ACTA PÆDIATRICA
NURTURING THE CHILD

Acta Pædiatrica ISSN 0803-5253

REGULAR ARTICLE

Rotation and generation of mental imagery in children with specific language impairment

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Keywords
Children, Mental imagery, Specific language impairment

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Received
15 July 2012; revised 14 December 2012; accepted 10 January 2013.

DOI:10.1111/apa.12162

ABSTRACT

Aim: To investigate the relationship between mental imagery and specific language impairment (SLI) and explore the assumption that children with SLI are less able to generate mental images and/or convert them, when compared to typical development (TD) children of the same age.

Methods: Twenty-four children, aged six to eight, took part in two tests to see how well they generated and rotated mental images. The participants were 12 SLI children (six boys and six girls) and 12 TD children (six boys and six girls), matched by age and gender.

Results: The statistical analysis showed a significant difference between the two groups when it came to generating mental imagery. However, there were no significant differences with regard to rotating mental imagery.

Conclusion: The results suggest imagery deficit in language-impaired children is not caused by mental rotation, but by other aspects of image processing, such as generation, maintenance and interpretation of visual images.

INTRODUCTION

Specific language impairment (SLI), also called specific development disorder in speech and language, is characterized by productive and receptive deficits that lead to difficulties in both producing and understanding language and in the use of syntactic rules. This impairment has been described as a specific difficulty in linguistic elaboration or, alternatively, as a more general deficit in information processing (1). The DSM IV (2) classification of diseases defines the exclusionary and discrepancy criteria required for a diagnosis of SLI. These criteria are as follows: performance on a language test is below the child's chronological age; a discrepancy exists between the child's language skills and his/her non-verbal abilities and the language impairment cannot be attributed to any other cause. The DSM IV also includes a criterion that the language difficulties interfere with academic or occupational achievement or with the social communication of the individual with SLI.

In addition, SLI children often show deficits in other cognitive abilities, such as memory, attention and visuo-spatial processes. Moreover, they are less able to use non-verbal representations, such as gestures, symbolic play, imitation and mental imagery, compared with typical development (TD) children (3–5).

Mental imagery is the activation of an internal representation without an external stimulus. It is independent, but strictly correlated with the other cognitive functions, such as perception (6). Scientific research on mental imagery has mainly focused on mental rotation, which is produced by the relationship between the spatial operations and the capacity to recognize movement. The pioneers of research on mental rotation in adults were Shepard and Metzler (7).

Gloria S Marmor adapted Shepard and Metzler's techniques for children and showed that, by the age of five, they have the ability to rotate mental images (8). Moreover, Kosslyn (9) has discovered that imagery is not a single ability, but a group of skills (image generation, maintenance, scanning and manipulation) that develop individually at first and then together as people get older.

Key notes

- Children with specific language impairment showed significant differences in how they generate mental imagery when compared with other six to eight-year-olds with typical development.
- However, there were no significant differences between the two groups when it came to rotating mental imagery.
- The results suggest imagery deficit in language-impaired children is not caused by mental rotation, but by other aspects of image processing, such as generation, maintenance and interpretation of visual images.

The relationship between mental imagery and SLI is of interest in clinical and research fields. Mental imagery has a powerful effect on comprehension, memory and reading performances. Moreover, representational imagery techniques could improve children's comprehension and memory (4). For example, Joffe, Cain and Maric (10) have shown that a relatively short intervention in the use of mental imagery is an effective way to boost how SLI children understand stories.

Research into mental imagery in SLI children has not produced consistent findings. Johnston and Weismer (11) showed that SLI subjects were slower to perform mental rotation than their age-matched peers. In contrast, Savich (12) found that SLI children differed from TD children in accuracy, but not in speed. Savich's findings agree with those obtained in several studies (13–17).

Our study investigated mental imagery in SLI children, based on the assumption that SLI children would find it more difficult to generate mental images and/or perform mental rotation than their TD peers. It sought to provide an in-depth investigation into the different aspects of mental imagery skills, in order to better analyse the relationship between mental imagery and SLI.

Previous studies have highlighted mental imagery in SLI children, but most of these were conducted using specific tasks. This study aims to overcome the limitations of previous studies using instruments that analyse the different aspects of mental imagery skills (generation, manipulation and rotation).

The findings of this study could be of interest to professionals working in educational, clinical and rehabilitative fields. They could also help physicians, psychologists, teachers and therapists to find new methods or intervention strategies to enable children with SLI communicate effectively.

METHODS

Participants

This research is a part of a larger study investigating cognitive abilities in children with SLI. Two groups of Italian children participated in this study: 12 SLI children (six boys and six girls with a mean age of 7.13 years, standard deviation 0.78) and 12 TD children (six boys and six girls with a mean age of 7.07 years, standard deviation: 0.83). The groups were matched by gender and age.

Diagnosis of the children in the SLI group was confirmed by Italian Public Health Services, according to the DSM IV criteria. In particular, the children were assessed by a psychologist using a standardized intelligence test and by a speech therapist using a standardized language development test. The *Illinois Test of Psycholinguistic Abilities* (ITPA) was also administered. The SLI children obtained scores (18) indicating language impairment. They were recruited from two rehabilitation centres in a town in southern Italy, where they took part in both individual and group speech/language therapy.

The second group comprised children with typical language development who were selected during a summer camp and chronologically age-matched within three months of the SLI children. None had a history of speech/language disorder, and they all attended public schools, where they achieved age-appropriate levels in both learning and behaviour. They also achieved normal scores in the ITPA.

All participants were of middle socio-economic status and native speakers of standard Italian. None had a history of any neurological deficit.

Procedures

Measures

The study was conducted using three instruments: the ITPA assessed language skills, the mental rotation test measured mental rotation and the Finke test measured mental imagery generation and manipulation.

The ITPA is an effective measure of children's spoken and written language. It contains 12 subtests that assess different aspects of language, including oral, written, reading and spelling and identifies children with general linguistic delay in the development of spoken and written language. The ITPA provides different composite scores for clinical and diagnostic use. Our research used the 'general language composite' score, which combines the results of all 12 subtests. According to the authors, this score is the best single estimate of linguistic ability, because it reflects the widest range of spoken and written language. The ITPA presents good psychometric features: internal consistency, stability, reliability and validity.

The mental rotation test consists of two tasks ('mental rotation of car' and 'rotation of hand'). It is a readjustment of the test used by Funk, Brugger and Wilkening (2005) in a study on mental rotation skills (19). The 'mental rotation of car' task (see Fig. 1) presents drawings of cars in four different angles of rotation, along the vertical axis and in two driving directions, facing to the right or to the left (at 0°). The eight stimuli are shown at random in the centre of a portable computer monitor, and the subject has to decide whether the car was driving to the right or left by pressing the left or right button in front of the monitor. Their 'accuracy' and 'response time' are assessed.

In the 'mental rotation of hand' task, the stimuli are photographs of human left and right hands, with palm or back view, each rotated at 0°, 90°, 180° and 270° (see Fig. 1). The 16 stimuli are shown at random in the centre of a portable computer monitor. Using the same keyboard as the car test, the children have to decide whether the stimulus represents a right or left hand. They then press the corresponding button. The children were not allowed to move their hands, and they were covered with a cloth so that they could not look at them. 'Accuracy' and 'speed' were assessed.

In the Finke test (20), subjects are shown simple geometric shapes presented in random order (a triangle, a semicircle and an upside down 'J'). They are asked to assemble all these elements and mentally generate an object, and interpret it in a way that the object would gain a meaning for them. In addition, the subjects were able to

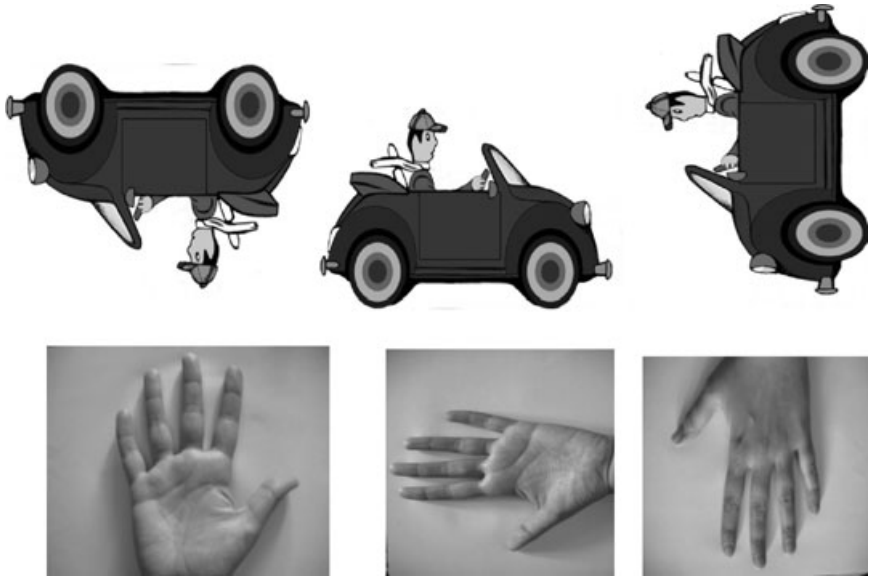

Figure 1 Sample stimuli out of the set of stimuli given during the mental rotation test (car and hand rotation test).

produce a completely new idea which could serve a specific purpose.

The scores covered the following variables: 'Shapes used', 'Rotation-reversal', 'Dimensional change', 'Overlap-intersection', 'Inclusion', 'Figurative authenticity' and 'Interpretative authenticity'. The scores for the first five variables ranged from 0 to 3, and the scores for the other variables ranged from 0 to 2.

The verbal instructions were simple and appropriate to the linguistic levels of the participants. Children did not have to give their answers verbally and were free to express themselves as they wished, for example through a gesture or drawing.

Statistics

T-test analyses and Mann–Whitney U-test examined differences in the mental rotation test scores with respect to the variables 'gender' and 'group' (SLI and TD children).

RESULTS

There were no significant gender differences with regard to the generation and rotation of mental imagery. Analysis of the two groups showed that SLI and TD children did not differ when it came to the 'accuracy' and 'speed' with which they performed mental rotation performances. Differences were observed between the two groups in the Finke 'Overlap-intersection', 'Figurative authenticity', 'Interpretative authenticity' and 'Novelty–utility' scores (see Table 1). In particular, the SLI subjects intersected or overlapped fewer shapes than the TD children of the same age. The SLI children were less adept at combining the stimulus shapes and less creative in providing an original meaning for the synthesis image created (Figurative Authenticity and Interpretative Authenticity). Moreover, the SLI children differed from the TD children in how they managed to produce a completely new idea that could serve a specific purpose (Novelty–Utility; see Fig. 2).

Table 1 Significant scores differences in the Finke test between SLI and TD children

	Groups†	Mean Rank	Mann–Whitney U-test
F Overlap-Intersection	SLI	9,50	36*
	TD	15,50	
F Figurative Authenticity	SLI	9,58	39*
	TD	15,42	
F Interpretative Authenticity	SLI	9,67	38*
	TD	15,33	
F Novelty–Utility	SLI	10,00	42*
	TD	15,00	

*Sig: $p < .05$.
†Groups: SLI, SLI children; TD, Typical development children.

In conclusion, the SLI children did not perform as well as their age-matched peers in the Finke test, but not in the mental rotation tasks. The SLI children did not present difficulties in mental rotation, but they did show a lower level of ability in the other aspects of mental imagery, such as generation, construction and manipulation, than their peers.

DISCUSSION

The present study highlights several interesting points concerning the relationship between mental imagery and specific language impairment (SLI). Preliminary, gender difference analysis showed that there are no significant differences in rotation and generation of mental imagery. This result is consistent with the findings of Roberts and Bell that gender differences strongly depended on the age of subjects (21).

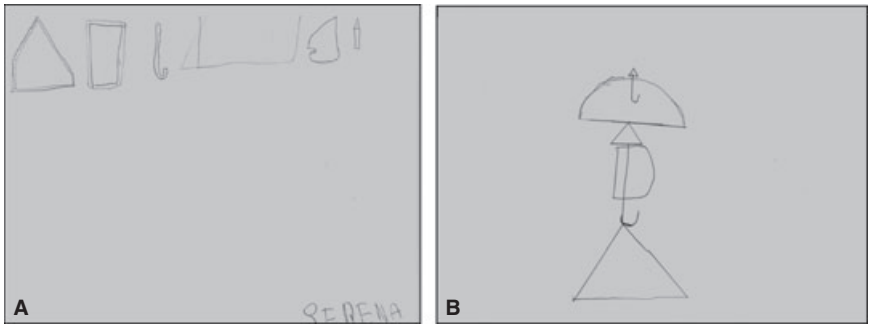

Figure 2 Examples of Finke test. (A) SLI child; name: square, 'It needs to do their homework'. (B) TD child, name: huge umbrella, 'It needs for shelter from the rain….but it is equipped with a instrument; a little light that allows you to see if it rains at night'.

With regard to the principal aim of this research, the findings showed that the SLI children did not differ from children with typical development with regard to mental rotation skill. The SLI children carried out mental rotations with the same 'accuracy' and 'speed' as the TD children. These results help to clarify the conflicting research results (11,12,17) on the relationships between language and mental imagery. The SLI children did not experience difficulties in mental rotation, but they struggled with the other aspects of image processing, including the generation, maintenance and interpretation of images (6). The Finke test showed that the SLI subjects intersected and overlapped fewer shapes than TD children of the same age. According to the Finke model, this indicates that the SLI children were less able to construct mental imagery. It is important to highlight that mental imagery construction plays a pivotal role in creativity, thinking, memory and imagination. It also influences problem-solving and reading performances. When the SLI children were compared to peers with typical development, they were less adept at generating stimulus shapes and less creative in interpreting the meaning of the synthesis image produced. In this regard, Kosslyn (22) assumes that various subcomponents of imagery processing are present with differential efficiency in the two cerebral hemispheres. In particular, the left hemisphere generates images that allow categorical relationships, while the right hemisphere specializes in generating images based on spatial coordinates, such as mental rotation. This could explain why the SLI children performed differently in the various mental imagery tasks. Their language difficulties would, in fact, suggest a left hemisphere dysfunction and would prove that these subjects experience no difficulties in mental rotation.

Our results show the strong relationship between language impairment and impairment in procedural skills, such as the ability to mentally represent an action, and to gain appropriate representational gestures (23). This impairment could result in a representational deficit that extends beyond language (24,25).

In conclusion, our findings could prove important and relevant to rehabilitative and clinical fields. Strategies and intervention programmes for language impairment often include techniques that require the use, generation or manipulation of mental images. For example, augmentative and alternative communication (AAC) uses visual language systems to help children with communication skills. AAC uses text, gestures, facial expressions, touch, sign language, symbols, pictures and speech generating devices, etc. The problems that children with SLI experience with mental imagery should be taken into account when using techniques that require the generation, construction, manipulation and use of mental images. For this reason, specific assessment and training in the use of mental imagery could be usefully inserted into rehabilitative programmes for SLI children, to increase their ability to use AAC techniques.

References

1. Camaioni L. Early language. In: Bremner G, Fogel A, editors. *Blackwell handbook of infant development*. Oxford, England: Blackwell, 2001.
2. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision*. Washington, DC: American Psychiatric Pub, 2000.
3. Leonard LB. Language impairment in children. *Merrill-Palmer Q* 1979; 225: 205–32.
4. Botting N, Riches N, Gaynor M, Morgan G. Gesture production and comprehension in children with specific language impairment. *Br J Dev Psychol* 2010; 28: 51–69.
5. Marton K. Imitation of body postures and hand movements in children with specific language impairment. *J Exp Child Psychol* 2009; 102: 1–13.
6. Kosslyn SM. *Image and mind*. Cambridge, Massachusetts and London, England: Harvard University Press, 1980.
7. Shepard RN, Metzler D. Mental rotation of three-dimensional objects. *Science* 1971; 171: 701–3.
8. Marmor GS. Development of kinetic images. When does the child first represent movement in mental images?. *Cogn Psychol* 1975; 7: 548–59.
9. Kosslyn SM, Margolis JA, Goldknopf ES, Daly PF, Barrett AM. Age differences in imagery abilities. *Child Dev* 1990; 61: 995–1010.
10. Joffe VL, Cain K, Maric N. Comprehension problems in children with specific language impairment: does mental imagery training help? *Int J Lang Commun Disord* 2007; 42: 648–64.
11. Johnston JR, Weismer SE. Mental rotation abilities in language-disordered children. *J Speech Hear Res* 1983; 26: 397–403.

12. Savich PA. Anticipatory imagery ability in normal and language-disabled children. *J Speech Hear Res* 1984; 27: 494–501.
13. Inhelder B. Cognitive development and its contribution to the diagnosis of some phenomena of mental deficiency. *Merrill-Palmer Q* 1966; 12: 299–319.
14. Inhelder B. Observations on the operational and figurative aspects of thought in dysphasic children. In: Morehead DM, Morehead AE, editors. *Normal and deficient child language.* Baltimore: University Park Press, 1976.
15. De Ajuriaguerra J, Jaeggi A, Guignard F, Kocher M, Maquard M, Roth S, et al. The development and prognosis of dysphasia in children. In Morehead DM, Morehead AE, editors. *Normal and deficient child language*. Baltimore: University Park Press, 1976.
16. Johnston J, Ramstad V. Cognitive development in preadolescent language-impaired children. *Paper presented at the Annual Convention of the American Speech and Hearing Association*. Chicago, 1977.
17. Whitmire BM, Addison Stone C. Visual imagery skills and language abilities of normal and language-learning-disabled children. *Learn Disabil Q* 1991, 14, 49–59.
18. Kirk Samuel A, McCarthy James J, Kirk Winifred D. *I.T.P.A. Illinois Test of Psycholinguistic Abilities*. Italian Translation, adaption: Nardocci F, Stella G, Ferrari F, Gibertoni M, Ciotti F, Papperini R. Torino, Italy: Omega Edizioni, 1997.
19. Funk M, Brugger P, Wilkening F. Motor processes in children's imagery: the case of mental rotation of hands. *Dev Sci* 2005; 8: 402–8.
20. Finke RA. *Creative imagery: Discoveries and inventions in visualization.* Hillsdale, NJ: Erlbaum, 1990.
21. Roberts JE, Bell MA. The effects of age and sex on mental rotation performance, verbal performance and brain electrical activity. Wiley Periodicals, Inc. *Dev Psychobiol* 2002; 40: 391–407.
22. Kosslyn SM. Seeing and imaging in the cerebral hemispheres. A computational approach. *Psychol Rev* 1987; 94: 148–75.
23. Hill EL, Bishop DVM, Nimmo-Smith I. Representational gestures in Developmental Coordination Disorder and specific language impairment: error-types and the reliability of ratings. *Hum Mov Sci* 1998; 17: 655–78.
24. Rescorla L, Goossens M. Simbolic play development in toddlers with expressive language delay. *J Speech Hear Res* 1992; 35: 1290–302.
25. Thal D, Bates E. Language and gesture in late talkers. *J Speech Hear Res*, 1988; 31: 115–23.