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Spatial language in Williams Syndrome: Evidence for a special interaction?*

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ABSTRACT

We present data on the language of space in Hungarian individuals with Williams syndrome (WS; 19 in the first, 15 in the second study, between 8;0 and 21;11) and a verbal control (VC) group of typically

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developing (TD; 19 in the first, 15 in the second study, between 3;5 and 10;7) children from: (1) a study of elicited production and comprehension of spatial terms; and (2) a sentence completion task on case markers in their spatial and non-spatial use. The first study showed poorer performance in the WS group, but similar performance patterns and a special difficulty of SOURCE terms in both groups. We did not find overall group differences in the second study. We argue that WS performance patterns reflect WS spatial abilities and seem to be constrained by the same factors in WS as in TD. Results also lead us to conclude that, contrary to most previous claims, there is no selective deficit of spatial terms within WS language, and they also suggest that not all uses of spatial terms require activation of mental models of space.

INTRODUCTION

Williams syndrome (WS) is a rare (1 in 25 000) genetically-based condition caused by hemizygous micro-deletion of genes on the long arm of chromosome 7. Physical characteristics include typical facial features, joint limitations, endocrine and cardiovascular problems, infantile hypercalcemia and supravalvular aortic stenosis (Williams, Barratt-Boyes & Lowe, 1961). Individuals with WS typically live with mild to moderate mental retardation, with an average IQ of 56, but the WS phenotype is also characterized by a very specific pattern of behavioral and cognitive strengths and weaknesses. In contrast to serious deficits in cognitive domains in general, children with this syndrome have surprisingly good language abilities not typically found in other groups with mental retardation. While early research emphasized the selective intactness of language (e.g. Bellugi, Wang & Jernigan, 1994), or more specifically, grammar in WS (Clahsen & Almazán, 1998; Clahsen & Temple, 2003), the majority of research now shows that although linguistic performance in WS is undoubtedly impressive, it lags behind that of age matched, and sometimes even mental age matched TD controls (e.g. Volterra, Capirci, Pezzini, Sabbadini & Vicari, 1996; Lukács, 2005), and the trajectory of language acquisition can be atypical too (Karmiloff-Smith *et al.*, 1998; Thomas & Karmiloff-Smith, 2002).

In sharpest contrast to good language abilities, people with WS show serious deficits in spatial cognition and motor skill learning. Visuospatial abilities usually lag behind expectations based on mental age. In everyday life, they have problems finding their way even in simple or familiar settings, and their drawing abilities are poor. Several studies have shown that in WS spatial short-term memory span is severely reduced relative to verbal span (Wang & Bellugi, 1994; Jarrold, Baddeley & Hewes, 1999; Racsmány, Lukács & Pléh, 2002; Racsmány, 2004). People with WS tend to perform especially low on tasks requiring visuospatial construction (like block design tasks), and it has been proposed that they have a deficit in processing configural spatial organizations, showing a bias towards local features in visual displays (Bihrle, Bellugi, Delis & Marks, 1989; e.g. when they are asked to copy an image of a large D built up from small Ys, they tend to reproduce the Y in drawing). WS drawings are often disconnected parts of an object juxtaposed on the paper. Pani, Mervis & Robinson (1999) though, found in a visual search task that was sensitive to global organization that people with WS do not have a difficulty in perceiving global structure per se, but rather in switching from one level of organization to the other. These controversial findings seem to be resolved by a study of Farran & Jarrold (2003), who found that local bias in WS is not manifest in identification, but presents itself in drawing, suggesting that the problem does not reside at the perceptual level, but rather in relying on spatial relations necessary for integrating parts of an image in drawing. Despite their visuospatial organization problems, individuals with WS show surprisingly excellent performance in face recognition, which might indicate dissociation in the involvement of the dorsal and ventral brain streams responsible for visual processing (Atkinson, King, Braddick, Nokes, Anker & Braddick, 1997).

Because of the exceptional combination of a severe spatial impairment and relatively good language characteristic of WS, most researchers of WS spatial language expect WS data to bear on the issue of the nature of the relationship between language and thought. Spatial language in WS can be poor like spatial cognition, it can be strong like language, or as Landau & Zukowski (2003) point out, there is the possibility between the two extremes that 'spatial language may be selectively impaired in ways that closely reflect the nature of the non-linguistic spatial deficit' (p. 105).

Several studies have concluded that there is a selective deficit of spatial terms in language in WS. Some of these pointed out that children with WS have especially low scores on spatial items on the TROG (Test for the Reception of Grammar, Bishop, 1983) on the following blocks: K (*longer/bigger/taller*), M (*in/on*) and P (*above/below*) (e.g. Clahsen & Almazan, 1998; Phillips, Jarrold, Baddeley, Grant & Karmiloff-Smith, 2004). Italian children made several preposition errors in a Sentence Repetition test, which were also quite unlike anything seen in TD children: e.g. *The grandchildren pick up flowers with their grandmother* → *The grandchildren pick up flowers *on top of the grandmother* (Volterra *et al.*, 1996). Phillips and her colleagues tested participants on the understanding of both spatial and non-spatial comparisons (*above* or *lighter*), presented in the TROG format, but with a larger sample of both spatial and non-spatial items. Subjects with WS had lower scores than either TD children or subjects with mild learning difficulty.

Lichtenberger & Bellugi (1998) found that subjects with WS performed poorer on both comprehension and production of spatial terms than younger TD controls. In the production task, to describe a scene where an apple is in a bowl, subjects with WS gave answers like *apple without the bowl*, *the bowl is in the apple* and *the apple is around the bowl*. They made errors where they reversed Figure and Ground in the description, while retaining the preposition (e.g. *the bowl is in the apple*), used the opposite preposition (*the apple is around the bowl*) or gave completely inappropriate answers. Several of their answers were atypical, and never produced by TD children, whose errors mostly involved giving a response that was too general. Bellugi, Lichtenberger, Jones & Lai (2000) conclude that 'it appears that individuals with WS in particular may be having difficulty in the mapping between spatial representation and language representation' (p. 23). Another possibility is that they do not have any specific difficulty in MAPPING between the two representations; it is the spatial representations that are impaired or underspecified, which, then, even without a problem in mapping, result in inappropriate linguistic descriptions.

Other authors (Volterra *et al.*, 1996; Phillips *et al.*, 2004) also interpret their results as evidence for a specific interaction between cognition and language, and argue against any strict modularity of language. We believe, for reasons specified above, that examining spatial language seems to be crucial for different reasons: fine-grained scrutiny in the study of impaired spatial terms might lead to findings on the more specific organization and the structure of the spatial deficit. The only study of WS language conceived in this spirit that examined spatial language in its more specific organization was Landau & Zukowski (2003), which we discuss in more detail. While most studies of spatial language in WS emphasize the reflection of severe spatial deficit in language, Landau & Zukowski argue against a strong interaction between the two faculties and claim that 'non-linguistic spatial deficits shown by children with Williams syndrome have, at most, limited effects on their spatial language' (p. 105), and they have a non-trivial explanation for the pattern of performance on spatial descriptions observed in the WS group.

Landau & Zukowski elicited descriptions of 80 videotaped motion events (40 of which showed a single object moving, and 40 of which showed a moving Figure object and a stationary Ground object) from 12 children with WS, whose mental age matched controls, and adults. They checked the representations and linguistic encoding of all components of the spatial representation of motion events (Figure and Ground, Manner of Motion and Path, as listed by Talmy, 1975), which can all be potentially selectively impaired, since they differ in the spatial elements they grasp, and the mode and complexity of the linguistic encoding of that spatial element (see Landau & Zukowski, 2003: 109). Children with WS could represent Figure and Ground objects, their relative spatial roles and they could map them onto their appropriate syntactic roles of subject/object of preposition. They also correctly encoded, and thus perceived, manner of motion. Path seemed to be the most difficult element of the motion event for children with WS. But even here, the WS group tended to use largely the same set of expressions for all three path types as controls, and they made errors by using an expression of one path type to describe another. In contrast to previous observations, most of their mistakes did not involve using inappropriate spatial terms, but using either a vague expression (like *over*) or omitting the Path expression altogether. This tendency was strong with FROM and VIA paths, but not with TO paths.

The authors take an interesting position in interpreting their data. They explain this selective fragility as the interaction of language with the impaired non-linguistic spatial system. This deficit, as they say, 'appears most prominently in tasks requiring the retention of visual-spatial information over time (Wang & Bellugi, 1994), for example, the representation of spatial relationships which then must be reconstructed in an adjacent but separate space' (p. 26). Landau & Zukowski link it to the findings of Vicari, Carlesimo, Brizzolara & Pezzini (1996), that there is a normal recency effect but no primacy effect in recall in WS. With FROM and VIA paths, the Figure's final resting place does not coincide with the Ground. If the child cannot retain the representation of Ground object or Path over time, s/he will not be able to talk about it. So Landau & Zukowski take this fragility to be residing in spatial cognition, attributing it to the special difficulty of individuals with WS with retaining spatial representations in memory: one of the most established findings in WS is the dissociation between different components of working memory, with individuals showing relatively good capacities in verbal short-term memory and serious limitations in spatial memory span (Wang & Bellugi, 1994; Jarrold *et al.*, 1999; Racsmány, 2004). We will return to this issue in more detail in discussing our results.

As we have seen, data on spatial language in WS are often interpreted as reflecting a selective deficit of spatial terms in language, corresponding to the severe impairment in non-linguistic spatial cognition, and as evidence against the modularity of language and for the interaction between language and cognition (Lichtenberger & Bellugi, 1998; Volterra *et al.*, 1996; Phillips *et al.*, 2004). We argue that many studies of spatial language in WS are in fact studies of spatial cognition in WS, and this way can be useful and suggestive in determining the nature of the spatial deficit in WS and in outlining the factors influencing the acquisition of spatial terms in TD as well. Most previous studies of WS spatial language, with the exception of Landau & Zukowski (2003, see below), though, fail to make use of this interaction between language and spatial cognition, and do not go beyond the general statement claiming that WS performance on giving spatial descriptions is poor, which only confirms what we already know from studies of spatial cognition: that individuals with WS perform poorly on spatial tasks, whether the required response is linguistic or not (Bellugi *et al.*, 1994, 2000; Pani *et al.*, 1999; Farran & Jarrold, 2003). At this level of investigation it does not tell us any more about the interaction between language and cognition than the fact that if we have problems with numbers and mathematics, then although we might well know the names of numbers, we will not be able to either use or understand number terms properly. This interaction, though, is strong enough to make spatial language a window onto spatial cognition: since spatial abilities are not uniformly poor in WS, fine-grained examinations of spatial language can reveal strengths and weaknesses in spatial cognition. We propose that the problem of mapping should be of concern, too: we might be able to learn something about mapping from spatial representation to linguistic representation if: (1) the NATURE of the spatial deficit is reflected in the NATURE of deficit in spatial language, as this would imply a direct mapping between the two systems; and (2) both systems are deficient, but the patterns of deficits do not match, as this would argue against a direct mapping and for a more intricate interaction between spatial cognition and language. To answer these questions, studies focusing on the PATTERN of abilities in both the spatial and the linguistic domain are needed.

The two studies presented below were designed to take a step in this direction, by focusing on the pattern of performance of individuals with WS in the use and comprehension of spatial terms. Based on the above considerations, we hypothesized that:

(1) There is no selective deficit of spatial terms within language in WS.
(2) Poor performance on tasks involving spatial terms only reflects difficulties in non-linguistic spatial cognition. For this reason, problems with spatial language only appear in tasks with verbal instructions or answers that in the first place require working with real-world spatial arrangements, or mental modeling of spatial relations for their solution.
(3) WS performance on the elicited production and comprehension tasks tapping spatial language involving real-world arrangements would not be uniformly poor. Since the terms we test in Hungarian do not differ in formal complexity, difficulties with special types reflect problems in non-linguistic spatial cognition. and would reflect the nature of the spatial deficit.
(4) If performance patterns in all three tasks are similar in the WS and the TD group, there is no evidence for special interaction between language and thought in WS. We are not arguing against any interaction

TABLE 1. *Postpositions tested in the study*

Spatial relation	STATIC	GOAL	SOURCE
BEHIND	*mög**ött***	*mög**é***	*mög**ül***
IN FRONT OF	*el**őtt***	*el**é***	*el**ől***
UNDER	*al**att***	*al**á***	*al**ól***
NEXT TO	*mell**ett***	*mell**é***	*mell**ől***
BETWEEN	*köz**ött***	*köz**é***	*köz**ül***

TABLE 2. *Suffixes tested in the study*

Spatial relation	STATIC	GOAL	SOURCE
ON	*-on/en/ön*	*-ra/re*	*-ról/ről*
IN	*-ban/ben*	*-ba/be*	*-ból/ből*

between language and thought; we only claim that this interaction is the same that we observe in TD.[1]

(5) If there is no selective deficit of spatial terms within WS language, we do not expect worse performance in the WS group, even with spatial meanings in the sentence completion task not involving real-world arrangements.

In Study 1, we tested the use and comprehension of spatial postpositions and suffixes along three path types and seven spatial relations (see Tables 1 and 2). The symmetry of the Hungarian spatial system, which marks different path types differently but with expressions of the same formal complexity, makes it possible to test (3), and by comparing the comprehension and production of the same set of spatial terms, it is also relevant to (1) and (4). We tested (2) directly in Study 2 in a Sentence Completion task which required the use of suffixes in their spatial and non-spatial meanings: if there is a selective impairment of spatial terms within language, WS performance is expected to be worse than that of controls on a task that does not require direct reference to real-world spatial scenes, and it is expected to be worse with spatial than with non-spatial meanings of the same suffix forms.

[1] An anonymous reviewer pointed out that Landau & Zukowski are 'in fact invoking an account that says some very specific things about the relation between language and cognition' by claiming that interpretation of SOURCE relations places a memory burden on the child. In line with the argument presented above, we do not think it is a case for special interaction. It is again a non-linguistic difficulty that affects language only as long as the spatial task requires a verbal answer, but does not affect the structuring of spatial terms and their meanings within language.

The language of space in Hungarian

As all languages, Hungarian has several means of encoding spatial relations: suffixes, postpositions, verbal prefixes and adverbs. In this section we focus on suffixes and postpositions, because our studies revolve around these two types of spatial expressions, which are used in noun phrases coding for different REGIONS and RELATIONS using the nouns as REFERENCE OBJECTS. Suffixes encode simpler relations like SUPPORT or CONTAINMENT (IN, ON, AT) and obey the rules of vowel harmony. The system of postpositions is used to encode relations that are cognitively more complex (BEHIND, UNDER), sometimes require multiple reference objects (BETWEEN), and is structurally more systematic than the system of suffixes, as can be seen from Table 1 and Table 2. A STATIC postposition always ends in a geminate /tt/, GOAL-type postpositions end in a long low vowel /á/ or /é/ and SOURCE postpositions end in a round vowel+/l/ sequence. While the form of postpositions gives cues to the encoded path type, no such systematic cues are given by the general form of suffixes, but different suffixes are used for different path types.

Each kind of spatial relation can be encoded in three forms according to the dynamic aspect of coding the location and the path. For each spatial relation, Hungarian has a STATIC LOCATIVE term, and two DYNAMIC forms, one encoding the GOAL or end of the path, the other the SOURCE or starting point of the path (in colloquial speech, the GOAL form of the CONTAINER suffix is often used to mark both the GOAL and the STATIC relation). Differentiating all three path types linguistically but with the same complexity gives a good ground for testing path type effects on spatial language use, which is not available in all languages: English often uses the same prepositions for STATIC and GOAL relations where Hungarian uses two distinct forms: *a kép* ***mögött*** *van – it is* ***behind*** *the picture* vs. *tedd a kép* ***mögé*** *– put it* ***behind*** *the picture.*

It is important to emphasize that Hungarian is very systematic in encoding all three path types with terms of the same formal complexity. It differs in this respect from other languages, such as English for example, which in some cases uses expressions of different complexity for different path types of a spatial relation: *a kép* ***mögött – behind*** *the picture* vs. *a kép* ***mögül – from behind*** *the picture*. Just as in English, different verbs are used with different path types (see below), but SOURCE, STATIC and GOAL expressions for a specific spatial relation are always of the same linguistic complexity (e.g. all are one syllable suffixes or two syllable postpositions). A starting point for studies of these spatial terms in Hungarian was MacWhinney (1976): 'Hungarian inflections differ little in terms of formal complexity. Thus, differences in their emergence can be attributed to semantic–pragmatic factors' (p. 409). Similarly, specific patterns possibly emerging in WS usage will reflect the influence of such factors, giving a unique opportunity for testing these effects through the systematic linguistic marking of path types and without the confounding factor of differences in formal complexity.

Studying spatial language in Hungarian individuals with WS is motivated by several factors. Besides the rich morphology of the language, and the directional symmetry and structural homogeneity of the system of suffixes and postpositions, ample data are available on TD concerning the emergence and development of spatial expressions differing in linguistic and cognitive complexity, path type and relation (summarized in Király, Pléh & Racsmány, 2001). Earliest findings come from the study of MacWhinney (1976), emphasizing that early use of spatial expressions is dominated by CONTAINER type expressions. This was confirmed and complemented with further observations by Pléh, Vinkler & Kálmán (1997), who analyzed early use of spatial suffixes of children aged 1;5–2;9 in the CHILDES database. Frequencies reflected a preference for CONTAINER and GOAL type suffixes (CONTAINER 68%, SURFACE 19%, NEIGHBORHOOD 13%; GOAL 80%, STATIC 13%, SOURCE 7%), in accordance with Sinha, Thorseng, Hayashi & Plunkett (1994). These frequency distributions differ from adult frequencies, in which STATIC expressions are the most frequent, followed by GOAL expressions, and SOURCE expressions are the least frequent (this pattern is reflected in e.g. the frequency of postpositions in the Szószablya webcorpus-based frequency dictionary (www.szoszablya.hu; Halácsy, Kornai, Németh, Rung, Szakadát & Trón, 2003). The relative ease of learning both suffixes and GOAL type expressions were confirmed in learning artificial spatial terms (Király *et al.*, 2001).

Pléh, Palotás & Lőrik (2002, henceforth PPL) collected data from children between 5;0 and 8;0 on spatial postpositions and suffixes in an elicited production task. Path again had a significant effect, but not in the same way as in spontaneous data from younger children on suffixes. GOAL preference was matched by performance on STATIC expressions, reflecting again sensitivity to frequency of use in adult language. Results confirmed that SOURCE was most difficult, but STATIC was somewhat easier than GOAL. The authors argue that these results suggest that while GOAL plays a primary role in spontaneous encoding, in more complex relations encoded by postpositions STATIC might be treated more easily. A strong prototype effect was also observed in children: they tended to avoid using SURFACE type suffixes with CONTAINER reference objects (e.g. a glass standing upside down); instead they used more complex expressions with object part names (instead of *on the glass* they say *on top of the glass*). These general cognitive patterns influencing the development of spatial terms correspond to findings from other languages (e.g. Johnston & Slobin, 1978; Tanz, 1980; Sinha *et al.*, 1994).

STUDY 1: PRODUCTION AND COMPREHENSION OF SPATIAL POSTPOSITIONS AND SUFFIXES

Participants

Nineteen subjects with WS participated in this study (10 females, 9 males, mean age: 15;1, age range: 8;0–21;11, PPVT [the Hungarian standardized version of the Peabody Picture Vocabulary Test; Csányi, 1974] 99·3, range 55–143). Seventeen of them were FISH positive; two participants did not have a FISH test, but otherwise showed the diagnostic physical, clinical and behavioral features of WS (Udwin & Yule, 1990). Individuals with WS were matched on sex and PPVT scores by a VC group of 19 TD children (matching was done on an individual basis: mean age 7;2, age range 3;5–9;11, PPVT 99, range 53–143). Participants were given both the production and comprehension tests, with the exception of three participants with WS in the comprehension task. We did not include age-matched controls, because it was clear from our previous results with a smaller sample on production (Racsmány, 2004; Lukács, Pléh & Racsmány, 2004) that this group performs at ceiling level on the task.

Procedure

For testing production of spatial terms, we used the Spatial Postpositions and Suffixes subtest of PPL. Spatial postpositions were elicited using two toy wardrobes as reference objects with inherent orientation, both facing the experimenter and the child, who were sitting next to each other. Small, colored token circles, triangles and squares were used as target objects. Spatial suffixes were tested with the same target objects and two glasses as reference objects, one standing upright and the other standing upside down. The complexity of the two spatial arrangements (one with the wardrobes for postpositions, and the other with the glasses for suffixes) was the same, with an equal number of possible locations for the target objects, although the inherent orientations of the reference objects differed. The suffix task also contained a CONTAINER–SURFACE distinction, which was absent from the postpositions task. The experimenter put the target objects in different positions, and asked three kinds of question to elicit answers of the three path types. In these questions in Hungarian it is not only the verb but also the form of the question word that codes the Path type of the required answer: ***Hol*** *van a kör?* 'Where is the circle?' (STATIC), vs. ***Hová*** *teszem a kört?* 'Where do I put the circle?' (GOAL) vs. ***Honnan*** *veszem el a kört?* 'Where do I take the circle from?' (SOURCE). Participants did not have to repeat or use the appropriate verb forms in their answers, a noun + suffix or noun + postposition answer was enough, following standard Hungarian conversational practice. Knowledge of 15 postpositions (SOURCE, STATIC and GOAL forms of the Hungarian words for 'in front of', 'behind', 'below', 'between', and 'next to'), and 6 suffixes (SOURCE, STATIC and GOAL forms of the Hungarian suffixal equivalents of 'in' and 'on') – altogether 21 spatial items – was tested. Postpositions and suffixes used in our study are presented in Tables 1 and 2. For a more detailed presentation of the Hungarian spatial language system see Pléh *et al.* (1997).

Comprehension was tested with a modification of the Spatial Postpositions and Suffixes subtest of PPL. The same tools were used in this test (toy wardrobes, glasses and target objects) with the same arrangements, but the task of the child was now to follow the instructions of the experimenter making requests using the same postpositions (15) and suffixes (6; altogether 21 items) that were target answers in the production task (SOURCE, STATIC or GOAL forms of postpositions and suffixes), so the instructions had the verb and the locative as markers of the three path types: *Vedd el a kört a szekrény* ***mögül****!* 'Take the circle from behind the wardrobe!' *Legyen a háromszög a szekrény* ***mögött****!* 'Let the triangle be behind the wardrobe!' and *Tedd a négyzetet a szekrény* ***mögé****!* 'Put the square behind the wardrobe!'

RESULTS

Mean performance of the two groups is shown in Figures 1 and 2; a summary of means and standard deviations is given in Table 3. We conducted three-way ANOVAs with GROUP (WS, VC) and PATH TYPE (STATIC, SOURCE and GOAL) and TASK (PRODUCTION and COMPREHENSION) as factors. Results for postpositions and suffixes were not merged into one omnibus ANOVA because we had different numbers of items (5 for each path type with postpositions and 2 for each path type for suffixes). Where the effect of GROUP was significant, it was always to the advantage of the VC group; specific contrasts by *t*-tests are discussed below. On correct answers on SPATIAL POSTPOSITIONS, all three factors had a significant main effect: GROUP ($F(1, 30) = 11{\cdot}47$, $p < 0{\cdot}005$), PATH ($F(2, 60) = 3{\cdot}69$, $p < 0{\cdot}05$) and TASK ($F(1, 30) = 10{\cdot}99$, $p < 0{\cdot}005$). Of all possible interactions, only the PATH × TASK was significant ($F(2, 60) = 4{\cdot}26$, $p < 0{\cdot}05$); PATH effects disappeared in the comprehension task.

With SUFFIXES, again all three factors had significant main effects: GROUP ($F(1, 30) = 17{\cdot}61$, $p < 0{\cdot}001$), PATH ($F(2, 60) = 4{\cdot}57$, $p < 0{\cdot}05$) and TASK ($F(1, 30) = 27{\cdot}99$, $p < 0{\cdot}001$). Only the interaction of TASK × GROUP was significant ($F(1, 30) = 15{\cdot}19$, $p < 0{\cdot}001$); the advantage of the WS group for comprehension was greater than that of the control group. Specific results concerning task type and morphological types of spatial terms will be discussed in detail in the 'Errors' section below.

Pairwise comparisons with dependent *t*-tests showed that the VC group's performance was significantly better than that of the WS group on all

TABLE 3. *Means (M) and standard deviations (S.D.s) for the WS and VC groups on the production and comprehension of spatial postpositions and suffixes task (postpositions maximum 5; suffixes maximum 2)*

	WS M	WS S.D.	VC M	VC S.D.
Production				
Postpositions				
STATIC	3	1·7	4·47	1·35
SOURCE	2	2·05	3·79	1·93
GOAL	2·68	2·03	4·58	0·9
Suffixes				
STATIC	0·89	0·88	1·68	0·58
SOURCE	1·05	0·85	1·78	0·41
GOAL	1·16	0·69	2	0
Comprehension				
Postpositions				
STATIC	3·81	1·33	4·75	0·77
SOURCE	3·56	1·21	4·88	0·5
GOAL	3·88	1·41	4·81	0·75
Suffixes				
STATIC	1·69	0·6	2	0
SOURCE	2	0	2	0
GOAL	2	0	2	0

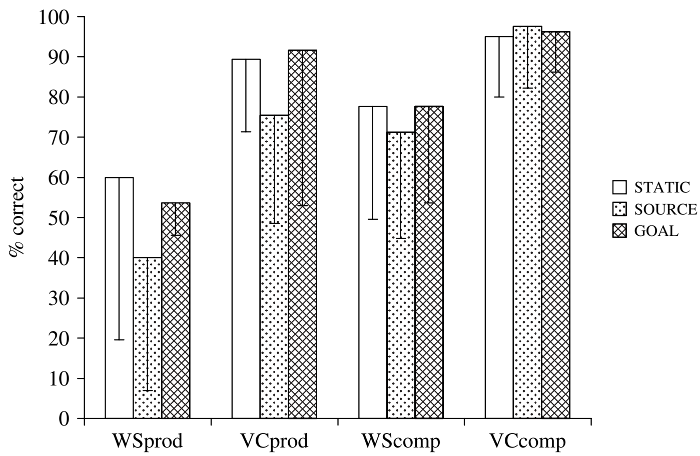

Fig. 1. Performance of WS and VC group on production and comprehension of spatial postpositions.

directions in both comprehension and production of postpositions. For suffixes, production performance of the two groups was significantly different on all directions; in comprehension the only difference was in STATIC suffixes which approached, but did not reach significance

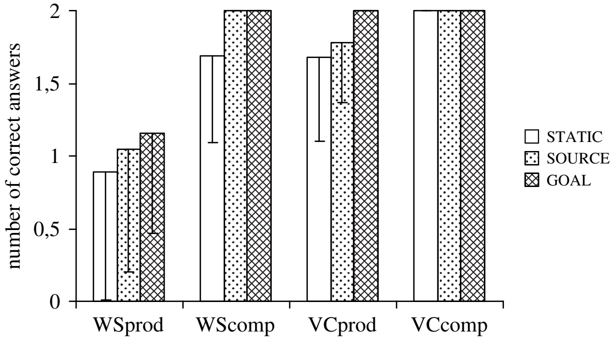

Fig. 2. Performance of WS and VC groups on production and comprehension of spatial suffixes. Here results are not given in percentage but average number of correct answers, since maximum score on each type was 2.

($t = 2{\cdot}08$, $p = 0{\cdot}055$). We also compared performance on different path types and tasks within groups. Within-group effects were very similar for most comparisons: for production of spatial postpositions SOURCE differed from both GOAL and STATIC, but the latter two did not show any difference (GOAL–SOURCE only approached significance in WS: $t(18) = 2{\cdot}05$, $p = 0{\cdot}055$; VC: $t(18) = 2{\cdot}28$, $p < 0{\cdot}05$; STATIC–SOURCE WS: $t(18) = 2{\cdot}73$, $p < 0{\cdot}05$; VC: $t(18) = 2{\cdot}39$, $p < 0{\cdot}05$; STATIC–GOAL WS: $t(18) = 1{\cdot}06$, n.s.; VC $t(18) = 0{\cdot}33$, n.s.). Comprehension of postpositions did not show any significant effects of PATH TYPE in either the WS or the VC group.

With suffixes, results were somewhat different. The WS group did not show any PATH TYPE effects in production of spatial suffixes. For controls, GOAL was significantly easier (no errors) than either STATIC or SOURCE, which did not differ (GOAL–STATIC $t = 2{\cdot}36$, $p < 0{\cdot}05$; GOAL–SOURCE $t = 2{\cdot}19$, $p < 0{\cdot}05$; STATIC–SOURCE $t = 1{\cdot}46$, n.s.). Performance of both groups was better on comprehension, with controls performing at ceiling on all directions, while the WS group showing ceiling performance on GOAL and SOURCE terms, and making 15·5% errors with STATIC suffixes.

The WS group was significantly better on comprehension than on production (WS $t = 3{\cdot}73$ $p < 0{\cdot}005$; postpositions $t = 2{\cdot}92$, $p < 0{\cdot}05$; suffixes $t = 4{\cdot}99$, $p < 0{\cdot}001$). In the VC group, the difference between comprehension and production performance was not significant given all the data, but they were better on comprehension with both postpositions ($t = 2{\cdot}16$, $p < 0{\cdot}05$) and suffixes ($t = 2{\cdot}38$, $p < 0{\cdot}05$). We also compared performance of both groups on postpositions and suffixes in comprehension and production (the

TABLE 4. *Mean percentage of correct answers made by the WS and VC groups by task type and spatial term type (S.D.s are given in parentheses)*

	Production		Comprehension	
	WS	VC	WS	VC
Postposition	49·1 (34·6)	85·6 (24·3)	75·0 (22·5)	95·4 (13·4)
Suffix	51·7 (34·7)	91·2 (16·1)	94·8 (10·1)	100

results are shown in Table 4).[2] The only significant difference was observed in the WS group on the comprehension task, with suffixes showing significantly better performance ($t=3{\cdot}84$, $p<0{\cdot}01$). Given the wide age range of the WS group, we also made comparisons splitting the groups into two based on verbal age, but it did not affect performance patterns or group differences, so we do not give details of this analysis here.

Summary of results from comparisons with the VC group

(1) WS performance was inferior to VC performance on both production and comprehension of postpositions and production of suffixes with all directions. Comprehension of suffixes was only significantly worse with STATIC IN and ON, due to near-ceiling performance of both groups on other directions.
(2) Within-group Path effects were very similar in the two groups. On postpositions, performance of both the WS and the VC group was significantly worse on SOURCE terms, while GOAL expressions did not differ from STATIC ones. In comprehension of postpositions, there was no effect of PATH in either group. In production of suffixes, there was no PATH effect in the WS group, while for controls GOAL was significantly easier than either STATIC or SOURCE. In comprehension controls performed at ceiling; the WS group made errors only on STATIC forms.
(3) Both the WS and the control group were better on comprehension than production with both postpositions and suffixes.
(4) Comprehension of suffixes was easier than that of postpositions for the WS group, while no difference was found between the two types of spatial expressions in WS and VC production, or in VC comprehension.

[2] It has to be mentioned that we calculated with percentages of correct answers on both types of spatial expressions to be able to compare them, but the data might be distorted by the fact that we tested altogether 15 postpositions and only 6 suffixes.

TABLE 5. *Percentage of errors relative to all answers made by the WS group according to spatial relation and task type on postpositions*

	Comprehension	Production	All
UNDER type	8·3	40·4	25·7
BETWEEN type	10·4	59·6	32·4
IN FRONT OF type	31·3	50·9	41·9
NEXT TO type	37·5	54·3	46·6
BEHIND type	37·5	38·6	38·1

Errors

The above results show a depressed, but not specifically deviant pattern in understanding and using spatial expressions in WS relative to receptive vocabulary matches. We were interested in a detailed analysis of the results and we also wanted to inquire into the nature of the errors individuals with WS make when they follow instructions and give descriptions concerning space. This section contains only descriptive generalizations on error patterns in the WS group, because the control group did not make enough errors to allow for pattern analysis. For this reason, we did not run any statistical analysis on these data, yet we feel it important to discuss them here because they are suggestive both for some of our conclusions and for further lines of research. We also compare patterns in the WS group to TD tendencies discussed in the literature on the acquisition of spatial terms. Comparing findings from WS to general tendencies observed in TD, we can test whether poor performance on spatial language is similar to the performance of TD children at younger ages, or whether we find atypical patterns of performance and error types not observed in TD.

First, we have to note that there were deviations from target answers that were coded correct. These included use of part names (*az alján* 'on the bottom of') or suffixes instead of postpositions (there were 5 such items in the whole WS sample, 2 suffixes and 3 part names), or use of part names instead of suffixes.

In the postpositions task, the same five spatial relations were presented (either spatially or linguistically) within each Path type: subjects saw or heard SOURCE, STATIC and GOAL forms of BEHIND, UNDER, IN FRONT OF, NEXT TO and BETWEEN. Table 5 presents errors made on spatial postpositions according to the type of spatial relation. As can be seen, the order of difficulty is not the same within each task type. We have data from TD for production from PPL with the following order of increasing difficulty: UNDER < NEXT TO, BEHIND, IN FRONT OF < BETWEEN. In our WS sample, the order of difficulty in production was: BEHIND, UNDER < IN FRONT OF < NEXT TO < BETWEEN.

TABLE 6. *Percentage of errors of all answers by type of spatial relation and task type in the WS group on suffixes*

	Comprehension	Production	All
CONTAINER	2	29·8	17·1
SURFACE	8·3	66·6	40

The main difference is the relative ease of BEHIND and the relative difficulty of NEXT TO in the WS group.[3] Increasing order of difficulty of spatial relations in comprehension was the following: BETWEEN, UNDER < IN FRONT OF < BEHIND, NEXT TO.

A possible explanation of the differences in difficulty of specific spatial terms is their relative frequency of use in adult language. We tested correlations with scores for specific postpositions (but not for classes) with their frequencies in the Szószablya web frequency dictionary (we used the frequency measures for cleaned data containing 113 million tokens and 4·5 million token types; Halácsy *et al.*, 2003), but no correlations were significant in either production or comprehension. One possible explanation for the lack of correlation is that we could not separate spatial and non-spatial occurrences in the frequency counts; we have to postpone our conclusion on frequency effects until have a better measure of frequency in adult usage.

Suffixes also contained a dimension not discussed in the 'Results' section because of ceiling or near-ceiling performance of the control group. Within all path types, we tested a CONTAINER and a SURFACE relationship. As the error percentages in Table 6 show, CONTAINER relations were systematically easier, and although performance in comprehension was at ceiling with GOAL and SOURCE expressions, a CONTAINER precedence was observed with STATIC relations and all three path types in production. This corresponds to findings from previous research from TD children (PPL), and also to the universal tendency of CONTAINER type relations to be encoded linguistically earlier in development (Johnston & Slobin, 1978; Landau & Jackendoff, 1993).

We distinguished two types of errors: errors made on path type, and errors made on spatial relation (all errors can be classified along these two dimensions). We discuss only path type errors in production. In principle, one can make a path type error in comprehension (e.g. when hearing *Put the circle behind the wardrobe!* the subject takes a circle from behind the

[3] Salience is a possible explanatory factor for the relative easiness of BEHIND type expressions. The NEXT TO type was probably relatively difficult because subjects tended to give too general descriptions (answering with the suffix *-nál/nél* 'at'), which was coded incorrect for postpositions, since the task here required descriptions of scenes where objects had inherent orientations.

wardrobe), but the specific arrangements used in the comprehension task did not allow for such mistakes (in the GOAL condition, there were no target objects in the scene that could be removed), and two conditions (GOAL and STATIC), in spite of using different types of spatial expression, required the same kind of action (putting the target object somewhere: *Put the … !* in the GOAL, and *Let the … be … !* in the STATIC condition). An example of a Path type error in production is answering with a STATIC term to a SOURCE type question (e.g. *Where do I take the circle from?* – *Behind the wardrobe*, instead of *from behind the wardrobe*). It is important to note that in Hungarian question words unambiguously encode path type. While in English the distinction between GOAL and STATIC is marked only by the verb (e.g. *Where do I put* … vs. *Where is* …, path type information is also unambiguously encoded by the verb in Hungarian as well), Hungarian has two distinct question words: *Hol* for STATIC and *Hová* for GOAL, and a third, *Honnan* for SOURCE. Since language serves as a crutch for decoding the path type encoded in the answer, on the basis of relatively good linguistic abilities, we expected relatively few errors concerning path type in the WS group. An error was coded as a spatial relation error if it encoded a different spatial relation from the one presented in the scene, e.g. instead of a BEHIND type expression, the subject used an IN FRONT OF type expression. An answer could be a path type error and a spatial relation error at the same time. There were other kinds of responses that were deviations from the target answers, to which we will return after discussing these two error types.

With path type errors, our findings did not confirm our expectations. In spite of clear linguistic cues for path type in the question words, children with WS tended to make quite a few path type errors. Error percentages for all different types (relative to all errors as 100%) are shown in Table 7. Both with postpositions and suffixes, SOURCE was most susceptible to path type errors: 84·2% of errors made in producing SOURCE postpositions and 66·6% of SOURCE suffix errors could be (also) classified as path type errors. There was a tendency to produce more path type errors on postpositions (57·5% of all errors) than on suffixes (38·2%). All substitutions were of GOAL and STATIC types, nobody used a SOURCE term for either a GOAL or a STATIC marker. It follows that all path type errors with STATICS resulted in using a GOAL type, and all errors with GOAL terms resulted in using a STATIC. From SOURCE errors, the majority were using a STATIC (73·6%), while GOAL terms were used 26·3% of the time. Susceptibility of different spatial relations to different error types is given in Table 8.

Spatial relation errors were not uniform, and they were made in both comprehension and production. One type of mistake was representing the opposite relation from the one presented either in the scene or by a spatial

TABLE 7. *Percentage of error types relative to all errors made by the WS group, by spatial term and path type*

	Only path type	Only spatial relation	Path type and relation	Relation all	Path type all	Absolute number of errors (100%)
Postpositions GOAL	18·1	56·8	22·7	79·5	40·8	44
Postpositions STATIC	8	65·7	26·4	92·1	34·4	38
Postpositions SOURCE	47·3	14	36·9	50·9	84·2	57
Postpositions all	27·3	41	30·2	71·2	57·5	139
Suffixes GOAL	0	62·5	18·75	81·25	18·75	16
Suffixes STATIC	19	66·6	9·5	76·2	28·5	21
Suffixes SOURCE	0	11·1	66·6	77·7	66·6	18
Suffixes all	7·3	47·3	30·9	78·2	38·2	36

TABLE 8. *Percentage of error types relative to all errors made by the WS group, by spatial relation type*

	Only path type	Only spatial relation	Type and relation	Relation all	Type all
IN FRONT OF	20·7	44·8	34·5	79·3	55·2
UNDER	52·1	34·8	8·7	43·5	60·8
BETWEEN	11·8	52·9	35·3	88·2	47·1
BEHIND	45·4	27·3	22·7	50	68·1
NEXT TO	16·1	41·9	41·9	83·8	58
SURFACE	2·6	57·9	28·9	86·8	31·5
CONTAINER	17·6	23·5	35·2	58·8	52·8

term. In production there were only 7 such mistakes (7·1% of all spatial relation errors in the production of postpositions), all included using a BEHIND type postposition instead of an IN FRONT OF type. In comprehension, there were again 7 errors (11·7% of all spatial relation errors made in comprehension of postpositions) of answering with the opposite spatial relation from the one encoded by the postposition (1 ON TOP OF instead of UNDER and 5 IN FRONT OF instead of BEHIND, with 1 BEHIND instead of IN FRONT OF). With suffixes, we were looking for a tendency to use CONTAINER type expressions instead of SURFACE types, or vice versa. In production, we found 4 such errors (7·3%; CONTAINER instead of SURFACE). In comprehension, of the 5 mistakes 2 involved using a CONTAINER type instead of SURFACE and 1 was using a SURFACE type instead of a container (60% of errors).

In production, the most frequently used postpositions were the following (absolute number of occurrences given in parentheses, out of a total of 99 spatial relation errors in production of postpositions): *mögé* (21), *mellett* (13), *mögött* (12), *alá* (11). All other postpositions were used less than 5 times.

We also found it useful to refer back to the error analysis of Tanz (1980), where children following instructions made many errors but placed the target object at cardinal directions along the front–back and side-to-side axes of the reference object in 96% of all placements. We were looking for answers that do not correspond to cardinal directions in our WS sample, and we found none. An important aspect of our study, as opposed to Tanz's, was that target answers here also made reference to the vertical axis as well as the horizontal one. Looking for mistakes in using the horizontal axis instead of the vertical one, or using the vertical axis instead of the horizontal, we do find misplacements and descriptions that were wrong even according this loose criterion. In production, there were altogether 20 answers (20·2%) that encoded an axis with a wrong orientation (GOAL 7; STATIC 8; SOURCE 5), while in comprehension there were 13 misplacements according to orientation of axis (21·6%), mainly in interpreting SOURCE expressions (GOAL 2; STATIC 1; SOURCE 10).

Summary of the results of error analysis

(1) Data from TD production concerning relative difficulty of spatial relations expressed by postpositions from PPL shows the following order of increasing difficulty: UNDER < NEXT TO, BEHIND, IN FRONT OF < BETWEEN. In our WS sample, the order of difficulty in production was: BEHIND, UNDER < IN FRONT OF < NEXT TO < BETWEEN. The main difference is the relative ease of BEHIND and the relative difficulty of NEXT TO in the WS group.

(2) CONTAINER relations were easier than SURFACE relations in the WS group, corresponding to general observations of TD tendencies in the literature (Pléh *et al.*, 1997).

(3) Children with WS made many Path type errors (e.g. answering with a STATIC expression to a SOURCE type question), somewhat more with postpositions than suffixes. All substitutions were GOAL and STATIC types. In SOURCE errors, the majority were using a STATIC term. Although Landau & Zukowski (2003) also found path type errors, this type of error made by Hungarian participants with WS is somewhat surprising, since the language straightforwardly encodes path distinctions linguistically in the question words.

Frequency effects could explain part of the results, but control data have to be gathered on this aspect.

(4) Spatial relation errors were very heterogeneous. Approximately 7–10% involved the opposite relation, and around 20% involved mixing up the vertical axis with the horizontal one, although misplacements and production errors were all made alongside the cardinal axes of the reference object, corresponding to the pattern observed by Tanz (1980) for errors of TD children. Again, control data are needed to make firm claims about the typicality of this pattern (i.e. mixing up vertical and horizontal).

Spatial postpositions and suffixes in other MR groups

Besides ample data on the acquisition of spatial terms in TD, results are also available from other groups with mental retardation (MR) on the very same task of production of spatial expressions. Radványi & Pléh (2002) compared the performance of 13 children with Down Syndrome (DS; mean age 11;2) matched on IQ with a group of 23 children with MR of other etiologies (mean age 11;1) on production of spatial suffixes and postpositions. Performance of the DS group was inferior to the performance of children with MR of other origin on all tasks. For both groups, CONTAINER type relations were easier to describe than SURFACE relations. Radványi & Pléh hypothesize that the inability of the DS group to use part names for non-prototypical SURFACE relations (a frequent strategy used by preschool TD children) stems from their global bias in spatial processing (Bihrle *et al.*, 1989; Rossen, Klima, Bellugi, Bihrle & Jones, 1996). As in TD, there was a path type effect, with SOURCE expressions being the most difficult. The type of relation also mattered for both mentally impaired groups, expressions with more arguments (BETWEEN type) and expressions coding a hidden object (BEHIND type) were the most difficult. Although the performance of the DS group was generally low and significantly worse than the scores of children in the MR group, the pattern of the effect of path type was similar in both groups to that of TD children, just like the performance pattern in the WS group.

DISCUSSION

The above results confirm our hypothesis that WS language performance is not uniformly poor. Our findings show that, in line with previous results, the use and the comprehension of spatial terms are difficult for individuals with WS, as shown by significantly poorer performance of this group relative to the VC group, but some expressions encoding certain path types and spatial relations are more difficult than others. Since the spatial terms under study were of equal formal complexity, and there was no significant correlation between the difficulty of a spatial term and its frequency, results must reflect areas of difficulty in spatial cognition. As revealed by the pattern of performance in the WS group, non-linguistic effects are similar to what we observe in TD children in both the control data and in earlier findings on production from a larger sample in PPL, indicating special difficulty with expressions for SOURCE type scenes. CONTAINER relations were easier than SURFACE relations, corresponding to findings from previous research from TD children, and also to the universal tendency of CONTAINER type relations to be encoded linguistically earlier in development (Johnston & Slobin, 1978; Landau & Jackendoff, 1993). All groups (WS, VC and participants in the PPL study) find SOURCE terms more difficult than STATIC or GOAL expressions. In the PPL study, this pattern was true for all the 5 age groups they tested (covering the age range for spatial controls of the WS group).

In our study, performance on STATIC and GOAL postpositions was at a similar level in both groups, while PPL found a slight advantage for STATIC expressions. They do not state whether this difference is statistically significant or not; the significant effect of path type that they describe might be due only to the outstanding difficulty of SOURCE expressions. Yet the direction of the difference between STATIC and GOAL terms in the WS group indicates the advantage of STATIC terms as well, so we regard this pattern as confirming the observations made with TD children. In the comprehension of postpositions, the lack of a path type effect makes the performance patterns of the two groups similar again. In controls, this might be due to near-ceiling performance. With suffixes, there are differences in the performance patterns of the two groups. In the production of suffixes, despite the differences in pattern shown by statistical analysis, the tendency is the same in the two groups, and in fact this same pattern was observed by PPL. It still demands an explanation as to why it was only understanding STATIC expressions that posed a difficulty for the WS group.

The results of error analysis show an interesting profile, and might reveal patterns that we do not encounter in TD, but these patterns do not in themselves allow for conclusions concerning atypicality since no analysis of error patterns of TD children is available. The WS pattern confirmed observations of TD children in that both groups found suffixes easier than postpositions, and performed better on CONTAINER type expressions than on SURFACE type expressions. We observed some differences as well: in contrast to the WS group, the VC group in this study did not make any path type errors (but these might be present in younger TD children), and the order of difficulty of different spatial relations in WS did not follow previous observations of TD children. The nature of the errors that the participants with WS made can also be the basis for further studies of spatial cognition. One possible question to test is whether the difficulty found with distinguishing vertical and horizontal axes reflects a deficit in cognition, or is present only in a task where participants have to give verbal answers.

Both the WS and the VC group were better on comprehension than on production with both suffixes and postpositions. Although in typical language use, comprehension of any kind of linguistic construction is always easier than its production, if there was a selective impairment of spatial terms in the WS group, we would not have expected their comprehension performance to be significantly better than their production, since this task required them to construct a spatial arrangement corresponding to the meaning of the spatial expression, i.e. it required participants to get from language to space. Path type effects also became smaller or disappeared in comprehension performances even in the WS group, where the lack of such effects cannot be explained by ceiling performance. The comparison of comprehension and production performance argues against selective difficulty of spatial terms within WS language.

STUDY 2: SENTENCE COMPLETION: SPATIAL SUFFIXES IN LOCAL AND NON-LOCAL USES

As was mentioned in the Introduction, we designed this study to test whether there is a selective deficit of spatial terms within WS language. To test the use of spatial language without the confounding factor of spatial cognition, we studied the use of spatial suffixes in both their spatial and non-spatial meanings in a Sentence Completion task that did not include descriptions of real-world spatial arrangements. Studies of German prepositions along this distinction by Friederici (1982) have shown that Broca's aphasics find prepositions that appear in their spatial or semantic use easier to produce than prepositions that have only a syntactic function (even if they have the same form), while Wernicke's aphasics display the reverse pattern. We chose sentences where in all conditions the correct solution of the task required lexical or pragmatic rather than spatial information. The selection of a Hungarian case marker may be determined by one of two different processes. The choice of suffix marking a complement may be governed directly by the predicate. In this instance, the case marker 'loses' its default meaning, as in example (a) below. The other process involves indirect selection, where the predicate subcategorizes for obligatory or optional argument of a certain thematic type, which may be marked by one of a set of suffixes.[4] The choice of suffix from within this set is determined by the properties of the noun host, as in example (b) below.

[4] We did not differentiate between obligatory and optional complements, since the children heard the sentences up to the test suffix, including the final noun.

The important point, as was mentioned above, was that in all of these sentences choosing the right suffix required lexical or pragmatic rather than spatial information. Since subjects heard the whole sentence up to the suffix, including the final noun, and they only had to supply the suffix, they could rely on the combined information from the verb and the noun. To take some examples, look at examples (a) and (b) below.

(a) *Pisti tanult a baleset**ből**.*
'Pisti learnt the accident-FROM.'
'Pisti learnt from the accident.'
(b) *Az oroszlán megszökött a ketrec**ből**.*
'The lion escaped the cage-FROM.'
'The lion escaped from the cage.'

While in sentence (a) the suffix is selected for by the verb, in sentence (b) the verb *megszökik* 'escape' requires only that the noun has a SOURCE type suffix. This information combines with the specifications by the noun *ketrec* 'cage', which is a container, unambiguously specifying the elative as the right suffix choice.

Hypothetically, individuals with WS might have difficulties choosing the right suffix with both spatial and non-spatial meanings. Errors with spatial use might arise from the spatial deficit, although we do not know how much speakers rely on spatial representations when they use spatial terms in the language without direct reference to a present real-world spatial arrangement, e.g. in saying a sentence such as *The lion escaped from the cage* in answer to a question such as *What made the director of the zoo so nervous?* We would also expect errors with spatial uses if there is indeed a selective deficit of spatial terms WITHIN language. On the other hand, as several studies have shown (e.g. Temple, Almazan & Sherwood, 2002), lexical representations in children with WS are often deficient, and/or they might have problems with the access and retrieval of such information. Participants with WS, according to the results of Karmiloff-Smith *et al.* (1998) from an online word-monitoring task, were not sensitive to subcategorization violations, while they were just as sensitive as controls to phrase structure and auxiliary violations. If poor performance on a task of retrieving subcategorization information from the lexicon is part of the general lexical deficit, we expect that the WS group will perform poorly with non-spatial meanings on this Sentence Completion task. We decided not to control for all of the factors determining the relationships between verbal prefixes, verbs and case markers, since our main focus of interest was whether people with WS show deficient use of spatial suffixes in a purely linguistic task, and whether their performance differs in such a task as a function of the meaning (local–non-local) of the suffix.

The design of the task also has the potential to teach us something about the language–cognition interface. Cognitive linguists argue that the semantic understanding of language is achieved through the activation of non-linguistic cognitive models (e.g. Talmy, 2000), which in the case of spatial terms means activating spatial mental models. There is a debate over whether these spatial models are activated during the metaphorical use of spatial terms as well (Lakoff & Johnson, 1980), or whether they are invoked only in understanding concrete spatial terms. If spatial models are active during language use, we should also find in this task the same effects of path types and spatial relation that we found in Study 1. If we find these effects only on the items with spatial meanings, that means that spatial models are not activated during the use of spatial suffixes in their non-spatial meaning. If these effects are lacking even with the spatial meanings, than we have evidence that the use of spatial linguistic terms does not necessarily require the activation of spatial models.

Participants

Fifteen subjects with WS (8 female, 7 male; mean age 15;10, range 10;6–21;10) and 15 VC (mean age 7;10, range 4;0–10;7) participated in the Sentence Completion task.[5] The two groups were matched on sex and PPVT scores (participants in the control group were exact matches of individuals with WS on the PPVT; mean PPVT score for both groups 105·8, range: 55–142).

Procedure

The participants' task was to complete sentences with the suffixes missing from the last noun. The experimenter read out the sentence without the suffix, and waited for the participant to finish it. There were five training sentences to make sure that the participant understood the task.[6]

All sentences were illustrated by pictures to make the task more interesting. In many cases the pictures were not necessary to elicit the answers, but they came in handy with some sentences when the sentence fragment was ambiguous and allowed different endings. In these cases, the picture either depicted the relevant one or could be used to show it. During actual testing, the pictures slowed down the procedure, and were very rarely necessary, so they were used only when the participant's answer was either too general or different from the target answer. We tested all the nine spatial suffixes of Hungarian, given in Table 9, all with both local and non-local meanings. The target sentences included the spatial and non-spatial meanings of

[5] Subjects were the same as in Study 1, with the exception of four subjects who were unwilling or unable to complete the Sentence Completion task.

[6] This test was developed on the basis of a Sentence Completion task for aphasic patients compiled by Katalin Szentkuti-Kiss and Éva Mészáros.

TABLE 9. *Target suffixes in the sentence completion task*

	STATIC	GOAL	SOURCE
CONTAINER	*-ban/ben* in inessive	*-ba/be* into illative	*-ból/ből* out of elative
SURFACE	*-on/en/ön* on superessive	*-ra/re* onto sublative	*-ról/ről* off delative
NEIGHBORHOOD	*-nál/nél* at adessive	*-hoz/hez/höz* to allative	*-tól/től* from ablative

all suffixes. Each type was represented by 5 sentences, adding up to 2 (local–non-local) × 9 (case) × 5 = 90 sentences. The nine suffixes were chosen to encode information along the two dimensions already discussed: spatial relation and path type. Along the spatial relation dimension, suffixes distinguish between CONTAINER (IN type), SURFACE (ON type) and NEIGHBORHOOD (AT type) relations. The dimension of path type encodes distinctions between one STATIC and two dynamic (SOURCE and GOAL) relations, discussed in detail above. These distinctions are kept for the non-spatial meanings of the suffixes as well. In principle, they can be relevant if spatial mental models are activated during metaphorical uses, and even if the meanings of these factors are not evident with metaphorical usage, they can be used to classify the suffix forms used in this study. Table 10 gives examples of the target sentences with both spatial and non-spatial uses of the suffixes. Target suffixes are given in bold. We also give the English translations, but for the sake of brevity, we do not give the grammatical details of the original sentences.

Scoring

All correct answers were given a score of 1, incorrect answers were scored 0. Correct answers included target suffixes, and also included some deviations from target answers. With some sentences and structures two suffixes may be in free variation (or in some cases dialectal variation) with the meaning of the structure preserved (*A mamut hasonlít az elefánt**ra*** vs. *elefánt**hoz***. 'The mammoth resembles the elephant', where 'elephant'-ONTO and 'elephant'-TO are both acceptable). Substitutions that resulted in a slight change in sentence meaning relative to the target were also accepted, provided that the subject's sentence described the situation appropriately (*A katona hátralépett a kaputól* vs. *kapuból*. 'The soldier stepped back from the gate', where both 'gate'-FROM and 'gate'-OUT OF are acceptable. Grammaticality in itself, though, was not enough for getting a score. A

TABLE 10. *Examples of sentence used in the sentence completion task*

	SPATIAL	NON-SPATIAL
-ban/ben	*A kismadarak ott vannak a fészek**ben**.* 'The birds are there in the nest'.	*Kristóf hisz az angyalok**ban**.* 'Kristóf believes in angels.'
-ba/be	*Nagyi elment a templom**ba**.* 'Grandma went to church.'	*A nagynéni szerelmes a király**ba**.* 'Auntie is in love with the king.'
-ból/ből	*Az oroszlán megszökött a ketrec**ből**.* 'The lion escaped from the cage.'	*A tanárnak elege lett a sajt**ból**.* 'The teacher got tired of the cheese.'
-on/en/ön	*Az autó átment a híd**on**.* 'The car crossed the bridge.'	*Ildikó meglepődött az ajándék**on**.* 'Ildikó was surprised at the present.'
-ra/re	*A kertész felállt a létrá**ra**.* 'The gardener stepped up the ladder.'	*Pisti emlékezett a kirándulás**ra**.* 'Pisti remembered the trip.'
-ról/ről	*A cserepek leestek a tető**ről**.* 'The tiles fell off the roof.'	*Mindenki hallott már a delfinek**ről**.* 'Everybody has heard of dolphins.'
-nál/nél	*A busz megállt a piros lámpá**nál**.* 'The bus stopped at the red light.'	*A nyúl gyorsabban fut a csigá**nál**.* 'The rabbit runs faster than the snail.'
-hoz/hez/höz	*Péter elment a fogorvos**hoz**.* 'Péter visited the dentist.'	*Károly csatlakozott a kirándulás**hoz**.* 'Károly joined the trip.'
-tól/től	*Nagyi visszajött az orvos**tól**.* 'Grandma came back from the doctor's.'	*A húgom nagyon fél a halak**tól**.* 'My sister is very much afraid of fish.'

correct answer had to be grammatical, and it had to describe the specific situation depicted by the sentence and the picture at an appropriate level of specificity.

RESULTS

Results were entered into a four-way ANOVA ($2 \times 2 \times 3 \times 3$) with GROUP (WS, VC), SUFFIX MEANING (spatial–non-spatial), SPATIAL RELATION (CONTAINER, SURFACE, SIDE) and PATH TYPE (STATIC, SOURCE, GOAL) as factors. The overall effect of GROUP did not reach significance ($F(1, 28) = 3{\cdot}6$, $p = 0{\cdot}07$). SUFFIX MEANING had a significant main effect; both groups obtained higher scores for sentences with spatial meanings than for sentences with non-spatial meanings ($F(1, 28) = 25{\cdot}3$, $p < 0{\cdot}001$). The overall effect of PATH TYPE was also significant ($F(2, 56) = 32{\cdot}4$, $p < 0{\cdot}001$), while the effect of SPATIAL RELATION did not reach significance ($F(2, 56) = 1{\cdot}03$, n.s.). Of the possible interactions, three turned out to affect the results: SUFFIX MEANING × SPATIAL RELATION ($F(2, 56) = 18{\cdot}8$, $p < 0{\cdot}001$), SUFFIX MEANING × PATH TYPE ($F(2, 56) = 16{\cdot}5$, $p < 0{\cdot}001$) and SUFFIX MEANING × SPATIAL RELATION × PATH TYPE ($F(4, 112) = 7{\cdot}14$, $p < 0{\cdot}001$); all other interactions failed to reach significance. Figure 3 shows the performance of the two groups by PATH TYPE. Means and standard deviations are given in Table 11.

TABLE 11. *Means (M) and standard deviations (S.D.s) for the WS and VC groups on the sentence completion task by directionality*

	WS M	WS S.D.	VC M	VC S.D.
Spatial				
STATIC	12,47	3,6	14,4	1,12
SOURCE	12,80	2,81	13,93	2,12
GOAL	13,40	1,99	14,80	0,56
Non-spatial				
STATIC	9,2	4,75	11,6	3,29
SOURCE	12,53	3,31	13,87	1,77
GOAL	12,47	2,97	14,33	2,32

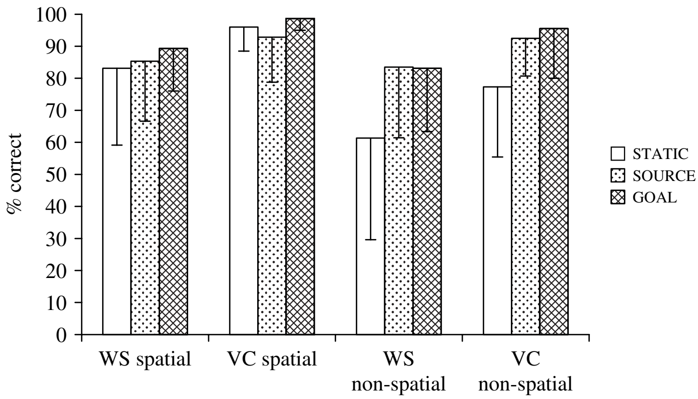

Fig. 3. Performance of the WS and VC groups on the task by path type.

Since neither the main effect of group, nor any interactions involving groups were significant, we did not further test any specific group effects. Comparisons within groups showed in many cases similar tendencies, as can also be seen in Figure 3. Both groups gave more correct answers on completing sentences with spatial meaning than on sentences with non-spatial meaning.

We also tested specific differences concerning spatial relations and path types over the two groups. Spatial use of suffixes showed the following pattern: CONTAINER relations were easier than either SURFACE or NEIGHBORHOOD relations, which did not differ ($t(30)=3{\cdot}1$, $p<0{\cdot}005$ and $t(30)=4{\cdot}2$, $p<0{\cdot}001$ respectively). Along the path type dimension, performance on STATIC and SOURCE terms did not differ, but performance on both was poorer than on GOAL suffixes ($t(30)=2{\cdot}3$, $p<0{\cdot}05$ for both). With non-spatial use of suffixes, the two groups' performance on CONTAINERS was inferior to their performance on both NEIGHBORHOOD ($t(30)=4$, $p<0{\cdot}001$) and SURFACE relations ($t(30)=2{\cdot}2$, $p<0{\cdot}05$) and they found non-spatial STATIC and SOURCE suffixes equally more difficult than GOAL suffixes in non-spatial uses ($t(30)=5{\cdot}9$, $p<0{\cdot}001$ and $t(30)=8{\cdot}0$, $p<0{\cdot}001$ respectively).

DISCUSSION

The results of this Sentence Completion task suggest that spatial language in itself, as revealed by the use of the spatial suffixes under study in this task, is not selectively impaired in WS when the task does not demand participants to describe a spatial situation. The two groups' overall performance was at a similar level, and this was true for both the spatial and non-spatial meanings of suffixes. The overall tendency of the VC group to show better performance reached significance only with spatial meanings, with SURFACE relations on the one hand and STATIC and GOAL type relations on the other. Is this an indication that some aspects of spatial language are indeed selectively impaired in WS? Individuals with WS obtained similar scores, and in fact displayed a similar pattern of performance as controls. Both groups produced more correct answers with sentences requiring suffixes in their spatial meanings. In contrast to results from the spatial suffixes and postpositions task, there was no effect of path type with spatial suffixes in either the WS or the VC group, i.e. SOURCE suffixes were just as easy as GOAL and STATIC ones. With spatial suffixes, CONTAINER relations were easiest for both groups. There was an effect of path type in both groups with non-spatial meanings, though. Both WS and VC individuals found STATIC suffixes more difficult than either GOAL or SOURCE suffixes. As with these markers case does not have an inherent meaning and is dependent only on lexical specification by the verbal head, this observation probably only reflects the relative difficulty of specific expressions in acquisition. The same is true for the observation in both groups that with non-spatial suffixes CONTAINER types were the most difficult ones.

Taken together, these results show that when spatial language is not prompted by the need to describe spatial relations in a scene, WS individuals' special difficulty with spatial language evaporates, and, in fact, with the very same suffixes there is better performance in spatial than in non-spatial use. We interpret better performance on suffixes with spatial meanings in the same way as we explained special difficulty with some types of spatial relations or instances of path type, i.e. not as reflecting peculiarities of organization of spatial cognition, but as reflecting relative frequencies of use in adult language and ease of acquisition. Hence, the severe spatial impairment in WS does not interfere with language in itself, and does not lead to a selective impairment of spatial terms WITHIN language.

Performance patterns are also relevant to debates over the nature of the interaction between language and cognition. The path types and spatial relations did not affect performance with the spatial use of suffixes, which supports an interpretation claiming that participants did not invoke spatial models when using spatial terms in their concrete meanings in this task. A path type effect was found on suffixes with non-spatial meanings, but it did not correspond to the path type effects observed in Study 1. The special difficulty with STATIC suffixes in non-spatial meanings probably reflects lexical effects such as frequency, or conceptual difficulty and age of acquisition, but since we have not measured them, these are only speculations, backed up by the differential difficulty of specific constructions within the STATIC type.

CONCLUSIONS

Spatial language in WS was suggested to be a prime test for studying the interaction between language and cognition. Our two studies have shown that we cannot really learn anything new about this relationship from studying this clinical group. We tested the comprehension and production of spatial postpositions and suffixes, and although we found that the performance of the WS group was poorer than the performance of VC group, they displayed the same pattern on various path types and spatial relations. We also argue against the hypothesis of a selective deficit of spatial terms within language based on two findings. First, the WS group, just like the controls, performed significantly better on the comprehension of spatial terms than on the production of the same items, showing that they find it easier to work from language to construct a spatial arrangement than to map a scene onto the appropriate linguistic expressions. Second, results from our Sentence Completion task showed that in a purely linguistic task, where participants do not have to rely on describing a real-world spatial arrangement, no overall differences were observed between the WS group and the VC group.

Taken together, our findings provide strong support for Landau & Zukowski's (2003) hypothesis that difficulty with retaining information in memory can account for the special difficulty with SOURCE paths. We have to point out, though, that this is a pattern similar to what we observe in typical development at earlier stages, and possibly the explanation is the same too: the spatial working memory capacity of younger children is smaller. A deficit in retention can also explain why the effect of path type, which is present in production, disappears in comprehension. The selective burden of retention in encoding SOURCE type spatial relations is not present in the language of spatial terms. All children find it easier to work from language to construct the spatial relation, and there is no special difficulty in SOURCE expressions in the language per se: spatial terms for all three path types are equally difficult to keep in mind. This finding is exactly what we would expect based on Landau & Zukowski's hypothesis, that SOURCE paths are difficult because they have a memory component missing from GOAL and STATIC scenes.

Besides results in the literature arguing for a dissociation of verbal and spatial short-term memory in WS (Wang & Bellugi, 1994; Jarrold *et al.*, 1999), previous results from our research group have shown that Corsi span (a measure of spatial working memory capacity) is just as strong a factor in predicting the performance of children with WS on spatial postpositions as digit span (measuring verbal working memory capacity), and in fact the performance of children with WS on the production of spatial expressions tends to be at the level of spatial controls matched on performance on the Block design task of the WISC-R (Racsmány *et al.*, 2002; Racsmány, 2004). The effect of visuospatial short-term memory is eliminated in comprehension, in line with the lack of Path type effects in our task. Data from other groups with MR also argue against a general retention problem. Performance of both the DS and the other MR group was poor on spatial descriptions, but the DS group scored significantly lower on each measure, in spite of being matched to the MR group on general level of IQ, which would predict the same degree of difficulty in retention.

Further experiments are needed to clarify the relationship of spatial short-term memory in effects observed in tasks requiring understanding or using spatial terms. It would be important to compare the performance of the WS group to controls matched on some measure of spatial short-term memory (e.g. on Corsi span). A further possibility is to test recognition memory in individuals with WS for the very same scenes that were used in the language tasks, or to ask participants to immediately reproduce the different scenes involving SOURCE, STATIC and GOAL paths after presenting them. Another alternative is to continuously or at least repeatedly present the different scenes to ease the burden of memory in giving spatial descriptions. Regarding the nature of interaction between language and thought, it would be important to make cross-linguistic comparisons by testing spatial language in WS populations speaking different languages with different systems of spatial terms on the same tasks.

Many questions remain to be answered on spatial language and spatial cognition in WS. Our own data so far have shown that the interaction of language and spatial cognition provides a possibility for testing the knowledge of spatial terms and can be a way of tapping into the nature of spatial deficits in WS, since this deficit is reflected in language. This is especially so in Hungarian, where the system of spatial expressions is symmetrical, having a different form for each of the three path types with each spatial relation with equal formal complexity. Since we did not find a selective deficit of spatial terms WITHIN language, we cannot argue that the nature of the WS deficit in spatial cognition structures or constrains items of spatial language in an atypical way. These observations in themselves do not argue against an interaction between language and cognition, but, based on our findings, there is no SPECIAL interaction in WS: the relationship between language and spatial cognition seems to be similar in WS and in TD. Alternatively, deficits in spatial cognition either concern finer distinctions or are along different dimensions from those that language encodes. This conclusion does not render research on spatial language futile. Indeed, our findings show that studying spatial language in WS is well suited to studies of spatial cognition, differing from other studies of spatial cognition in that they require verbal answers through which one can test sensitivity to the specific dimensions of space encoded by language. These studies can also be suggestive in explanations of patterns in TD: further experiments will test whether limitations of spatial working memory capacity cause special difficulties with SOURCE paths in TD and in WS alike.

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