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Representation of survey and route spatial descriptions in children with nonverbal (visuospatial) learning disabilities

Irene C. Mammarella [a,*], Chiara Meneghetti [b], Francesca Pazzaglia [b], Filippo Gitti [c], Claudia Gomez [c], Cesare Cornoldi [b]

[a] Department of Developmental Psychology, University of Padova, Italy
[b] Department of General Psychology, University of Padova, Italy
[c] Neuropsychiatric Developmental Center, Brescia Hospital, Brescia, Italy

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ABSTRACT

This study aims to investigate the types of difficulty encountered by children with nonverbal (visuospatial) learning disabilities (NLD) during the processing of spatial information derived from descriptions. Two spatial descriptions – one in survey, one in route perspective – and one nonspatial description were orally presented to children aged 9–12 divided in three groups: (i) with NLD ($N = 12$), (ii) with reading disability (RD) ($N = 11$), and (iii) without learning disabilities who served as controls ($N = 16$). Children performed two tasks: sentence verification and location. In the verification task, NLD performed worse in survey text than control and RD groups. Moreover, in the location task NLD were worse than controls in both survey and route descriptions, but significantly poorer than the RD group only in the survey description. The results are discussed considering their implications in understanding the neuropsychological profile of NLD and the processes involved by different types of spatial descriptions.

1. Introduction

Children exhibiting nonverbal (or visuospatial) learning disabilities (NLD) typically show problems in visuospatial-organizational, psychomotor, tactile-perceptual and nonverbal problem-solving skills – which are associated with a right hemisphere dysfunction (Nichelli & Venneri, 1995; Tranel, Hall, Olson, & Tranel, 1987) – but perform normally in linguistic tasks such as rote verbal learning, verbal classification and regular phoneme-grapheme matching.

According to Rourke (1995; see also Rourke et al., 2002), NLD syndrome is characterized by significant primary deficits in some dimensions of tactile perception, visual perception, complex psychomotor skills and in dealing with new circumstances. These primary deficits lead to secondary deficits in tactile and visual attention, and to tertiary deficits in visual memory, concept-formation, problem-solving, and hypothesis-testing skills. Finally, there are very evident and significant impairments in language prosody, content, and pragmatics, while performance in other linguistic tasks (e.g., language form, amount of verbal association and language output) is normal at primary school level, although it may be impaired in children aged 7–8 years (Drummond, Ahmad, & Rourke, 2005). Children with NLD might also encounter difficulties in various other aspects of academic learning, especially in drawing, science (Pelleiter, Ahmad, & Rourke, 2001), arithmetic (Mammarella, Lucangeli, & Cornoldi, submitted for publication; Rourke, 1993; Venneri, Cornoldi, & Garuti, 2003) and in informal learning during spontaneous playing activities and other social situations. Problems in the social sphere seem to be due to very limited competence in comprehending nonverbal communicative signs in social and emotional contexts (Petti, Voelker, Shore, & Hayman-Abello, 2003). A recent study also demonstrated that nonverbal learning disability children show problems in the processing and transfer of knowledge acquired in one situation or context to another (Schiff, Bauminger, & Toledo, 2009).

Although studies have focused on examination and demonstration of visuospatial deficits of NLD children, concluding that visuospatial working memory (VSWM) tasks may be useful for identifying children with this disability (e.g., Cornoldi, Dalla Vecchia, & Tressoldi, 1995; Mammarella et al., 2006), NLD children seem also to exhibit significant linguistic deficits. Indeed, the language of such individuals may be moderately to severely deficient in content and pragmatics. Pragmatics refers to the functional and contextual aspects of language, including an appreciation of the rules of social discourse, the speaker's purpose for communication, and how language is modified to fit different situations (Bloom, 1988; Boone & Plante, 1993). Children with NLD are especially deficient in this dimension of language. They tend to be verbose, but their speech is inclined to be straightforward, repetitive, and rote.

* Corresponding author. Address: Dipartimento di Psicologia dello Sviluppo, Università degli Studi di Padova, Via Venezia, 8, 35131 Padova, Italy. Fax: +39 0498276600.
E-mail address: irene.mammarella@unipd.it (I.C. Mammarella).

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Discourse lacking in content and organization, with minimal speech prosody, low appreciation of the social aspects of the discourse is common in children with NLD (Rourke & Tsatsanis, 1996).

Support for Rourke's hypothesis that language comprehension is a further ability impaired in NLD children was offered by Humphries, Cardy, Worling, and Peets (2004), who investigated the narrative discourse comprehension and story retelling abilities of NLD children by comparing them with typical controls and with children identified as having verbal impairment. Results showed the presence of both narrative comprehension and retelling difficulties in NLD children. The narrative performance of the NLD group was not significantly different from that of children with verbal impairment on all the comprehension or story retell measures, and they were poorer than typically functioning children in comprehending inferences, but not literal content.

Other studies seem to suggest that language comprehension difficulties are related in particular to the processing of spatial information. Worling, Humphries, and Tannock (1999) found that children with NLD have difficulty with language inferencing, specifically when this depends on appreciation of spatial relationships. In this study the comparison of an NLD group, a verbally impaired group and typical controls indicated that the language inferencing difficulties of NLD children are as severe as those associated with the general verbal impairment group. The NLD group performed as poorly as the verbally impaired group on all language inferencing tasks. Moreover, for NLD children alone, spatial inferencing problems were significantly correlated with difficulties in emotional inferencing. These results revealed that NLD children have difficulty in developing spatial mental models (Johnson-Laird, 1983), offering support for the multidimensionality of mental models, including those representing spatial information, characters' emotions, characters' goals, and plans and temporal information (Zwaan, Langston, & Graesser, 1995).

Finally, some preliminary studies (Pedroni, Molin, & Cornoldi, 2007; Rigoni, Cornoldi, & Alcetti, 1997) examining drawings and object locations based on descriptions of spatial relationships found that NLD can have difficulty in understanding spatial descriptions. In conclusion, these results revealed that NLD children may have problems in processing texts containing spatial information. However, the construction of spatial mental models was not systematically studied. Furthermore, the difficulties met by NLD could be due to a severe and general cognitive impairment rather than a specific weakness related to the NLD profile.

The main aim of the present research was to examine the difficulties shown by NLD children in processing spatial and nonspatial descriptions. Many studies (Bryant, 1997; Perrig & Kintsch, 1985; Taylor & Tversky, 1992; Tversky, 1991) have demonstrated that spatial mental models are spontaneously constructed as a result of reading descriptions of spatial patterns and environments, and maintain spatial properties isomorphic to those of the environments represented (Bower & Morrow, 1990; Mani & Johnson-Laird, 1982; Morrow, Bower, & Greenspan, 1989). Furthermore, literature on spatial cognition shows that an environment's description can assume two different main perspectives, i.e., route and survey (Tversky, 1991). Route descriptions take the point of view of a person moving within the environment. They are characterized by the use of an intrinsic frame of reference and egocentric terms such as right, left, front and back, and have a linear organization given by the order in which landmarks appear along the route itself. Survey descriptions instead provide an overview of the spatial layout, sometimes with strong hierarchical organization; they are characterized by an extrinsic frame of reference and canonical terms such as north, south, east and west.

Developmental studies showed that children's representations of large-scale environments tend to be sequential in nature (Allen & Kirasic, 1985; Piaget, Inhelder, & Szeminska, 1960; Siegel & White, 1975). Siegel and White (1975) proposed a model that posits a progression from representing landmarks, then routes, and at the highest-level integration into a spatial mental model. The first type of representation (landmark) represents environmental patterns that are perceptually salient or important for the person involved (e.g., the home). As a second step, children develop a route representation based on routes generally used to connect landmarks. This representation is based on an egocentric frame of reference, and directions follow a precise sequence of motor actions (e.g., turn left, then go straight). Finally, children around 8-years-old can create a survey representation, in which the environment is represented in an overall configuration. This implies the encoding of directions and distances between places regardless of the person's position, and is based on allocentric frame of references. In a recent study, Uttal, Fisher, and Taylor (2006) demonstrated that children who learned from a map performed significantly better than those learning from a verbal description. Moreover, young children retained the sequential information but did not integrate the relations into a survey-like cognitive map. These studies suggest that children with difficulties in processing spatial information, such as children with NLD, might have less difficulty with route descriptions than with survey descriptions, if these descriptions really involve different processes and representations. The difficulties shown by NLD children in processing spatial descriptions may depend critically on type of task, not just on type of description. In the present study we therefore also examined the different implications of two different tasks, i.e., a sentence verification task, devised to examine memory recall of specific information presented in the description, and a subsequent task (i.e., location task) in which the overall organization of the environment has to be reproduced, devised to assess the spatial mental model generated by the child. NLD and reading disabled (RD) children, with decoding but not comprehension impairments, were compared with a control group of children without learning disabilities: the inclusion of the RD group served to distinguish between specific difficulties related to the NLD condition and more general failures.

Specifically, our purposes were: (a) determine if children with NLD have problems in the comprehension of spatial descriptions in survey and route perspective, and (b) evaluate if children with NLD are able to process and construct mental models of spatial descriptions, i.e., locate landmarks of the environments described in the descriptions. These issues are critical to understanding of the pattern of deficits and resources in children with NLD, and in fact may show the extent to which also language may be impaired in children with NLD. In particular, within the framework of the present study, the predicted differentiation between survey and route representations should offer specific insights into the nature of spatial representations and their implications for children with NLD.

2. Method

2.1. Participants

The sample comprised 39 children aged 9–12 years. Twelve (11 boys and 1 girl, mean age 9.5 years, *SD* = 1.31) had received a clinical diagnosis of NLD at the Neuropsychiatric Developmental Center of Brescia Hospital (Italy), and 11 (9 boys and 2 girls, mean age 10.27 years, *SD* = 1.27) had been given a diagnosis of reading disability (RD, i.e., dyslexia) (seven were tested at the University Center for Learning Disability, Padova, and four at the Neuropsychiatric Developmental Center of Brescia Hospital). The 16 control children (mean age 9.69 years, *SD* = .49) were typically developing 4th and 5th graders, and were tested in local schools. In particular, the con-