Language and Cognition: Insights From Williams Syndrome

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What is the relation between spatial language and spatial cognition? Is the way we talk about space based on our non-linguistic spatial representations? Presently, there are at least two major hypotheses about the nature of this relation. On the one hand, there is a cognitive hypothesis. According to this hypothesis, spatial language is grounded on spatial cognition. Our non-linguistic spatial representations constrain the acquisition of spatial language during ontogeny. On the other hand, contrary to the first assumption, there is a so-called Sapir-Whorf hypothesis. According to it, spatial language constrains spatial cognition. Languages with different frames of spatial reference induce speakers to different spatial reasoning. Today, there is a broad debate on this topic with empirical data supporting both hypotheses. We can try to evaluate these ideas by looking at the interaction between spatial language and spatial cognition in cases where the latter is impaired. This is the case of Williams syndrome. Williams syndrome is a rare neuro-developmental disorder with a genetic origin. Individuals with Williams syndrome show an uneven cognitive profile. They have severe visuo-spatial deficits in spite of apparently good language skills. Lately, several studies have been carried out on spatial language in Williams syndrome showing evidence of a selective deficit in linguistic encoding of spatial relations. The study of spatial language in Williams syndrome could show that spatial language is, in a complex way, grounded on spatial cognition.

Keywords: spatial language, spatial cognition, Williams syndrome

Introduction

The relationship between language and space is a widely discussed topic. Currently, there are at least two different ways of looking at this relation. On the one hand, there is cognitive hypothesis. According to this hypothesis, language is grounded on cognitive abilities. These are a prerequisite for acquisition of language during ontogeny. Particularly, spatial language is built upon our non-linguistic spatial representations. Non-linguistic spatial concepts, originating in the brain (Landau & Jackendoff, 1993; LI & Gleitman, 2002), are a universal basis for acquisition of spatial language. This conceptual common ground is the reason of commonalities in linguistic encoding of space in languages all over the world. In fact, following Talmy (1975; 1983; 2000; 2003), we can identify universal elements in how languages encode spatial relations. Regardless of modality (spoken or signed), languages structure spatial description by coding, in grammar or lexicon, a “figure object”, a “ground object”, a “path” (from, via and to paths) and a “manner of motion”.

On the contrary to the cognitive hypothesis, there is the idea that language shapes our cognitive abilities. This hypothesis, known as Sapir-Whorf hypothesis, is based on two principles: linguistic determinism and linguistic relativity (Whorf, 1956). Although languages have many common universal features and this is...
evident after Chomskian linguistics (Chomsky, 1957), nevertheless, they differ in many other aspects. According to the Sapir-Whorf hypothesis, language influences and directly affects thought (linguistic determinism). Hence, differences in languages lead to differences in their users’ reasoning (linguistic relativity). Speakers of different languages categorize the world in different ways.

Today, experimental evidence is shown by supporters of both hypotheses and there is a broad debate on this topic (Brown & Levinson, 1993; Pederson, Danzigier, Wilkins, Levinson, Kita, & Senft, 1998; LI & Gleitman, 2002; Levinson, Kita, Haun, & Rasch, 2002). In fact, many studies lately have focused on the relation between spatial language and spatial cognition. In a neo-Whorfian account, these works aim to demonstrate that spatial language affects spatial reasoning. Languages differ by frames of spatial references that can be egocentric (centred on the viewer) or allocentric (centred on a landmark, externally to the viewer). Terms such as “left” and “right” are egocentric, while “uphill” or “downhill” are allocentric expressions. In some languages, both frames of references are available though one of them is mostly preferred to the other. For example, many European languages routinely use an egocentric system in descriptions of spatial relations despite of the fact that allocentric directions are also available. However, in many other languages only one frame of spatial reference is attainable. As Levinson and his colleagues (Brown & Levinson, 1993; Pederson et al., 1998) argued that people categorize spatial information in non-linguistic tasks according to linguistic frame of reference in use of their languages. Thus, language communities with different frames of spatial references (egocentric or allocentric) have different spatial thinking.

Data by Levinson and co-workers have been challenged by LI and Gleitman (2002). As they claimed, spatial reasoning can vary in monolingual speakers depending on the environment. Thus, English speakers\(^1\) in their experiment used an egocentric or allocentric frame of reference in a non-linguistic task according to the experimental set\(^2\). In this account, variation in spatial reasoning is not due to language but to circumstances in which speakers find themselves. In their view, language does not determine spatial reasoning.

The debate of language and space has a long tradition in linguistics, philosophy and psychology. We will try to assess assumptions previously discussed by looking at spatial language in atypical circumstances.

What happens to spatial language when non-linguistic spatial skills are impaired? Will impaired spatial cognition lead to impairments in spatial language? Or, will spatial language affect and compensate for impaired spatial cognition? These are the questions we are going to address by looking at spatial language in Williams syndrome. By answering these questions, we aim to evaluate cognitive and Sapir-Whorf hypotheses.

**Studies on Williams Syndrome**

**Williams Syndrome Cognitive Profile**

Williams syndrome is a rare neuro-developmental disorder with a genetic origin. This disease is due to the micro-deletion of elastin gene in chromosome 7. Individuals with Williams syndrome generally show a mild to moderate mental retardation and an uneven neuro-psychological profile with strengths and weaknesses in each cognitive domain. This feature, known as “peaks and valleys” cognitive profile, leads Williams syndrome subjects to have, in the same domain, top and bottom performances. For example, in language domain, vocabulary is a peak, being overall mental age (Bellugi, Bihrlne, Neville, Doherty, & Jernigan, 1992), while

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1 Experiments were carried out on monolingual English speakers.
2 The experiment was carried out in a first condition in a room without any landmark and in a second condition in a room with landmarks or other cues.
morphology, compared to linguistic performance of mental age controls, is a valley (Clahsen & Almazan-Hamilton, 1999).

Especially, Williams syndrome individuals have severe visuo-spatial deficits. Drawing, constructing designs of blocks or reproducing hierarchically organized figures are valleys (Farran & Jarrold, 2003; Bellugi et al., 1992), whereas face processing is a peak. Poor spatial skills in individuals with Williams syndrome are tightly tied to motor-planning difficulties, but according to findings of Hoffman, Landau and Pagani (2003) and Farran and Jarrold (2004), they may in part be due to perceptual and representational problems.

Moreover, after the works by Ungerleider and Mishkin (1982) and especially by Goodale and Milner (1992), we know that there are two different kinds of neural systems—dorsal and ventral, which provide for elaboration of spatial information. Particularly, the dorsal system guides and controls actions while ventral system controls visual perception. In Williams syndrome, the dorsal stream of spatial information is severely impaired. This selective impairment might explain peaks in some perception tasks and valleys in planning and controlling of actions.

Other characteristic features of Williams syndrome subjects are cardiovascular defects, hyperacusis and a distinct facial aspect (elfin like face).

In the past years, interest in Williams syndrome became evident, because this genetic pathology seemed to lead to dissociation of cognitive functions with spared language and impaired cognitive abilities. After a first work of Bellugi, Sabo and Vaid (1988), many linguists and philosophers of language such as Pinker (1994) looked at Williams syndrome as an empirical proof of a genetical-based and autonomous module of language. Spared syntax and impaired cognitive skills in Williams syndrome seemed to give evidence of an innate Chomskian mechanism for language acquisition. However, further researches have shown that although language in Williams syndrome is relatively in advantage over non-linguistic skills, it is neither intact nor autonomous (Giannotti & Vicari, 2004). Several studies in the past decades have considered the interaction between language and cognition. Many have looked at the mapping between language and space. In fact, several studies, specifically devoted to a better understanding of the problematic interaction between spatial language and spatial cognition in Williams syndrome, have been carried out.

**Spatial Language in Williams Syndrome**

How does spatial language work in this population? This question was posed in a study of Landau and Zukowski (2003). They tested Williams syndrome children, typically developing controls matched for mental age and adults on a spatial language task. Assignment was to describe motion events seen in short movies. The authors looked at the ability of the subjects to correctly handle with all the elements that according to Talmy (1975) we use to describe a motion event.

Williams syndrome individuals showed to be able to correctly use almost all the elements (ground object, figure object, path and manner of motion) that we need to talk about movement. However, they had significantly lower performance in encoding from paths producing errors, ambiguous answers or omissions. Authors considered that this result might depend on a deficit of spatial component of the working memory. Williams syndrome individuals have difficulties in talking about the source of a motion event, because they have difficulties in retaining this kind of information in their spatial working memory. After all, spatial

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3 Especially, impaired spatial cognition.

4 Figure object, ground object, path and manner of motion. See above for a more detailed description.
language is not entirely impaired. On the contrary, according to Landau and Zukowski (2003), it is fairly preserved. Nevertheless, there is a selective impairment in descriptions of from paths that might be related to bad performances of the spatial component of working memory. Thus, this selective defect in spatial language could be tied to non-linguistic spatial problems.

Moreover, taken together, findings of Landau and Zukowski (2003) suggest some consideration about the nature of spatial language itself and its interaction with spatial cognition. In fact, as they claimed spatial language might require coarser spatial information than spatial cognitive systems. That is, we need more accurate spatial representations for perception and action than for their linguistic encoding. Thus, even if spatial cognitive systems are partially impaired, we can acquire spatial language.

However, it is worth noting that other findings (Lakusta & Landau, 2005; Lakusta, Wagner, & Landau, 2007) have shown a "goal bias" in linguistic encoding of motion events among Williams syndrome children, normally developing controls and adults. Language shows a strong asymmetry in description of movement. Goals are by far more present than sources when subjects linguistically encode motion events. Talking about people’s or animals’ moving in space, we prefer to describe the destination rather than the origin of the path. This linguistic asymmetry seems to be grounded on prelinguistic representations of movement. In fact, as Lakusta, Wagner and Landau (2007) have shown, prelinguistic infants are capable of representing both sources and goals in their perceptions of movement, even though representation of goals is prominent. When both source and goal are present in a perceptual scene, infants prefer to encode the goal, showing a robust “goal bias”. Even if only the source is present in a perceptual scene, infants do not pay much attention to it.

These findings were obtained to show to prelinguistic infants a toy duck moving on a stage. During familiarization trials, infants saw the duck moving on the stage in three different conditions: From a source object but without any goal object; towards a goal object but without any source object; with both a highlighted source object and a normal goal object. During test trials, these conditions were altered. Infants’ looking times, however, increased only when experimenters manipulated goal object. In fact, if the duck moved from a different source, infants did not show to be surprised with looking times remaining the same. On the contrary, if the duck moved towards a different goal object, infants were surprised and their looking times increased significantly. Therefore, there is an asymmetry in prelinguistic representation of motion events. We find the same asymmetry in linguistic description of movement. This homology between linguistic and non-linguistic representation of movement, following Lakusta et al. (2007), could reflect conceptual foundations of spatial language. Hence, the goal-path bias, adding evidence for a non-linguistic support for spatial language, sustains the cognitive hypothesis previously discussed.

Many other studies on spatial language in Williams syndrome have been carried out. Philips, Jarrold, Baddeley, Grant and Karmiloff-Smith (2004) realized two different tests on Williams syndrome and control subjects respectively. The first was the TROG (Test for Reception of Grammar) (Bishop, 1983). This test assesses comprehension of several grammatical structures. The test is carried out by asking the subjects to choose one of four pictures that depict a word or a sentence they have previously listened to. The TROG has three blocks with spatial meaning: K, M and P. Block K assesses use of comparative forms of spatial adjectives (longer, taller and bigger). Bocks M and P assess spatial prepositions (in, on, above and below). Other grammatical structures evaluated by the TROG are, for example, singular and plural noun inflection (J),

5 The duck moved from a different source or towards a different goal.
masculine and feminine personal pronouns (I) or reversible passive (L) for a total amount of 20 blocks.

The subjects of the experiment were matched on the level they reached on the TROG test. For each Williams syndrome subject, there were a normally developing child and a child with moderate learning difficulties with the same score on the TROG. In this way, being the same of the overall level in the task, it was possible to compare all the groups according to the distribution of the mistakes. Williams syndrome subjects concentrated their errors in the spatial components of the TROG (K, P and M) scoring in the other blocks of the task as well as controls, with only one exception. In fact, individuals with Williams syndrome outperformed controls in block S that tests comprehension of negation. However, being Williams syndrome performances in the other blocks of the TROG that valuate negation (O and Q) not above controls, data from block S was not considered significant.

Following their first study, Philips et al. (2004) contrived a second test with the same procedure of the TROG but with a higher number of spatial blocks. This test, named TRUST (Test for Receptive Understanding of Spatial Terms), has eight spatial blocks that assess prepositions and comparative adjectives and eight non-spatial blocks for many other grammatical constructions. Again, Williams syndrome subjects made a significantly higher amount of errors in comprehension of spatial terms. On the contrary, in non-spatial terms, the average of errors was similar to controls except for non-spatial comparative adjectives. In this study, Williams syndrome individuals produced a high number of mistakes. Thus, this second task supports findings of the first study of Philips et al. (2004), showing that Williams syndrome individuals have problems in comprehending spatial terms. Certainly, it remains to be understood the nature of these problems. As Philips et al. (2004) claimed, individuals with Williams syndrome might have difficulties in creating spatial mental models (Knauff & Johnson-Laird, 2002). Moreover, spatial mental models may be required not only for comprehending spatial terms, but also for understanding expressions not strictly spatial in their meaning. Indeed, according to the authors, comparative adjectives seem to be represented using an axis with positive comparative adjectives (like “better”) set at the top and negative comparatives adjectives (like) “worse” set at the bottom. This hypothesis, following Philips et al. (2004), can explain errors of Williams syndrome individuals in non-spatial comparative adjectives in the tasks.

In a different study, Landau and Hoffman (2005) considered spatial language in Williams syndrome wondering if spatial language, in order to be acquired, needs support of non-linguistic spatial representations. In this case, it would reflect features of non-linguistic representations of space. With the aim of answering this question, they looked at performances of Williams syndrome subjects and controls on tasks that assessed their use of linguistic and non-linguistic frames of spatial reference. In non-linguistic tasks, subjects looked at a standard display with a dot and a square. Assignment was to choose one of two panels that matched disposition of the dot in relation to the square in the standard display. This task was carried out in a delayed condition and in a no delay condition with the difference that in the delayed task, standard and test panels were presented subsequently, while in no delay condition standard display and panels were simultaneously present.

On the other side, linguistic tasks used the same array both in comprehension and in production. In comprehension, subjects were asked to put a mark in a location around the square, following the experimenter’s instructions. In production, they had to look at the display and name the position of the dot in relation to the square reference object.

In spite of their severe visuo-spatial deficits, Williams syndrome individuals show, according to Landau and Hoffman (2005), preservation of axial frames of spatial reference both in linguistic and in non-linguistic
tests. Nevertheless, subjects with Williams syndrome showed fragility in encoding directions within axes significantly confusing “above” and “below” or “left” and “right” both in linguistic and in non-linguistic tasks. Difficulties in non-linguistic tasks, however, were evident especially in the delayed condition when subjects had to remember the position of the dot. This and other previous findings suggest, as Landau and Hoffman (2005) claimed, an impairment in visual spatial memory.

Ultimately, evidence shown by Landau and Hoffman (2005) indicated a direct effect of non-linguistic spatial breakdown on spatial language. In fact, directional fragility manifested in non-linguistic tasks with subjects misunderstanding direction within axes is paralleled in linguistic tasks. Faced with the task of naming the position of a target object in relation to a reference object, individuals with Williams syndrome used axial spatial terms but confused significantly the direction within the axes. However, following Landau and Hoffman (2005), we have to recognize that language is, to a certain extent, capable of compensating for non-linguistic breakdown. In fact, production of general terms like “near” and “far” in the place of more informative axial terms like “above” and “below” observed in Williams syndrome individuals, though more vague, still allows verbal description of what we see. Thus, Williams syndrome subjects, although they have impaired spatial cognition, can acquire spatial language, their languages still reflect non-linguistic spatial breakdown.

The conclusion that spatial language in Williams syndrome is selectively impaired was drawn in a study by Laing and Jarrold (2007). They claimed that, according to Johnson-Laird (1983), spatial language is grounded on a mental model of spatial arrangements. Individuals with Williams syndrome have difficulties to create this mental model and this affects selectively their spatial language. It is worth noting that the same hypothesis was proposed by Philips et al. (2004) and, to a certain extent, by Landau and Zukowsi (2003). However, Williams syndrome subjects, as Laing and Jarrold (2007) argued, have a basic understanding of spatial semantics. Their impairment is evident when a linguistic task requires them to use a mental model of spatial relations. These findings were achieved by assessing performances of Williams syndrome subjects and controls on two picture matching tasks. Both tasks assessed the use of spatial adjectives in comparative form (taller, smaller, shorter, etc.). None of them assessed spatial prepositions.

In the first task, subjects were required to choose one of four pictures depicting a sentence previously being listened to. Pictures in this task portray animals of different colours but the same sizes. Sentences focused on comparison of colours and sizes of animals (for example, “the blue animal is taller than the red animal”). Being the same sizes of animals in the pictures, in order to correctly perform the task, subjects need to use their semantic knowledge about sizes of animals in the real world. This task does not demand them to compare effective sizes of animals in the drawings to properly choose the picture. Semantic knowledge is enough to accomplish the task.

On the contrary, the second picture matching task requires the subjects to deal with actual spatial representations. In fact, pictures in this task depict animals of different colours and different sizes. In order to choose the picture that matches the spoken sentence, subjects need to create a mental model of spatial arrangements.

Performances of Williams syndrome individuals were as well as controls on the semantic picture matching task and by far worse than controls on the spatial picture matching task.

Thus, findings of Laing and Jarrold (2007) supported the claim that language and spatial cognition are not independent, and suggested the conclusion that comprehension of spatial language is selectively impaired in Williams syndrome. Indeed, semantics of spatial language is not per se impaired, but comprehension of spatial
language is delayed when spatial descriptions require operating with a spatial mental model.

Finally, Lukacs, Pleh and Racsmay (2007) concluded to similar findings. More precisely, they carried out two studies on spatial suffixes and postpositions, which are used to linguistically encode spatial relations in Hungarian. They argued that spatial language is not specifically impaired, but it looks poorer only when speakers have to manage with spatial arrangements in the real world, and they have to create a mental model of them. In other words, Williams syndrome subjects seem to understand the semantics of spatial language by itself, yet their performances are lower when they need to use spatial language to refer to the real world both in comprehension and in production. These results were achieved through two different kinds of tasks. The first was aimed to test comprehension and production of spatial postpositions and suffixes in descriptions of the real world. Subjects had to describe the disposition of toys put in front of them or, following linguistic instructions by an experimenter, they had to modify that same disposition. Carrying out this task, as Lukacs et al. (2007) argued, involves the creation of spatial mental model. On the contrary, the second was a sentence completion task that tested production of suffixes in spatial and non-spatial uses without addressing any description of the real world. In this case, the assignment was to complete a sentence with a missing suffix. The task was entirely linguistic, because completion of sentences did not rely on a description of a real situation.

Performances of Williams syndrome individuals were significantly poorer than controls in the first task and comparable in the second one. Nevertheless, it remains open to discussion whether this is a clear evidence of intactness of spatial language or of autonomy of language and spatial cognition. Lukacs et al. (2007) concluded that spatial language in Williams syndrome is not selectively impaired. However, their findings support evidence shown by Landau and Zukowski (2003) for a goal path bias in spatial language. Following Landau and Zukowski’s (2003) hypothesis, Lukacs et al. (2007) claimed that this bias can be explained by a deficit of spatial working memory. Williams syndrome individuals have difficulties in retaining spatial information in their working memory, and thus, they find difficult in talking about the source of a motion event. The same pattern of errors, moreover, is shown by typically developing controls revealing a bias of human cognition. Thus, findings of Lukacs et al. (2007), although they claimed the absence of a selective deficit of spatial language in Williams syndrome, seem to show that language reflects cognition.

Conclusion

This review of studies on spatial language in Williams syndrome can give us some hints in the hard task of understanding the relation between language and cognition.

As we have seen, spatial language is, in a complex way, grounded on spatial cognition. In fact, spatial language cannot work completely by itself. The mental model hypothesis previously discussed has shown the need to create a mental model of spatial relation in order to represent spatial arrangements and talk about what we see.

Language is not completely autonomous but it is certainly not at all a mirror system of spatial cognition. Indeed, it can sometime compensate for non-linguistic impairments as we have seen in Landau and Hoffman (2005).

Many questions are open and we still have a long road to walk before reaching the answers. For further researches, the most fascinating area of study seems to be the ontogenetically and phylogenetically co-evolution of language and cognition. This co-evolution seems to be at the heart of human nature.
References


