categories. A further, novel non-spatial category was also included to give a total of 8 non-spatial categories. The comparatives 'darker than/lighter than' (in colour) were included as a comparison for the spatial comparatives (e.g., longer than/shorter than). The spatial and non-spatial categories used in the TRUST are shown in Table III. There were 96 items in total: 6 of each of the spatial and non-spatial categories. In contrast to the TROG, items were not presented in blocks. Instead trials from the different spatial and non-spatial categories were interleaved in a fixed, but unpredictable order, and participants were given a short break halfway through the task. The full list of statements used in the TRUST, in order of presentation, is given in appendix 2.

The TRUST was presented in essentially the same manner as the TROG, though in this case it

TABLE III
Categories of Spatial and Non-Spatial Terms Used in the TRUST

Key	Spatial terms	Non-spatial terms
1	above	lighter/darker
2	below	neither X nor Y is.....
3	in	.....is neither X nor Y
4	on	not only X but also Y is.....
5	behind	..... is not only X but also Y
6	in front of	reversible passive (X is pushed by Y)
7	shorter/smaller	X but not Y is.....
8	longer/bigger	..... is X but not Y

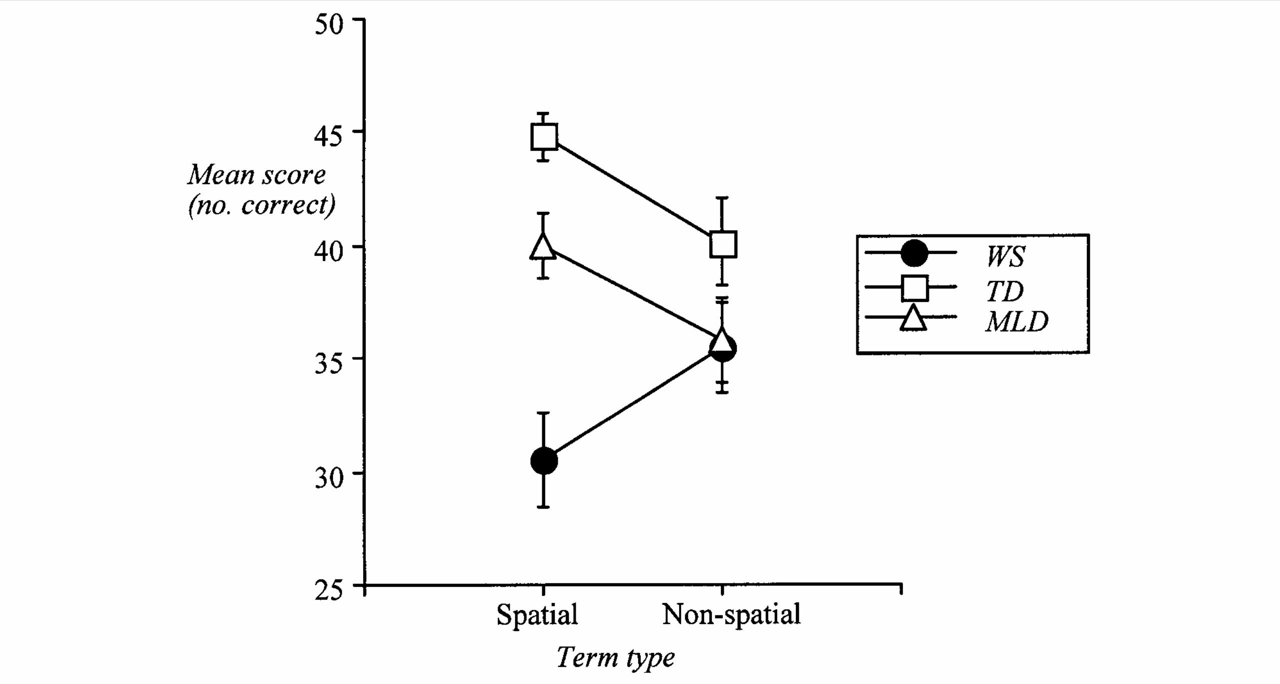

Fig. 2 – *Mean Score for Each Group on Spatial and Non-Spatial Terms.*

was computerised using Hypercard experimental software presented on a Macintosh Powerbook. On each trial the participant was presented with four pictures displayed in the four quadrants of the screen, and heard a sentence spoken by the computer (a recorded sample of the experimenter's natural speech). The participant was then asked to point to the picture that they believed to be the correct representation of the sentence. Each picture showed easily identifiable and discriminable line drawings of common objects. These were drawn in appropriate colours to facilitate identification, with the exception of trials were colour was used to discriminate the target picture from the other incorrect pictures (e.g., 'Neither the square nor the circle is blue'). In these instances, objects without a characteristic natural colour were employed. The majority of correct, target pictures contained two objects. This was the case for all the spatial items, where one object was necessarily in a spatial relation to another, and for non-spatial items with two subjects (non-spatial categories 1, 2, 4, 6, and 7, see Table III). On the other trials, only one object was shown in each target picture. Care was taken to ensure that trials could not be solved simply on the basis of semantic association between items, and consequently objects were not always drawn to scale or in a typical relationship. This allowed for the use of counter-intuitive sentences such as 'The dog is smaller than the hen' (see appendix 2).

The three distractor pictures were created so that the task mirrored the TROG in its design. All three distractor pictures contained the same objects that were present in the target picture, but in a different arrangement or with modifications appropriate to the target sentence. In each case, one distractor picture showed the exact opposite scene to that described by the target sentence. For spatial items this simply involved the opposite positioning of the two objects in relation to one another. For non-spatial items the logical opposite of the statement was depicted (e.g., 'neither X nor Y is' – became 'both X and Y are'; 'is X but not Y' became 'is Y but not X'). The other two distractor pictures presented on each trial were neutral foils. For spatial categories 1 to 6 (see Table III) these involved the same two objects being shown alongside each other but not in the correct (or opposite) spatial relationship. For categories 7 and 8 the objects were drawn to the same size and placed alongside each other with their relative positions (to left or right, or above or below) switched in the two foil pictures. Non-spatial foil pictures depicted a state of affairs in between the true and opposite depictions of the target statement. So, for example, in the case of the statement 'The box but not the cup is green', one foil showed both objects in green, and the other showed both objects in purple. The position of the correct and opposite pictures was varied in a fixed and pseudo-random order across trials, with the constraint that the target and opposite picture occurred approximately equally often in each of the four screen positions throughout the task (each occurring in each position on between 22 and 27 occasions).

Results

Figure 2 plots the mean performance of each group on the spatial and non-spatial terms of the TRUST. These data were analysed with a two

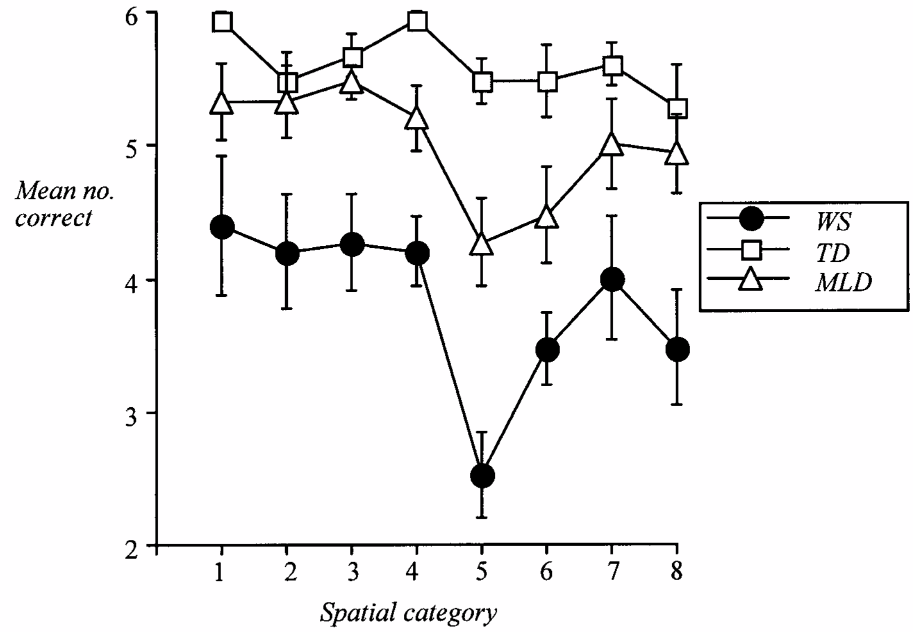

Fig. 3 – *Mean Score on the 8 Spatial Categories.*

factor ANOVA design, with the factors of group (independent measures, 3 levels) and term type (repeated measures, 2 levels). This revealed a significant main effect of group [F (2, 42) = 8.16, p < .001], due to poorer performance among individuals with Williams syndrome than typically developing individuals (p < .01, post-hoc Newman-Keuls test). The main effect of term type was non-significant [F (1, 42) = 2.93, p = .10], but there was a significant interaction between group and term type [F (2, 42) = 16.62, p < .001].

The cause of this interaction was explored by post-hoc analysis of simple effects. Both the TD group [F (1, 14) = 10.04, p < .01] and the MLD group [F (1, 14) = 13.21, p < .01] made significantly fewer errors on the spatial terms than they did on the non-spatial terms. The Williams syndrome group, however, showed the opposite pattern, making significantly more errors on spatial as opposed to non-spatial terms [F (1, 14) = 13.63, p < .01]. The effect of group on performance on the non-spatial terms was not significant [F (2, 42) = 1.76, p = .18]. In contrast, there was a significant effect of group for the spatial terms [F (2, 42) = 20.80, p < .001]. A Scheffé test comparing the performance of the Williams syndrome group with the combined performance of the 2 control groups, confirmed that the Williams syndrome group scored significantly lower than the controls on the spatial terms [F (2, 42) = 37.05, p < .001].

Among individuals with Williams syndrome, chronological age was not significantly related to performance on either spatial (Pearson's r = .14, df = 13, p = .63) or non-spatial items (r = .30, df = 13, p = .28). VMA was reliably related to performance on both term types (r = .59, r = .57 respectively, df = 13, p = .02), while RCPM score was somewhat more closely related to performance on spatial (r = .64, df = 15, p = .01) than non-spatial (r = .50, df = 13, p = .06) items. As groups were matched for VMA it is not possible that differences in this measure could cause the group effect for comprehension of spatial terms. However, analyses of covariance were conducted to determine whether group differences in RCPM score or vocabulary IQ might account for this effect. When entered as separate covariates, neither RCPM score [F (2, 41) = 12.88, p < .001] or vocabulary IQ [F (2, 41) = 5.63, p < .01] removed the reliable group effect for comprehension of spatial terms.

Two additional analyses explored the pattern of performance shown by each group on the different categories of spatial and non-spatial terms respectively. Figure 3 shows the performance of each group on the 8 separate spatial categories (see Table III for a key to the category type). These data were analysed using a two factor ANOVA design, with the factors of group (independent measures, 3 levels) and spatial category (repeated measures, 8 levels). This revealed a significant man effect of group [F (2, 42) = 20.80, p < .001], due to poorer performance among the individuals with Williams syndrome than controls (p < .001, Scheffé test). The main effect of spatial category was also significant [F (7, 294) = 7.80, p < .001]. However, there was no significant group by spatial category interaction [F (14, 294) = 1.34, p = .18].

A similar analysis was performed on the data for the 8 non-spatial categories, which are shown in Figure 4. This revealed a non-significant main effect of group [F (2, 42) = 1.76, p = .18]. The main effect

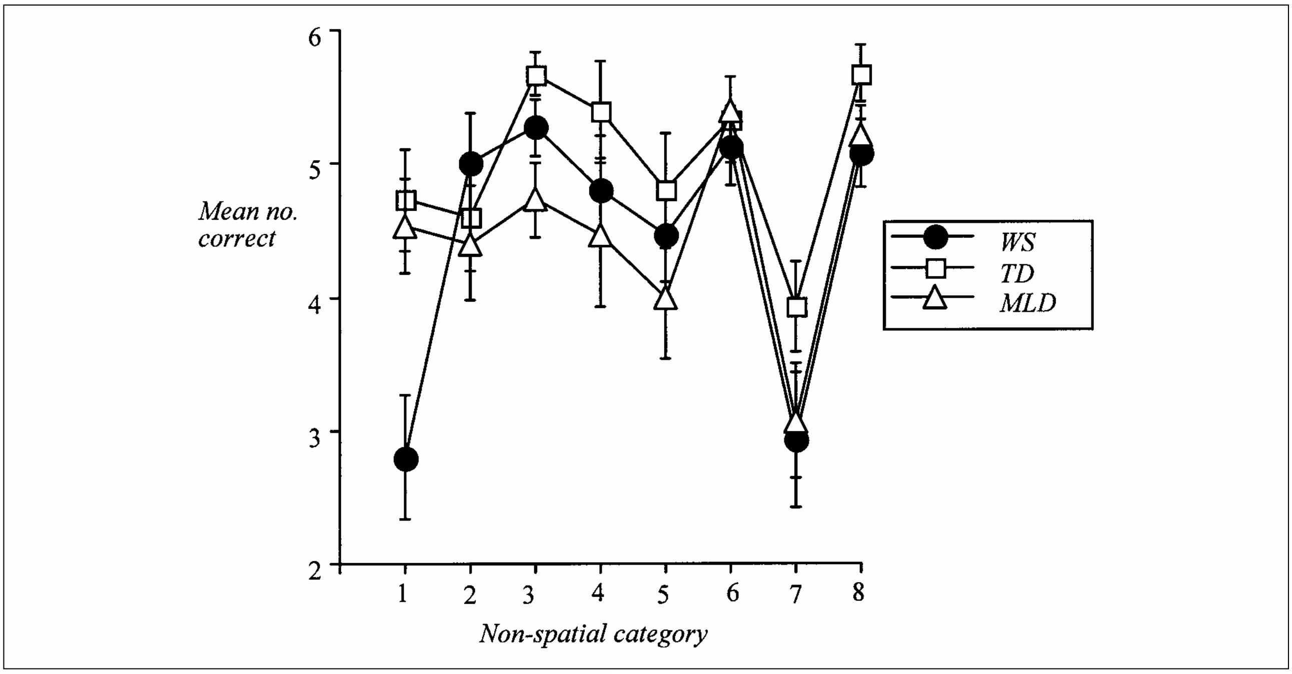

Fig. 4 – *Mean Score on the 8 Non-Spatial Categories.*

of non-spatial category was significant [F (7, 294) = 17.76, p < .001], as was the group by non-spatial category interaction [F (14, 294) = 2.38, p < .01]. This interaction was explored by post-hoc analysis of simple effects, which revealed significant effects of group for categories 1 [lighter/darker, F (2, 42) = 6.91, p < .001] and 3 [neither x nor y, F (2, 42) = 4.43, p < .02], in contrast to non-significant effects of group for the other categories [F (2, 42) = 1.91, p = .16]. These two significant group effects were examined further by Scheffé tests comparing the performance of the individuals with Williams syndrome to that of the combined controls. This confirmed that the Williams syndrome group were impaired on category 1, lighter/darker [F (2, 42) = 13.70, p < .01], but indicated that they were unimpaired relative to controls on category 3 [F (1, 42) = 0.06, p = .97]. Instead the group effect for this category reflected a difference in performance between the MLD and TD groups (see Figure 4). Further, analysis of covariance controlling for individual differences in vocabulary IQ did not remove the reliable group effect on performance on non-spatial category 1 [F (2, 41) = 3.47, p = .04]. However, when RCPM score was entered as a covariate, this group effect was reduced to a non-significant level [F (2, 41) = 2.24, p = .12].

A final analysis explored the pattern of errors made by individuals from each group across spatial and non-spatial terms. As noted above, when an individual made an error on any trial this could be of one of two types. They might select the one item that corresponded to the opposite of the spoken description, or they might select one of the two remaining foils. The analysis focussed on the *proportion* of 'opposite' errors made by individuals from each group, in order to control for the differences in overall levels of performance observed above (note, chance performance for this measure is .333). It was not possible to conduct this analysis at the level of the different categories of spatial and non-spatial terms (cf. Figures 3 and 4), because a number of individuals in each group made no errors within particular categories. Instead, errors were aggregated and proportionalised at the level of term type (spatial and non-spatial). Even at this level, 3 typically developing individuals made no errors on the spatial items, and their error data for both term types were excluded from the analysis. Figure 5 plots the mean proportions of 'opposite' errors for the remaining participants. One-sample t-tests showed that the probability of making an opposite error for spatial terms was significantly greater than chance for individuals with Williams syndrome [*t* (14) = 10.56, p < .001] and with MLD [*t* (14) = 2.30, p = .04], but not for typically developing individuals [*t* (11) = 1.15, p = .27]. In the case of non-spatial terms, the probability of making an opposite error was not significantly different from chance for either both clinical groups [*t* (14) = .47, p = .65 in both cases], or for typically developing individuals, although the difference approached significance in this latter instance [*t* (11) = 2.19, p = .051].

These data were further analysed using a two factor ANOVA design, with the factors of group (independent measures, 3 levels) and term type (repeated measures, 2 levels).This revealed a non-significant main effect of group [F (2, 39) = 0.39, p = .68], and a significant main effect of term type [F (1, 39) = 10.85, p < .01] due to a larger proportion of opposite errors on the spatial rather than non-spatial items. The group by term type interaction was significant [F (2, 39) = 5.69,

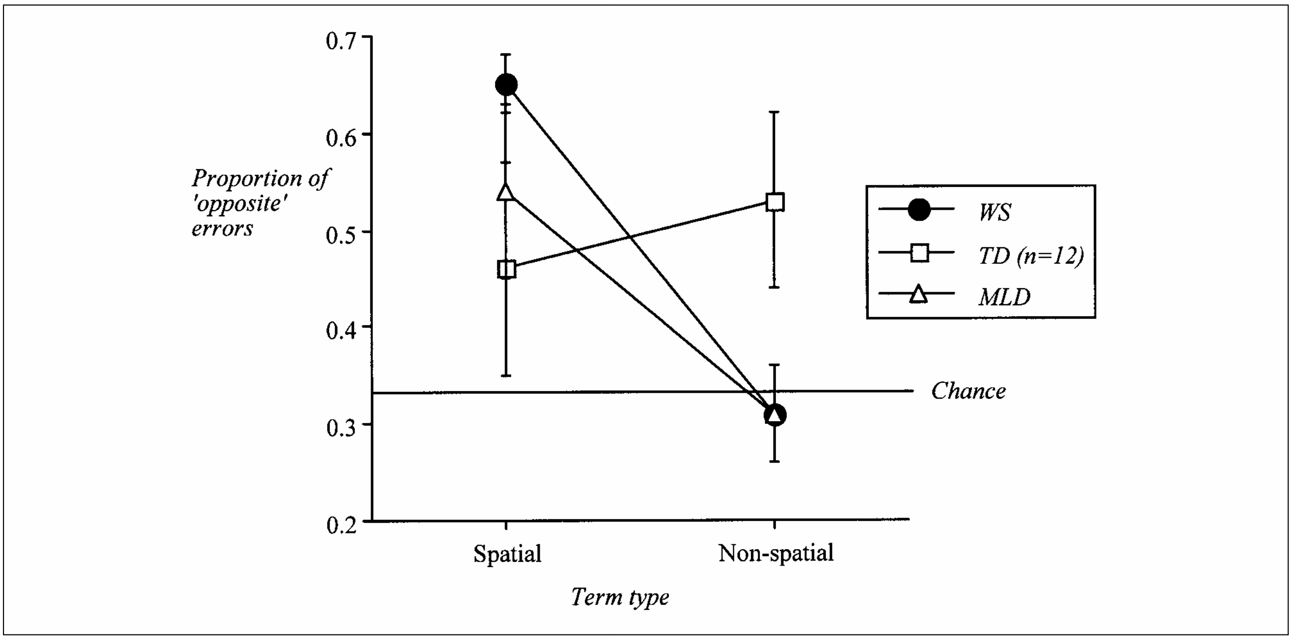

Fig. 5 – *Proportion of Opposite Errors Made by Each Group on Spatial and Non-Spatial Terms.*

$p < .01$]. *Post-hoc* analysis of simple effects showed that the effect of group was not-significant for proportion of opposite errors made in response to spatial terms [F (2, 39) = 1.40, p = .26], but was significant for non-spatial terms [F (2, 39) = 3.70, p = .03] due to relatively more opposite errors being made on these items by typically developing individuals than members of the other two groups ($p < .05$, Newman-Keuls tests). In addition, the effect of term type described above was reliably observed for both individuals with Williams syndrome [F (1, 14) = 40.58, $p < .001$] and with MLD [F (1, 14) = 10.64, $p < .01$], but not for typically developing individuals [F (1, 11) = .28, p = .61]. A further analysis comparing the two clinical groups only showed that the magnitude of the term type effect was comparable among these individuals [F (1, 28) = 1.77, p = .19, group by term type interaction].

Discussion

The results from this second study support those of study 1, and confirm that individuals with Williams syndrome have relatively specific difficulties in making sense of spoken descriptions of spatial relationships. Individuals with Williams syndrome were impaired in their comprehension of spatial terms relative to controls, despite the fact that all three groups were matched for level of receptive vocabulary. This indicates that this problem is not the result of any general language difficulty associated with Williams syndrome, a point that is emphasised by the finding that the deficit observed here did not extend to non-spatial terms. In contrast to controls, individuals with Williams syndrome made significantly fewer errors on non-spatial as opposed to spatial terms. In fact, the three groups performed comparably on the non-spatial terms, indicating that comprehension of general spoken descriptions in this sample of individuals with Williams syndrome is in line with levels of receptive vocabulary.

Although the three groups employed in this study differed in age, and therefore in vocabulary IQ given the matching for vocabulary level, it is important to note that this discrepancy cannot explain the findings obtained here. First, for difference in IQ to account for this pattern of specific impairment, vocabulary IQ would have to be more closely related to comprehension of spatial than non-spatial terms; there is no obvious reason for suspecting this to be the case. Second, the data themselves suggest that IQ differences are unrelated to problems with comprehension of spatial terms. The individuals with MLD were necessarily older than the typically developing individuals, and therefore these groups differed significantly in their IQ level. Despite this, these two control groups showed entirely similar patterns of performance on the two types of terms, with no evidence of a particular problem in comprehension of spatial terms in the MLD group (see Figure 2). In addition, an analysis of covariance that directly controlled for differences in verbal IQ across the groups did not remove the group effect on performance with spatial terms. It therefore appears that individuals with Williams syndrome do have particular problems in comprehending verbal descriptions with a spatial component.

Having said that, it is worth noting that despite this difference in performance, when individuals with Williams syndrome make errors on this task they do so in a way that matches that seen among individuals with MLD. Figure 5 shows that both of these groups tend to choose the picture that depicts the exact opposite of a spatial term when they fail to select the correct picture, doing so reliably more often than would be expected by chance. This indicates that these individuals are making systematic errors, which in turn suggests that they do not have any particular difficulty in understanding the broad sense of what a term refers to – 'behind' and 'in front of' involve occlusion for example. Instead their difficulties are presumably either in discriminating these terms from one another, or in representing the ordering of the relation between the two objects. In contrast, when these individuals make errors on the non-spatial items these seem to be less systematic; in this case opposing depictions are not selected any more often than would be expected by chance. This may reflect a more basic difficulty with the semantics of these items. The fact that typically developing individuals differ from the two clinical groups in making significantly more opposite errors for non-spatial items than one would expect by chance might suggest a slightly advanced understanding of these terms. This, in turn, would be consistent with the slightly elevated level of absolute performance in this group (see Figure 1).

Two other important aspects of these data are seen in the pattern of correct performance of all three groups on the various non-spatial categories (Figure 4). First, although the groups performed at the same overall level on non-spatial terms, the individuals with Williams syndrome showed a different pattern of relative difficulty across these categories. Individuals with Williams syndrome made significantly more errors on terms from non-spatial category 1, which tested comprehension of 'lighter than' and 'darker than'. The implications of this particular finding are discussed below, but it is worth emphasising that scores from this category are included in individuals' overall non-spatial score (see Figure 2). If this one category were to be excluded, then the performance of individuals with Williams syndrome on the remaining non-spatial terms would be even more comparable to that shown by controls of an equivalent level of vocabulary. Second, and relatedly, the comparability of performance across groups on the other non-spatial items suggests that individuals with Williams syndrome do not have a particular strength, at least relative to receptive vocabulary level, in the comprehension of negation (tested in categories 2-5 and 7 and 8). This in turn suggests that the finding of superior performance on block S of the TROG in Study 1 may be an unsystematic consequence of the matching procedure employed there.

General Discussion

The two studies presented here examined the ability of individuals with Williams syndrome to understand spoken spatial terms such as locative prepositions and comparative adjectives. The findings from both studies provide strong evidence that people with Williams syndrome have particular difficulties with these descriptions. The first study showed that even when the Williams syndrome group were performing at the same overall level as the two control groups on a test of receptive grammar, they made more errors on items that contained spatial terms. The second study strengthened these findings by demonstrating again how individuals with Williams syndrome had particular difficulties in comprehending spatial descriptions. In contrast to controls, the Williams syndrome group performed less well on spatial descriptions compared to descriptions that did not contain a spatial element. They also performed at a significantly lower level than the two control groups on these spatial terms.

These results are broadly consistent with those of Lichtenberger and Bellugi (1998) and Landau and Zukowski (2003), who have also looked at the relationship between spatial abilities and language in Williams syndrome. Lichtenberger and Bellugi (1998) asked participants with Williams syndrome to generate verbal descriptions of the spatial relationships between items, or to pick out visual representations of spoken prepositions. They report that participants with Williams syndrome made more errors on both of these tasks relative to a group of typically developing individuals, although it is not clear how the two participant groups were matched in this study (see also Bellugi et al., 2000). Landau and Zukowski (2003) compared 12 children with Williams syndrome to typically developing children matched for mental age, as well as typically developing adults, on a task in which participants were asked to describe 80 simple videotaped motion events. Forty of these events involved one object moving in relation to another (for example, the paper floats into the box). Individuals with Williams syndrome were able to label the component objects in these events (paper, box), and almost never (2 occasions only) switched the syntactic roles of the two objects (e.g., the box floats into the paper). They also described the manner of motion comparably to controls (see also Jordan et al., 2000). However, when describing the path taken by one object in relation to another, individuals with Williams syndrome, although sensitive to variations in path type, produced significantly fewer correct path terms than their matched controls. These individuals showed a tendency ($p = .07$) to produce 'incorrect' path terms, and also produced ambiguous path terms or omitted a path term significantly more often than controls. Landau and Zukowski (2003) argue that these strengths in describing objects and manner of motion indicate that individuals with Williams syndrome are relatively unimpaired in ascribing certain semantic and syntactic roles in spatial utterances. However, they suggest that on-line problems in representing and reconstructing spatial relationships on which to base production of utterances may be impaired in Williams syndrome, leading to 'fragility' in path descriptions.

Taken together, these results indicate that individuals with Williams syndrome have problems comprehending spatial descriptions, which in turn suggests that their particular difficulties in spatial awareness impinge on aspects of their language performance. This is an important point to emphasise, given that previous reviews of the cognitive phenotype of Williams syndrome have tended to highlight the dissociation between verbal and non-verbal abilities (e.g., Bellugi et al., 1994, 1996; Flavell et al., 1993; Levy, 1996; Pinker 1994). The current data show that these two domains are not necessarily as distinct from one another as has typically been thought.

What is less apparent from the present findings is the means by which spatial difficulties interact with language performance in Williams syndrome. This is clearly an area for further research, but there appear to be two main interpretations of the data presented here. The first is that this interaction is a reflection of conceptual difficulties in the comprehension of space rather than in any fundamentally linguistic difficulty with spatial language per se. In other words, it is perhaps unsurprising that individuals with Williams syndrome have difficulty in making sense of spoken language that takes as its content a domain which is problematic for them. In the same way, one might well have difficulties comprehending a discussion of, say, quantum physics if not a specialist in that area, regardless of one's general level of language ability. Alternatively, it may be that spatial difficulties in Williams syndrome interact in a more fundamental way with the 'on-line' comprehension of spoken descriptions of space (cf. Hayward and Tarr, 1995; Landau and Jackendoff, 1993; Talmy, 1983). In particular, it is possible that individuals with Williams syndrome have difficulty in constructing spatial 'mental models' of verbal descriptions of space (cf. Johnson-Laird, 1983; Johnson-Laird and Byrne, 1991; Tversky, 1991).

As noted, the current data cannot decide conclusively between these two possibilities, although they and the results of Landau and Zukowski's (2003) study provide tentative reasons for favouring the mental model account. First, Landau and Zukowski argued that aspects of spatial semantics are intact in Williams syndrome. In line with this, the error patterns seen for spatial items of the TRUST task employed in the current Study 2 suggests that individuals with Williams syndrome, and individuals with MLD, do have some grasp of the semantics of spatial terms when they fail to select the correct response. However, although these two groups appeared to adopt the same approach to this task, the individuals with Williams syndrome clearly applied this approach less successfully. Second, the data from Study 2 also suggested that individuals with Williams syndrome had problems in comprehending comparative adjectives regardless of whether they are obviously spatial in nature or not. One possible reading of this result is that comprehension of all comparative adjectives requires the creation of an on-line internal spatial representation. There is certainly evidence that adults apply spatial directions to certain non-spatial comparatives (e.g., Boroditsky, 2000). For example, when asked to place the terms "better" and "worse" into a two-dimensional horizontal-vertical axis, people tend to place better at the top of the vertical axis and worse at the bottom (De Soto et al., 1965). It is therefore possible that individuals with Williams syndrome have difficulty in making sense of comparative adjectives because comprehension of such terms typically involves relational reasoning based upon a spatial mental model of the comparison (Evans et al., 1993; Knauff and Johnson-Laird, 2002). This would be consistent with Landau and Zukowski's suggestion that the creation of on-line spatial representations is problematic for individuals with Williams syndrome.

At present this can only be a tentative interpretation of this particular finding, as our second experiment only assessed comprehension of one pair of non-spatial comparatives – lighter than and darker than. To be confident that comprehension of non-spatial comparatives is impaired in Williams syndrome one would certainly want additional data from additional terms such as older/younger than, lighter/heavier than, etc. In addition, in order to be certain that this problem is related to spatial mental model creation one would need to show that individuals with Williams syndrome do not suffer from some general difficulty in relational reasoning. However, if this were confirmed it would provide further evidence that individuals typically create on-line mental models to reason about spoken descriptions of space, and, crucially, would also indicate that the creation of such models is dependent on individual variation in general spatial ability. In addition, this line of research would provide further indication of the conditions under which otherwise strong language skills in Williams syndrome are adversely affected by spatial difficulties, with consequent implications for day-to-day functioning and educational practice.

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Chris Jarrold, Centre for the Study of Memory and Learning, Department of Experimental Psychology, University of Bristol, 8 Woodland Road, Bristol BS8 1TN, UK. e-mail: C.Jarrold@bristol.ac.uk

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APPENDIX 1

The blocks of the TROG: note only blocks J to T employed in Study 1

Block	Grammatical construction(s) tested
A	Noun
B	Verb
C	Adjective
D	Two element combination
E	Negative
F	Three element combination
G	Singular/plural personal pronoun
H	Reversible active
I	Masculine/feminine personal pronoun
J	Singular/plural noun inflection
K	Comparative/absolute (longer/bigger/taller)
L	Reversible passive
M	In and on
N	Postmodified subject
O	X but not Y
P	Above and below
Q	Not only X but also Y
R	Relative clause
S	Neither X nor Y
T	Embedded sentence

APPENDIX 2

Items of the TRUST

Item	Target sentence	Category
1	The telephone is behind the banana.	Spatial 5
2	The snowman has not only a scarf but also a hat.	Non-spatial 5
3	The banana but not the umbrella is blue.	Non-spatial 7
4	The toothbrush is longer than the pencil.	Spatial 8
5	The pig is pushed by the dog.	Non-spatial 6
6	The fish is above the toothbrush.	Spatial 1
7	The snowman is shorter than the penguin.	Spatial 7
8	The bottle has a top but no label.	Non-spatial 8
9	The flower is bigger than the hen.	Spatial 8
10	The hat is lighter than the boot.	Non-spatial 1
11	Neither the dog nor the pig is sitting.	Non-spatial 2
12	Neither the square nor the circle is blue.	Non-spatial 2
13	The apple is below the well.	Spatial 2
14	The dog is in front of the house.	Spatial 6
15	Not only the boat but also the well is red.	Non-spatial 4
16	The snowman is behind the rabbit.	Spatial 5
17	The cake has neither a cherry nor candles.	Non-spatial 3
18	The box is behind the penguin.	Spatial 5
19	The apple is not only green but also red.	Non-spatial 5
20	The hat is on the pencil.	Spatial 4
21	The square is in the circle.	Spatial 3
22	The boat is in front of the banana.	Spatial 6
23	The dog but not the hen is sitting.	Non-spatial 7
24	The dog is darker than the rabbit.	Non-spatial 1
25	The duck is above the boat.	Spatial 1
26	The frog is orange but not spotty.	Non-spatial 8
27	The rabbit is pushed by the snail.	Non-spatial 6
28	The box is in the cup.	Spatial 3
29	The dog is smaller than the hen.	Spatial 7
30	The frog is pushed by the bird.	Non-spatial 6
31	The bird is below the flower.	Spatial 2
32	Not only the knife but also the toothbrush is yellow.	Non-spatial 4
33	The snowman is bigger than the house.	Spatial 8
34	The book is on the chair.	Spatial 4
35	Neither the chair nor the drum is green.	Non-spatial 2
36	Not only the square but also the circle is yellow.	Non-spatial 4
37	The pencil but not the phone is red.	Non-spatial 7
38	The boot is smaller than the bird.	Spatial 7
39	The monkey has not only food but also a drink.	Non-spatial 5
40	The ruler is below the pencil.	Spatial 2
41	The stool is shorter than the chair.	Spatial 7
42	The frog is darker than the hen.	Non-spatial 1
43	The circle is in front of the square.	Spatial 6

Item	Target sentence	Category
44	The phone is above the pig.	Spatial 1
45	The strawberry is neither blue nor red.	Non-spatial 3
46	The pencil is neither blue nor striped.	Non-spatial 3
47	The book is behind the pig.	Spatial 5
48	The house has neither windows nor doors.	Non-spatial 3
49	The ruler but not the toothbrush is red.	Non-spatial 7
50	The apple is in the basket.	Spatial 3
51	The frog is above the well.	Spatial 1
52	The snail is in front of the hat.	Spatial 6
53	The bird is on the box.	Spatial 4
54	The pig is muddy but not pink.	Non-spatial 8
55	The bottle is in the boat.	Spatial 3
56	The basket is lighter than the flower.	Non-spatial 1
57	The dog is below the drum.	Spatial 2
58	The house has not only windows but also a door.	Non-spatial 5
59	Not only the hat but also the boot is grey.	Non-spatial 4
60	The book has a name but no picture.	Non-spatial 8
61	The duck is in front of the well.	Spatial 6
62	The frog is smaller than the strawberry.	Spatial 7
63	The boat is pushed by the duck.	Non-spatial 6
64	Neither the hen nor the duck is standing.	Non-spatial 2
65	The knife is longer than the ruler.	Spatial 8
66	The monkey has neither food nor a drink.	Non-spatial 3
67	The strawberry is on the snail.	Spatial 4
68	The monkey is behind the drum.	Spatial 5
69	The toothbrush is below the knife.	Spatial 2
70	The boat is pushed by the fish.	Non-spatial 6
71	The strawberry is in the circle.	Spatial 3
72	The circle is not only yellow but also orange.	Non-spatial 5
73	The duck is sitting but not eating.	Non-spatial 8
74	The foot is longer than the fish.	Spatial 8
75	Not only the chair but also the stool is red.	Non-spatial 4
76	The umbrella is above the snowman.	Spatial 1
77	Neither the flower nor the fish is pink.	Non-spatial 2
78	The penguin is pushed by the dog.	Non-spatial 6
79	The umbrella is lighter than the bottle.	Non-spatial 1
80	The pig but not the foot is blue.	Non-spatial 7
81	The telephone is in front of the boot.	Spatial 6
82	The hen is on the hat.	Spatial 4
83	The cake has not only candles but also a cherry.	Non-spatial 5
84	The box but not the cup is green.	Non-spatial 7
85	The banana is below the apple.	Spatial 2
86	The fish is shorter than the pencil.	Spatial 7
87	The square is in the apple.	Spatial 3
88	Not only the dog but also the hen is sitting.	Non-spatial 4
89	The apple is behind the cup.	Spatial 5
90	The snail is darker than the fish.	Non-spatial 1
91	The square is green but not striped.	Non-spatial 8
92	The snowman has neither a hat nor a scarf.	Non-spatial 3
93	The stool is on the frog.	Spatial 4
94	Neither the hat nor the boot is black.	Non-spatial 2
95	The strawberry is above the cake.	Spatial 1
96	The bottle is bigger than the book.	Spatial 8