



Relations between home numeracy experiences and basic calculation skills of children with and without specific language impairment

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ABSTRACT

The present study examined the relations between home numeracy experiences (i.e., parent–child numeracy activities and parents' numeracy expectations) and basic calculation skills (i.e., addition and subtraction) of children with Specific Language Impairment (SLI) and their peers with Normal Language Achievement (NLA), while taking into account their cognitive and linguistic capacities. Fifty children with SLI and 100 children with NLA were tested on cognitive, linguistic, and basic calculation skills, and their parents filled in questionnaires on home numeracy activities and numeracy expectations. The results showed parents of children with SLI report engaging in fewer numeracy-related activities and have lower numeracy expectations for their children than parents of children with NLA. Furthermore, parent–child numeracy activities were more strongly associated with addition and subtraction for children with SLI. It is thus especially important that parents of children with SLI are made aware of their important role in the development of their child's basic calculation skills.

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Specific Language Impairment (SLI) is characterized by severe deficiencies in language development in the absence of intellectual or physical disabilities, hearing loss, or environmental influences (Bishop, 1992). Previous research has consistently indicated that children with SLI exhibit developmental weaknesses in the domain of phonological, lexical, and grammatical abilities (Bishop & Snowling, 2004) which puts them at risk for developing academic difficulties in primary education. To be more specific, next to poor literacy and reading skills (Catts, Fey, Tomblin, & Zhang, 2002), a growing number of studies also indicates that, compared to their peers with Normal Language Achievement (NLA), children with SLI have lower basic calculation skills (i.e., addition and subtraction of numbers less than ten) (Cowan, Donlan, Newton, & Lloyd, 2005; Fazio, 1996; Koponen, Mononen, Räsänen, & Ahonen, 2006). This can tentatively be explained from the fact that the acquisition of arithmetic is related to the language system (Dehaene, Piazza, Pinel, & Cohen, 2003; Simmons, Singleton, & Horne, 2008), and that the impaired language abilities of children with SLI are negatively related to their basic calculation skills (e.g., Cowan et al., 2005; Kleemans, Segers, & Verhoeven, 2012). However, besides these child abilities, numeracy experiences in the home may be an important contextual factor in the development of basic calculation skills (LeFevre, Skwarchuk, Smith-Chant, Fast, Kamawar, & Bisanz, 2009). Home numeracy experiences can

be defined as a combination of unique, yet interrelated, aspects that stimulate the numeracy skills of children, such as parent–child numeracy activities (LeFevre et al., 2009) and parents' numeracy expectations (LeFevre, Polyzoï, Skwarchuk, Fast, & Sowinski, 2010). In the research conducted so far, the relations between home numeracy experiences and basic calculation skills in children with SLI have not been established yet. This is puzzling, as unique relationships between home numeracy experiences and basic calculation skills have been found in children with NLA (LeFevre et al., 2009), and it has been suggested in previous research that the interaction between contextual factors and deficiencies in language development places children with SLI at an elevated risk for learning difficulties (Martin, Volkmar, & Lewis, 2007). In the present study, we therefore examined to what extent home numeracy experiences relate to the basic calculation skills of children with SLI, while taking into account cognitive and linguistic factors.

1. Child factors of basic calculation skills

The ability to add or subtract is first preceded by early numeracy skills (e.g., counting, arithmetic conceptual knowledge) (Desoete & Grégoire, 2006; Nunes & Bryant, 1996). Previous research has shown that addition and subtraction are processed in different parts of the brain, and can thus be seen as different types of mental calculations underlying basic arithmetic skills (Dehaene et al., 2003). Although little is known about which other child abilities are related to the development of arithmetic, a framework on the

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acquisition of basic calculation skills can be derived from previous research according to which both cognitive and linguistic factors are found to play a role (cf. Kleemans, Peeters, Segers, & Verhoeven, 2012; LeFevre, Fast et al., 2010). With respect to cognitive factors, general intelligence and working memory have been found to be associated with basic calculation outcomes of both children with SLI (e.g., Cowan et al., 2005) and NLA (e.g., De Smedt, Janssen, Bouwens, Verschaffel, Boets, & Ghesquière, 2009; Stock, Desoete, & Roeyers, 2009). Linguistic factors such as phonological awareness and grammatical ability are also related to basic calculation skills. Problems in phonological awareness negatively influence the efficient use of the verbal codes needed during simple arithmetic (Simmons & Singleton, 2008). Likewise, grammatical ability and basic calculation skills both rely on common syntactical rules and structures (cf. Baldo & Dronkers, 2007; Jackendoff, 2002). Phonological awareness and grammatical ability have been found to relate to basic calculation skills in both children with SLI and NLA (Kleemans, Segers et al., 2012).

Finally, naming speed is another child factor that needs to be taken into account. Both naming speed and basic calculation skills rely on fast and efficient retrieval of linguistically dependent representations from long-term memory (Koponen et al., 2006). Kleemans, Segers, et al. (2012) found naming speed to differentially relate to learning outcomes in basic calculation skills in children with SLI. They suggested that the level in which naming speed is impaired may act as a clinical marker in identifying those children with SLI who are likely to develop problems in basic calculation skills.

2. Home factors of basic calculation skills

Next to child factors, individual differences in learning are related to variations in experiences in the home as well (Melhuish et al., 2008). Research on the extent to which home numeracy experiences are associated with basic calculation outcomes in both children with SLI and children with NLA is scarce, especially when contrasted to what is known about the relationships between home literacy experiences and literacy outcomes in both typical (e.g., Sénéchal, LeFevre, Thomas, & Daley, 1998) and atypical populations (e.g., McGinty & Justice, 2009; Van der Schuit, Peeters, Segers, Van Balkom, & Verhoeven, 2009). Studies on the role home literacy experiences in literacy skills showed that parent literacy activities were directly related to children's early literacy skills, even after parent education and child's vocabulary skills were controlled for (Sénéchal, 2006). Van der Schuit and colleagues (2009), studying children with intellectual disabilities, suggested that parents adapt their level to the developmental level of their children, which may not always be the most stimulating option for children who lag behind. Indeed, Skibbe, Justice, Zucker, and McGinty (2008) found parents of children with SLI report engaging in fewer literacy-related practices and also have lower literacy expectations than parents of children with NLA, whereas McGinty and Justice (2009) showed the quality of home literacy experiences to be associated with print knowledge in children with SLI. Given the relatedness between linguistic and arithmetic skills, similar results may be expected for aspects of home numeracy experiences on basic calculation skills, as recent research indicates that aspects of home numeracy experiences relate to individual differences in basic calculation skills as well (LeFevre et al., 2009; Melhuish et al., 2008).

The two most important aspects of home numeracy experiences that can be extracted from research in typically developing children are parent-child numeracy activities and parents' numeracy expectations. With regard to parent-child numeracy activities, Blevins-Knabe and Musun-Miller (1996) found the frequency of numeracy-related activities in the homes of 49 American

kindergarten children to be both positively (e.g., the parents using number words) and negatively (e.g., the parent reciting the numbers) related to the children's early numeracy skills. The authors explained the negative correlations by the fact that parents possibly spend more time on numeracy-related activities when children have difficulties in numeracy skills. In another study, Blevins-Knabe, Berghout, Musun-Miller, Eddy, and Jones (2000) did not find relationships between parent-child numeracy activities and children's early numeracy skills. Both studies of Blevins-Knabe and colleagues (1996, 2000) used correlations between individual items and early numeracy skills, instead of factor scores which would increase reliability.

The relationships between the frequency of parent-child numeracy activities and later basic calculation skills have been reported in other research. To begin with, Huntsinger, Jose, Larson, Balsink Krieg, and Shaligram (2000) found the efforts of Chinese American and European American parents to teach their children simple sums in kindergarten, to be positively related to later achievement in basic calculation skills. Pan, Gauvain, Liu, and Cheng (2006) reported similar results for Chinese-speaking children: The frequency of parent-child numeracy activities was significantly related to later performance on counting and addition. Finally, LeFevre et al. (2009) found that parent-child numeracy activities measured at kindergarten was associated with addition and subtraction in Grade 1, even when verbal ability and working memory were taken into account.

With respect to the relations between parents' numeracy expectations and basic calculation skills, the literature is much less developed. To the best of our knowledge, only two comprehensive studies in relating parents' numeracy expectations to numeracy skills were conducted so far. LeFevre, Polyzoi, et al. (2010) showed that parents with higher numeracy expectations engaged in more numeracy-related practices, which was associated with better achievement on the part of the child. And Kleemans, Peeters, et al. (2012) found similar results for 89 kindergartners: The higher the parents' numeracy expectations, the better the child's early numeracy skills.

Previous research focused on either parent-child numeracy activities or parents' numeracy expectations in relation to basic calculation outcomes, but the two have not been combined in one design, leaving the question how the combination of both aspects of home numeracy experiences are uniquely associated with the acquisition of basic calculation skills. Furthermore, child factors (i.e., general intelligence, working memory, phonological awareness, grammatical ability, and naming speed) relate to basic calculation skills, and thus also need to be included. In a recent cross-sectional study, Kleemans, Peeters et al. (2012) combined both child and home factors in relating aspects of home numeracy experiences to early numeracy skills and found both parent-child numeracy activities and parents' numeracy expectations to be associated with early numeracy skills of children with NLA, next to such child factors as phonological awareness and grammatical ability.

3. The present study

Converging evidence shows home numeracy experiences (i.e., parent-child numeracy activities, parents' numeracy expectations) to be related to basic calculation skills. However, no research conducted so far related these aspects to basic calculation skills of children with SLI, even though exposure to numeracy-related activities at home may be an important way to reduce their delays in basic calculation skills. In the present longitudinal study, we therefore examined the relations between home numeracy experiences (i.e., parent-child numeracy activities and parents' numeracy expectations), measured in the second year of kindergarten, and

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