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A pilot study of the effects of RightStart instruction on early numeracy skills of children with specific language impairment

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ABSTRACT

This pilot study investigated the effects of an early numeracy program, RightStart Mathematics (RS), on Finnish kindergartners with specific language impairment (SLI). The study applied a pre-test–instruction–post-test design. The children with SLI ($n = 9$, $M_{age} = 82.11$ months) received RS instruction two to three times a week for 40 min over seven months, which replaced their business-as-usual mathematics instruction. Mathematical skill development among children with SLI was examined at the individual and group levels, and compared to the performance of normal language-achieving age peers ($n = 32$, $M_{age} = 74.16$ months) who received business-as-usual kindergarten mathematics instruction. The children with SLI began kindergarten with significantly weaker early numeracy skills compared to their peers. Immediately after the instruction phase, there was no significant difference between the groups in counting skills. In Grade 1, the children with SLI performed similarly to their peers in addition and subtraction skills (accuracy) and multi-digit number comparison, but showed weaker skills in arithmetical reasoning and in matching spoken and printed multi-digit numbers. Our pilot study showed encouraging signs that the early numeracy skills of children with SLI can be improved successfully in a kindergarten small-classroom setting with systematic instruction emphasizing visualization.

1. Introduction

Previous research has shown that children with specific language impairment (SLI) often demonstrate weaker mathematics performance compared to their age peers before the onset of formal schooling (e.g., Kleemans, Segers, & Verhoeven, 2011). Follow-up studies (Fazio, 1996, 1999; Morgan, Farkas, & Wu, 2011), as well as cross-sectional studies conducted with older children with SLI (Fazio, 1999; Koponen, Mononen, Räsänen, & Ahonen, 2006; Pulkkinen-Kantonen, 2012), have indicated that difficulties in mathematics learning are persistent. In SLI, the normal language acquisition patterns are disturbed in the early stages of development, conditions not caused by neurological or speech mechanism abnormalities, sensory impairments, mental retardation, or environmental factors (ICD-10: World Health Organization, 2010). In addition to language impairment, many of these children also show limitations in working memory and processing speed (Montgomery, Magimairaj, & Finney, 2010), all shown in relation to mathematics performance in early childhood (e.g.,

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Friso-van den Bos, van der Ven, Kroesbergen, & van Luit, 2013; Geary, 2011; Purpura, Hume, Sims, & Lonigan, 2011). In this light, children with SLI in early childhood are already at risk for low performance in mathematics. Mathematics intervention research has provided evidence that pedagogical interventions can improve the early numeracy skills of children with initially low performance (e.g., Jordan, Glutting, Dyson, Hassinger-Das, & Irwin, 2012), but such research on children with SLI is lacking. In this study, we investigated the effects of RightStart Mathematics instruction (Cotter, 2001) on the development of early numeracy skills among kindergartners with SLI.

1.1. Early numeracy skills in children with SLI

A review of the literature concerning the development of early mathematics skills of children with SLI (Appendix A) showed that children with SLI have severe deficits in counting (Arvedson, 2002; Cowan, Donlan, Newton, & Lloyd, 2005; Donlan, Cowan, Newton, & Lloyd, 2007; Fazio, 1994, 1996; Kleemans et al., 2011) and arithmetic skills (Cowan et al., 2005; Donlan et al., 2007; Jordan, Levine, & Huttenlocher, 1995; Kleemans, Segers, & Verhoeven, 2012; Mainela-Arnold, Alibali, Ryan, & Evans, 2011). However, these children have demonstrated similar performance to their age peers and above their language peers in skills that seem to require less language processing, such as single-digit number comparison (Donlan, Bishop, & Hitch, 1998; Donlan & Gourlay, 1999) and number line estimation (Kleemans et al., 2011).

More specifically, counting difficulties seem to be present when oral counting is involved, such as in rote counting forward and backward, where number word sequence errors often surface (Cowan et al., 2005; Fazio, 1994, 1996). In object-counting tasks, children with SLI have generally demonstrated weaker performance when compared to their age peers (Fazio, 1994; Kleemans et al., 2011), unless they were operating in the number range within which they were confident (Fazio, 1996), or if oral counting was not required, such as in reproducing the same set of objects without oral expressions or through gestured counting (Arvedson, 2002; Fazio, 1994). Young children with SLI usually seem to understand conceptual counting principles, such as cardinality and one-to-one correspondence, similarly to their age peers (Arvedson, 2002; Fazio, 1994, 1996).

In arithmetic skills, children with SLI have demonstrated weaknesses in basic single-digit addition and subtraction tasks, regardless of the presentation format (written or spoken), and in accuracy and fluency, as well as in word-problem contexts (Cowan et al., 2005; Donlan et al., 2007; Fazio, 1996; Jordan et al., 1995; Kleemans et al., 2012; Samelson, 2009). Fazio (1996) noted that children with SLI often used more immature counting strategies (e.g., using fingers as memory aids and counting all) compared to their age peers, who were able to recall facts more often from memory. Furthermore, Mainela-Arnold et al. (2011) found that children with SLI showed delays in their understanding of mathematical equivalence (e.g., $5+3+2=5+\_\_$). Despite their weaknesses in arithmetic skills, children with SLI seem to have as strong conceptual understanding of arithmetic principles (Donlan et al., 2007). In nonverbal arithmetic problems (i.e., those in which an oral or written response is not required), children with SLI have performed with results similar to those of their age peers (Arvedson, 2002; Jordan et al., 1995; Samelson, 2009).

In addition to difficulties in counting and arithmetic skills, children with SLI show difficulties in the range of age- and grade-related mathematics tasks compared to their age peers in elementary school, according to a large-scale follow-up study conducted by Morgan et al. (2011). Cowan et al. (2005) found that seven- to nine-year-old children with SLI had difficulties operating on multi-digit numbers, transcoding numbers (reading and writing numbers, and matching spoken and printed numbers), and place value (measured as comparing numbers).

1.2. Reasons for weak early numeracy performance of children with SLI

Numerous studies conducted on typically developing children have reported that general intelligence (e.g., Geary, 2011; Li & Geary, 2013) and working memory (WM) (e.g., Friso-van den Bos et al., 2013) are related to children's performance in mathematics. In children with SLI, the children's general intelligence is thought to be within the normal range, but many show significant limitations in WM, merely in the central executive and phonological loop (Montgomery et al., 2010). The central executive is responsible for coordinating and controlling the different activities within working memory (Montgomery et al., 2010), and deficits may be illustrated in mathematics such as choosing wrong calculation operations, not being able to successfully switch between operations, strategies, and quantity ranges, forgetting intermediate results, and making procedural errors (Friso-van den Bos et al., 2013). The phonological loop, however, contributes to performance involving language-based information processing such as encoding and processing number words and numerals and retrieving linguistically stored representations of arithmetic facts from long-term memory (e.g., Krajewski & Schneider, 2009; Östergren & Träff, 2013). Since children with SLI have impaired language skills, the children may not be able to rely as heavily on the phonological system as their peers, and therefore, learning to count and to do arithmetic becomes a slow and error-prone process. These two WM components are related to the mathematics performance of children with SLI (e.g., Cowan et al., 2005; Kleemans et al., 2011).

The third component of WM, the visuospatial sketchpad, supports non-verbal numerical processing such as in tasks related to number magnitude, estimation, and mental number line (e.g., Bull, Espy, & Wiebe, 2008). Children with SLI do not show the same limitations in the visuospatial sketchpad as in the two other WM components (Montgomery et al., 2010), which may explain why these children perform similarly to their age peers on number comparison (Donlan & Gourlay, 1999; Donlan et al., 1998) and number line estimation tasks (Kleemans et al., 2011). The role of the visuospatial sketchpad is related

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to early mathematics performance more than later mathematics performance as children seem to shift from relying on the visuospatial system (e.g., using a mental model of objects or concrete objects in counting) to relying increasingly on the phonological system (e.g., using oral counting and fact retrieval) (De Smedt et al., 2009).

A growing number of studies have shown evidence that early numeracy performance and later mathematics development are highly dependent on early language skills, such as oral language skills (Purpura et al., 2011; Simmons, Singleton, & Horne, 2008; Vukovic & Lesaux, 2013a), phonological awareness (Simmons et al., 2008; Vukovic & Lesaux, 2013b), and print knowledge (Purpura et al., 2011; Zhang et al., 2013). Among young children with SLI, grammatical ability (included in oral language skills) and phonological awareness are precursors of early numeracy skills (i.e., relational and counting skills but not on non-verbal number line estimation) (Kleemans et al., 2011) and basic addition and subtraction skills (Kleemans, 2013) even when intelligence and WM were controlled.

Futhermore, children with SLI have often limitations in processing speed, typically measured as rapid naming (Montgomery et al., 2010). Processing speed can predict the performance of children with SLI in verbal early numeracy skills (Kleemans et al., 2011) and fast retrieval of basic addition and subtraction facts (Kleemans, 2013; Kleemans et al., 2012; Koponen et al., 2006).

To conclude, compared to age peers, the mathematics development of children with SLI is often more vulnerable, and problems in mathematics skills may stem from limitations in language skills, working memory, and processing speed.

1.3. Improving mathematics skills of children with SLI

Twenty years of research evidence have shown that children with SLI generally already perform worse in mathematics before the onset of formal schooling when compared to their age peers. Nevertheless, few evidence-based instruction tools are available to support these children's mathematics development. Among children with SLI between four and five years old, Fazio (1994) found that teaching a gestural counting technique resulted in improved oral and object-counting skills. However, based on body parts, this technique was limited to the numbers 1–7. Samelson (2009) examined how different scaffolds (traditional wording, traditional wording and gesture, rewording, or rewording and gesture) affected performance in addition and subtraction word problems. In her study, seven-year-old children with low-language skills benefited only from rewording word problems, but children with SLI did not benefit from any of the different types of scaffolds. To the best of our knowledge, only two controlled single-case mathematics intervention studies have been reported concerning older children with SLI (Koponen, Aro, Räsänen, & Ahonen, 2007; Koponen, Aro, & Ahonen, 2009); both focused on calculation strategy instruction to improve single-digit calculation fluency. Of two 10-year-old children, a child without processing speed difficulties progressed from using finger-counting strategies to retrieving facts, but the child with processing speed difficulties continued to use only finger-counting after the computerized game-like intervention ended (Koponen et al., 2007). In another intervention (Koponen et al., 2009), an 11-year-old child with SLI and processing speed difficulties benefited from instruction focusing on constructing decomposition strategies based on meaningful relationships between the arithmetical facts.

Explicit instruction and the use of visual representations have been identified as beneficial instructional approaches for teaching mathematics to children at risk for mathematics difficulties (e.g., Baker, Gersten, & Lee, 2002; Kroesbergen & Van Luit, 2003), but has not been examined specifically among children with SLI. However, using visual stimuli (i.e., visual representations and use of concrete objects) might benefit children with SLI in learning how to manage their working memory resources (Montgomery et al., 2010). In addition, since kindergarteners with SLI demonstrated a weaker performance compared to their age peers in mathematics, the role of the visuospatial sketchpad in mathematics learning, and therefore the need for visualization, is even greater at this age (De Smedt et al., 2009; Rasmussen & Bisanz, 2005).

1.4. Present study

In this study, we piloted the RightStart (RS) kindergarten mathematics curriculum in order to improve mathematics skills among kindergartners with SLI. We examined the program's effects at the individual and group levels. Our research questions were as follows:

(1) What is the effect of RS instruction on improving the early numeracy skills of children with SLI?
(2) To what extent do children with SLI and normal language-achieving age peers (NLP) children differ in mathematics skills in kindergarten and Grade 1?

Regarding the first research question, since RS instruction (see Section 2.3 for more details) applies explicit instruction and visualization and emphasizes non-counting strategies and transparent number-naming, and the instruction was conducted over a long period (seven months), we expected that the early numeracy skills of children with SLI would improve significantly. Regarding the second research question, based on previous findings (e.g., Fazio, 1994, 1996; Kleemans et al., 2011) we hypothesized that children with SLI would show weaker performance in their early numeracy skills at the beginning of kindergarten than their age peers. If the skills of the children with SLI were at the same level as their NLP group at the end of the kindergarten, we hypothesized that no performance differences would be found in first grade.

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2. Method

2.1. Participants

The RS instruction group (SLI) consisted of nine Finnish-speaking kindergartners (seven boys, two girls; $M_{age} = 82.11$ months, $SD = 8.67$ months, range 73–99 months) with SLI, as diagnosed by a pediatrician or phonetician following the *International Statistical Classification of Diseases and Related Health Problems* (ICD-10; World Health Organization, 2010) diagnostic criteria. The children with SLI from two kindergarten groups attended the same special state school for children with SLI in central Finland. The kindergarten teachers were qualified special educators, and both had many years of work experience with children with SLI. The children with SLI had an extended education plan, with two years of kindergarten education before starting first grade, and individual education plans (IEPs) in mathematics. In addition to these nine children, there were two other children in the kindergarten groups. Their performance was not analyzed, as one child demonstrated such attention and behavioral problems that not all tests could be properly administered, and one child was receiving mathematics instruction individually due to severe difficulties with mathematics. By first grade, one child was no longer attending the same school, which reduced the total number of participants in the delayed post-test analysis to eight. The reference group (NLP) consisted of 32 normal language-achieving kindergartners (21 boys, 11 girls; $M_{age} = 74.16$ months, $SD = 3.18$ months, range 69–80 months) from two general education kindergarten groups from two cities in southern Finland. Due to illness during the measurements, one child did not participate in the cognitive and language measures at pre-test time. At the delayed post-test time, the attrition rate was three children, which reduced the total number of participants in the delayed post-test analysis to 29 children. There was a significant age difference between the SLI and NLP groups ($U = 48.50$, $p = .002$); some children with SLI had started kindergarten a year later than other children. All children had written authorization from their parents and the school administration to participate in the study.

2.2. Measures

2.2.1. Nonverbal reasoning

Raven's Coloured Progressive Matrices (Raven, 1965) were used to measure the children's nonverbal reasoning. There are 36 items on this test. On each test item, the child is asked to identify, from six choices, the missing element that completes a pattern. One point is given for a correct answer. The reliability in this sample, in terms of Cronbach's coefficient alpha with a 95% confidence interval ($CI_{0.95}$), was .75 ($CI_{0.95} = .62–.85$).

2.2.2. Receptive vocabulary

Receptive vocabulary was assessed individually with the Peabody Picture Vocabulary Test-Revised (PPVT-R, Form L; Dunn & Dunn, 1981), using a shortened version adapted in Finnish (Lerkkanen et al., 2010). For each test item (with a total of two practice items and 30 test items), there are four pictures to a page. The examiner states a word describing one of the pictures and asks the child to point to the picture that the word describes. One point is given for a correct answer. Cronbach's alpha for these data was .68 ($CI_{0.95} = .52–.81$).

2.2.3. Early numeracy

The Finnish Early Numeracy Test (ENT; Van Luit, Van de Rijt, & Aunio, 2006) is a standardized test for measuring children's early numeracy. There are 40 items, and each item is scored as either zero for a wrong answer or one for a correct answer. There are two scales on the ENT: one measures relational skills, and one measures counting skills (Aunio & Niemivirta, 2010). The relational scale includes 20 items that measure comparison, classification, correspondence, and seriation abilities. The counting scale comprises 20 items that require the ability to use number words, synchronous and shortened counting, resultative counting, and a general knowledge of numbers (see Aunio, Hautamäki, Heiskari, & Van Luit, 2006). Cronbach's alpha for these data at pre-test time was .87 ($CI_{0.95} = .81–.92$) for the entire scale, .68 ($CI_{0.95} = .52–.81$) for the relational scale, and .83 ($CI_{0.95} = .74–.90$) for the counting scale, which are in line with the reliabilities of the normed data (Aunio et al., 2006).

2.2.4. First-grade mathematics

To measure mathematics performance in Grade 1, we used BANUCA (BAsic NUmerical and Calculation Abilities; Räsänen, 2005). This standardized test measures the basic numerical and calculation skills of children who are between seven and nine years old. Five of the nine scales, those appropriate for first graders, were used: number comparison, addition, subtraction, number words, and arithmetic reasoning.

The number comparison scale with multi-digit numbers assesses understanding of the base-10 system. In each of the ten items, the child is asked to identify the largest of four numbers by drawing a cross over the number. The five first items are from the number span 1–60, and the last (the tenth) item includes a comparison with thousands. There is a four-minute time limit for completing the scale. One point is given for each correct answer.

On the addition scale, the child has to write an answer for eight addition problems with the numbers 1–10 presented horizontally. Half of the items include carrying over 10. The subtraction scale is similar to the addition scale. On the scale, the child has to write an answer to eight subtraction problems with the numbers 1–15 presented horizontally. Half of the items

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include numbers over 10, and three carry over 10. There is a four-minute time limit for completing the addition and subtraction scales, so they measure accuracy over fluency.

On the number words scale, knowledge of spoken and written numbers and the base-10 system is assessed. There are eight items in this scale. The examiner says a number word, which is one of the numbers in a row of five numbers. The child has to identify the correct number within 20 s by drawing a cross over the number. The first four items are within the number span 1–80, and the last (eighth) item includes numbers in the tens of thousands. One point is given for each correct answer.

On the arithmetic reasoning scale, a child sees a pattern of three numbers (e.g., 2, 4, 6). The child has to choose which of the four alternative numbers given (e.g., 3, 8, 7, 4) will best continue the number sequence. There are 15 items on the scale, all of which fall within the number span 1–100. There is an eight-minute time limit for completing the task.

The maximum number of points for the entire scale is 49. Cronbach's alpha for the whole scale in this sample was .93 ($CI_{0.95}$ = .89–.96).

2.3. RightStart Mathematics instruction

We used the RightStart Mathematics Kindergarten (RS) curriculum program (Cotter, 2001) as an instruction method for children with SLI. RS, which is the outcome of Cotter's work (1996), now has material covering all primary grades (www.rightstartmath.com). Although RS has primarily been designed for general education core instruction, we found instructional elements in the program that we thought would benefit the mathematics learning of children with SLI, and were used less often in Finnish mathematics instruction.

In the RS program, learning to name numbers is first based on the transparent number-naming system (e.g., 14 is ten-four, 23 is two-ten-three), which is then followed by the typical number-naming system in the child's own language. A transparent number-naming system (such as that found in Chinese) has been shown to positively affect the learning of mathematics skills (including among children with mild intellectual disabilities, Van Luit & Van der Molen, 2011) compared to an irregular number-naming system, like those often seen in languages used in Western countries, such as English, French, or German (Miura & Okamoto, 2003). RS de-emphasizes counting one by one in object counting and basic calculations (addition and subtraction), and instead encourages subitizing skills in counting small quantities (1–4), which means the total quantity is said, and groupings of fives and tens are used with large quantities and numbers. For example, the number eight is first taught as "eight is five and three," and this is demonstrated with beads of two different colors on an abacus (e.g., five blue and three yellow beads). The RS program focuses on manipulating numbers in the range from 0 to 20; however, at the end of kindergarten, children are introduced to numbers up to 1000, along with supporting manipulatives.

Visualization is emphasized in the program. In activities, all children have access to carefully thought-out manipulatives: abacuses based on groupings of five and 10 beads with two colors (also known as Slavonic abacuses), number and quantity cards, base-10 cards, tiles, and tally sticks are used regularly throughout the program (see Fig. 1). Learning follows the concrete-representational-abstract (CRA) levels. First, a new concept is practiced with a concrete manipulative (e.g., showing a quantity of six with tally sticks or on an abacus). This is then followed by a semi-concrete representation (e.g., quantity of six as tally marks on a card). Finally, the concept is practiced as abstract representation (e.g., number symbol of six on a card). Written work with numbers (i.e., worksheets) is avoided until a child has understood the mathematical concept.

There are 77 lesson plans in the manual. One lesson is composed of a short warm-up activity (usually practicing different types of number word sequences, subitizing, or days of the week) and three to six learning-by-doing activities (e.g., teacher-guided or pair activities with manipulatives or card games) focused on one or two learning objectives. In learning, understanding is highly emphasized, not learning by rote. The role of the teacher is to encourage thinking by asking questions and having discussions with the children, not simply to give answers. The instructions for the activities are specific, and include questions the teacher should ask.

The learning objectives of the RS program for the kindergarten year are listed in Appendix B. In comparing the learning objectives of the RS program with the Finnish national mathematics core curriculum guidelines (Finnish National Board of Education, 2000), we found that RS covered the main learning aims and was therefore eligible for use in this study with

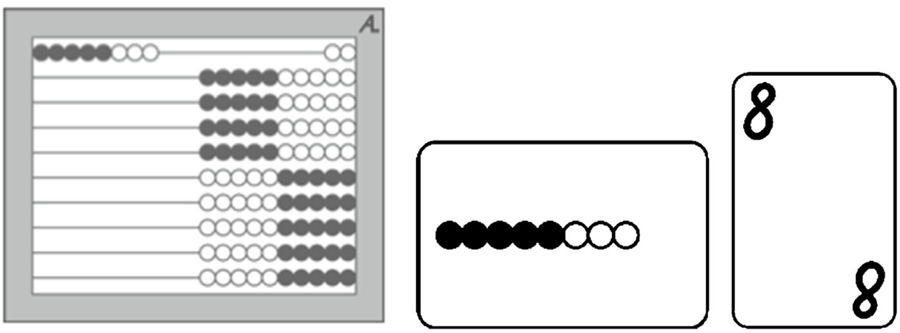

Fig. 1. Manipulatives of RightStart Mathematics program for working on concrete (abacus), representational (bead card), and abstract (number card) levels.

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Finnish kindergarten children. We were given permission by the author to translate the original material into Finnish and to use the program in our study. The translation was checked in a multi-language team of researchers. The Finnish version included 87 lessons; for practical reasons, we divided some of the 2-h lessons into two 1-h lessons. Furthermore, some cultural aspects affected the translation work (e.g., the money used is the euro instead of the dollar, a 24-h clock is used instead of a 12-h clock), but the content of the manual and the tasks were kept as similar to the original manual as possible.

2.3.1. Teacher feedback concerning instruction

The teachers of the SLI groups were asked to keep a log for every lesson given. They evaluated the functionality of every task in the lesson (1 = not good, 2 = good, 3 = very good, or x = not completed) and the motivation of the teacher and of the children (from the teacher's point of view, on a scale ranging from 4 = poor to 10 = excellent, a common assessment scale used in Finnish schools) using a structured log book, including space for free comments. The teachers from the reference groups were asked to fill out a questionnaire about the mathematics content taught during the kindergarten year, based on the teaching objectives included in the textbook material they used. In addition, a questionnaire with structured and open questions was collected from all teachers concerning the implementation of and satisfaction with the program used during the year.

2.4. Procedure

2.4.1. Data collection

This study was part of our larger pilot study examining the RS program among kindergartners. Pre-testing took place at the beginning of the kindergarten year, in fall 2009, and immediate post-testing was in spring 2010, at the end of the kindergarten year. A delayed post-test was carried out in first grade in winter 2010. Raven and PPVT-R were assessed as individual interviews at the pre-test time, which took 15–20 min. The children's early numeracy skills (ENT) were assessed in individual interviews in kindergarten, which took 30–40 min. The ENT relational scale was not used in the post-test among the NLP children, because of the ceiling effect in children over 6.5 years old (Aunio et al., 2006). The pre-test and immediate post-test were conducted by a trained research assistant, teachers familiar with the tests, or the first and third authors, in a quiet room in the kindergarten. The delayed post-test (BANUCA) was conducted in the first-grade groups by the first author for the NLP groups and by a trained teacher for the SLI groups, and took 30–40 min. The BANUCA subscales were presented in the following order: addition, comparison, subtraction, number words, and arithmetical reasoning.

2.4.2. Instruction in the SLI groups

Before RS instruction took place, the first author briefly introduced the RS program and the study procedure to the teachers using the RS program. The teachers were provided with a teacher's manual and the manipulatives (e.g., abacuses, tiles, number and dot cards) required for implementing the program. They were advised to follow the order of the tasks in the program manual and to conduct a lesson three times a week, with each lasting about 30–45 min. The teachers could contact the first author, if needed, throughout the year. They sent the completed logbook sheets to the authors every other month.

2.4.3. Instruction in the NLP groups

The teachers in the reference groups were encouraged to continue their business-as-usual mathematics instruction throughout the kindergarten year. Both teachers used the same kindergarten instruction material (*Kindergarten of The Little Forest*, Wäre et al., 2009a, 2009b), which follows the Finnish national curriculum mathematics objectives (see the key objectives of the material in Appendix B). In addition to mathematics, this material includes lessons for science and early reading, so all three skill areas are covered under the same changing theme. In addition to whole-group mathematics activities, small-group activities such as board games are often used. Most activities are teacher guided, and children are encouraged to investigate and discuss mathematics topics. Many activities are supported with manipulatives (e.g., cubes and dot or number cards), and the children have mathematics activity books. Compared to RS, the main differences between the two sets of materials is that RS emphasizes more non-counting strategies, presents quantities based on groupings of five and ten, applies transparent number-naming, and uses specific manipulatives, such as abacuses, systematically throughout the program.

The sessions were held in groups of 13–16 children. In Finnish kindergarten, there is no set timeframe for the number of mathematics lessons that should be covered each week. Usually mathematics instruction includes specific learning sessions focused on mathematics, but shorter activities, such as math-related songs and stories, are also included in morning circle time. At the end of the kindergarten year, the teachers in the control groups reported the mathematics content of the program they had taught and the time it had taken during the kindergarten year.

2.5. Design and data analysis

This study applied a quasi-experimental design, including a pre-test, an instruction phase, an immediate post-test, and a delayed post-test. Due to the small sample of children with SLI, we used non-parametric tests to analyze the data. To answer question 1, the performance growth of the children with SLI on the ENT was analyzed as a group as well as individually. At the group level, gain score comparisons between the SLI and NLP groups were used to measure the instruction effect, since the

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numeracy pre-test scores might differ significantly between the groups. Gain scores were calculated by subtracting the pre-test scores from the immediate post-test scores. To answer question 2, immediate post-test and delayed post-test comparisons were used to show if the children with SLI had reached the performance level of the NLP children after the instruction phase and in first grade. The effect sizes for each group comparison were calculated as Pearson's correlation coefficient (r) using the following formula (Rosenthal, 1991): $r = z/\sqrt{N}$, where z is the z-score value produced from the analysis and N is the total number of observations. The effect sizes of $r = 0.10$ can be interpreted as a small effect, $r = 0.30$ as a medium effect, and $r = 0.50$ as a large effect (Cohen, 1988).

3. Results

3.1. Performance differences at the beginning of kindergarten

We administered two measures with all the children as control measures: nonverbal reasoning (Raven) and receptive vocabulary use (PPVT-R). The SLI and NLP groups performed at a similar level on Raven, $U = 96.50$, $p = .167$ (SLI: $M = 22.11$, $SD = 3.06$, $Med = 23.00$; NLP: $M = 19.77$, $SD = 4.56$, $Med = 20.00$). A statistically significant difference was found for PPVT-R, which favored the NLP group, $U = 253.50$, $p < .001$ (SLI: $M = 12.56$, $SD = 3.57$, $Med = 13.00$; NLP: $M = 18.65$, $SD = 2.99$, $Med = 18.00$).

At pre-test time, the NLP group significantly outperformed the SLI group on the relational and counting scales (means, standard deviations, and medians with statistical significance are presented in Table 1). Concerning the normed data of the ENT (Aunio et al., 2006), the average performance of children with SLI on the relational and counting scales were at the level of five year olds (normed data, relational: $M = 13.41$; counting: $M = 7.48$), whereas the performance of the NLP children corresponded to the level of 6.5-year-olds (normed data, relational: $M = 17.25$; counting: $M = 12.96$). As shown in Table 2, children with SLI had the lowest mean scores on seriation tasks on the relational scale, and on synchronous and resultative

Table 1
Means, standard deviations, medians, group differences, and effect sizes (r) for the pre-test, post-test and gains in Early Numeracy Test (ENT).

Measure		SLI ($n = 9$)			NLP ($n = 32$)			z[b]	p	Effect size (r)
		M	(*SD*)	*Med*	*M*	(*SD*)	*Med*			
ENT										
Relational scale (max. 20 p.)	Pre-test	13.22	(2.77)	14.00	16.97	(2.07)	17.00	3.273	.001	.51
	Post-test	16.33	(3.00)	17.00	–[c]	–	–	–	–	–
	Gain[a]	3.11	(2.37)	3.00**	–	–	–	–	–	–
Counting scale (max. 20 p.)	Pre-test	7.89	(3.37)	7.00	13.31	(4.01)	14.50	3.195	.001	.50
	Post-test	14.11	(5.30)	14.00	15.81	(3.00)	17.00	0.761	.466	.12
	Gain	6.22	(3.96)	7.00*	2.50	(3.01)	2.00***	−2.468	.013	−.39

Note. SLI = a group of children with specific language impairment, NLP = normal language-achieving age peers.
[a] Gain is the score difference between pre- and post-test, asterisk (*) indicate statistical significance between pre- and post-test time within group.
[b] A standardized test statistic value from Mann–Whitney U test.
[c] Not measured.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 2
Means and standard deviations in Early Numeracy Test of the children with SLI ($n = 9$) at pre- and post-test times.

Measure	Pre-test				Post-test			
	Range (min–max)	*M*	(*SD*)	*Med*	Range (min–max)	*M*	(*SD*)	*Med*
ENT relational scale								
Comparison (max. 5 p.)	2–5	3.67	(1.00)	4.00	3–5	4.67	(0.71)	5.00
Classification (max. 5 p.)	2–5	3.56	(1.13)	4.00	3–5	4.33	(0.71)	4.00
Correspondence (max. 5 p.)	2–5	3.44	(0.88)	3.00	2–5	4.00	(1.12)	4.00
Seriation (max. 5 p.)	0–5	2.56	(1.33)	3.00	0–5	3.33	(1.73)	4.00
ENT counting scale								
Number words (max. 5 p.)	0–4	2.11	(1.27)	2.00	1–5	4.00	(1.41)	5.00
Synchronous counting (max. 5 p.)	0–3	1.78	(0.97)	2.00	0–5	3.56	(1.51)	4.00
Resultative counting (max. 5 p.)	0–4	1.78	(1.30)	1.00	0–5	2.89	(1.62)	3.00
General knowledge of numbers (max. 5 p.)	1–4	2.22	(1.09)	2.00	1–5	3.67	(1.41)	3.00

Table 3
Descriptives of children with SLI and pre-, post-, and delayed post-test scores in cognitive and mathematics measures.

Case	Gender	Age at pre-test time (in months)	PPVT (max. 30)	Raven (max. 36)	ENT relational (max. 20 p)			ENT counting (max. 20 p)			BANUCA (max. 49 p)
					Pre-test	Post-test	Gain	Pre-test	Post-test	Gain	
1	G	80	14	18	12	13	1	8	13	5	14
2	B	76	10	24	9	15	6	6	14	8	36
3	B	78	13	18	14	14	0	3	2	−1	19
4	B	73	15	19	14	17	3	12	13	1	–
5	B	91	14	26	18	20	2	12	19	7	35
6	G	79	9	22	11	12	1	5	15	10	14
7	B	75	12	25	14	20	6	7	18	11	38
8	B	88	7	24	11	17	6	6	13	7	29
9	B	99	19	23	16	19	3	12	20	8	31

Note. G = girl, B = boy; PPVT = the Peabody Picture Vocabulary Test-Revised; ENT = Early Numeracy Test; BANUCA = Basic Numerical and Calculation Abilities test.

counting tasks on the counting scale. Children with SLI had the highest mean scores on comparison tasks on the relational scale, and on tasks measuring general knowledge of numbers on the counting scale.

3.2. RS instruction effects on mathematics skills

3.2.1. Group level

Although both groups showed significant improvement on the ENT counting scale from the pre-test to the immediate post-test time (SLI: $z = -2.494$, $p = .012$; NLP: $z = -3.848$, $p < .001$), the SLI group showed significantly more improvement than the NLP group, $U = 66.00$, $p = .014$, $r = .39$. There was no statistically significant difference between the groups on the ENT counting scale at post-test time. According to the normed ENT data (Aunio et al., 2006), the performance of both groups in counting was at the level of seven year olds (normed data, $M = 14.64$), although the NLP group level neared that of 7.5 year olds (normed data, $M = 16.27$).

3.2.2. Individual performance of children with SLI

Table 3 presents the individual pre- and post-test scores of children with SLI on the ENT relational and counting scales. We compared the children's individual performance to ENT normed data (Aunio et al., 2006), with each child's age taken into consideration. To identify children who performed low on the relational and counting scales, we defined the cut-off score for low performance as performing under minus one standard deviation from the age-level mean score (following Aunio et al., 2005). This revealed that two children (case numbers 4 and 7) performed at their age level on the relational and counting scales at the pre- and immediate post-test time. They were the youngest of the children with SLI. One child (5) performed at his age level on the relational scale at the pre- and immediate post-test time, and one child (1) did so on the counting scale at the pre- and immediate post-test time. At the pre-test time, six children (1, 2, 3, 6, 8, and 9) had low performance on the relational scale, and six (2, 3, 5, 6, 8, and 9) on the counting scale. Accordingly, five of these children performed low on both early numeracy scales. At the immediate post-test time, the performance of two of these children (8 and 9) had improved on the relational scale and now fell within their age level, while four children (1, 2, 3, and 6) still performed low on the relational scale. On the counting scale, four children (2, 5, 6, and 9) reached age-level performance at the immediate post-test time. Two children (3 and 8) continued to have low performance. If the children were older than the highest age level (7.5 years) provided on the ENT standardized scores, their performance was compared to that level. In sum, most of the children with SLI benefited from RS instruction and showed age-level or near age-level performance on the relational and counting scales right after the instruction phase. However, some children did not respond to the instruction, and remained low performers compared to their age peers.

3.3. Performance in first grade

In Grade 1, six months after the instruction phase, the NLP group statistically significantly outperformed the SLI group on the entire BANUCA scale, $U = 37.00$, $p = .002$, $r = .48$ (for more details, see Table 4, and Table 3 for individual scores of children with SLI), particularly on the scales for number words, $U = 48.00$, $p = .009$, $r = .42$, and arithmetic reasoning, $U = 48.50$, $p = .010$, $r = .41$. No statistically significant differences between the groups were found for the number comparison and addition scales ($p > .05$), and the statistical significance was at the boundary ($p = .05$) on the subtraction scale. The mean performance of the NLP group on the addition and subtraction scales showed a near-ceiling effect.

3.4. Teacher feedback

The teachers for the SLI groups followed the RS program for teaching mathematics for seven months, two to three times a week, which replaced the typical mathematics instruction. According to the logbook information, teacher A conducted 56

Table 4
Means, standard deviations, medians, group differences, and effect sizes for the delayed post-test in BANUCA.

Measure	SLI ($n=8$)			NLP ($n=29$)			z[a]	p	Effect size (r)
	M	(*SD*)	*Med*	*M*	(*SD*)	*Med*			
BANUCA									
Comparison (max. 10 p.)	7.38	(1.85)	8.00	8.52	(1.30)	8.00	−1.367	.171	−.22
Addition (max. 8 p.)	5.50	(2.83)	6.00	7.24	(1.30)	8.00	−1.843	.072	−.30
Subtraction (max. 8 p.)	4.12	(3.76)	5.00	7.00	(1.44)	7.00	−1.953	.050	−.32
Number words (max. 8 p.)	4.63	(1.51)	4.50	6.31	(1.58)	7.00	−2.557	.009	−.42
Arithmetic reasoning (max. 15 p.)	5.38	(3.46)	6.00	9.28	(3.70)	10.00	−2.503	.010	−.41
Whole scale (max. 49 p.)	27.00	(9.91)	30.00	38.34	(6.98)	38.00	−2.922	.002	−.48

Note. SLI = a group of children with specific language impairment, NLP = normal language-achieving age peers.
[a] A standardized test statistic value from Mann–Whitney U test.

lessons and teacher B 44. However, if the activities of one lesson plan took more time with the children than initially planned, both teachers spent another 40 min on the same lesson; there were about 15 such lessons. The total instruction time was 2720 min (68 × 40 min) in teacher A's classroom and 2320 min (58 × 40 min) in teacher B's. The program learning objectives not covered during the kindergarten year included counting by fives and tens, operating with numbers over 20 (place value), money, time, and fractions. Teachers reported that "children were well-motivated and engaged in taking part in the activities," "activities supported with manipulatives interested children," and the "focus was on mathematical thinking instead of repetitive paper-and-pencil work." However, keeping pace with the curriculum (i.e., covering all lesson activities in 40 min) was challenging with children with SLI, and in the end, the teachers were not able to cover all of the lesson plans in the manual.

The teachers in the NLP groups reported that they had taught almost all the main mathematics sections according to their material during the kindergarten year. The instruction time used for mathematics varied from 45 to 75 min per week. The teachers were satisfied with the material they had used.

4. Discussion

We piloted the RS program in order to investigate its effect on improving the early numeracy skills of kindergartners with SLI at the individual and group levels. We were also interested in the extent to which children with SLI differed in mathematics skills in kindergarten and first grade compared to normal language-achieving peers who received business-as-usual mathematics instruction. Although the children with SLI began kindergarten with significantly weaker early numeracy skills compared to their peers (e.g., Kleemans et al., 2011), they had improved their counting skills to the level of their peers after the RS instruction ended. In first grade, the children with SLI performed similarly to their peers in addition and subtraction accuracy and multi-digit number comparison, but showed weaker skills in arithmetical reasoning and in matching spoken and printed multi-digit numbers.

4.1. Effects of RS instruction

Overall, the children with SLI responded successfully to the RS instruction. First, the oral and object counting skills of the children of SLI as a group improved to the level of the NLP group. At the immediate post-test time, eight of the nine children with SLI could recite number words up to 20, which gave them confidence to perform object-counting tasks in this number range (Fazio, 1996). Since transparent number-naming (e.g., "fourteen" is first practiced as "ten-four") with supporting visual material was emphasized in RS, results of this study indicate it is a beneficial method for teaching teen numbers to children with SLI (Van Luit & Van der Molen, 2011). Moreover, non-counting strategies and systematic visualization of quantities with manipulatives, such as abacuses, may have supported the learning of counting skills. The children were not forced to depend only on their weak oral counting skills, which are affected by the central executive and phonological loop mechanisms (e.g., Krajewski & Schneider, 2009) and are often weak in children with SLI (Montgomery et al., 2010). Instead, through visualization and working with concrete objects, children with SLI may have been able to reduce their working memory load and possibly were able to rely more on their stronger visuospatial sketchpad component (Montgomery et al., 2010).

Since the number of children with SLI was small and previous studies have found the group of children SLI is heterogeneous in their mathematics skills (Koponen et al., 2006), we examined the children's performance individually. This revealed that some of the children with SLI performed at their age level in early numeracy skills (either in relational or counting or both) in the beginning of the kindergarten year. In addition, some children did not respond to the RS instruction, meaning that their skills were at the low-performing level during the entire kindergarten year. Even with instructional programs that are successful for most children, some children do not respond to the instruction (Fuchs & Fuchs, 2001). Since the core instruction in a small group did not benefit these children, they might need intensified one-on-one tutoring in mathematics.

4.2. Performance in first grade

By first grade, the SLI group had multi-digit number comparison skills similar to those of the NLP group. Our results contradict earlier results (Cowan et al., 2005; Donlan et al., 2007) that reported children with SLI showed weak multi-digit number comparison skills. The task used in our study differed from two previous studies, since we included a comparison between four numbers instead of two, although it measured accuracy in a similar way. Comparison of numbers has been suggested to be in the area of non-verbal mathematics (Koponen et al., 2006) and not involve verbal processing but support of the visuospatial sketchpad, which may partly explain why children with SLI succeeded in the task.

The addition and subtraction skills of the children with SLI were as accurate as the NLP group's, contrary to previous findings (e.g., Cowan et al., 2005; Donlan et al., 2007; Fazio, 1996; Jordan et al., 1995). In the tasks, no fast retrieval of facts was required. Thus, possible weaknesses in processing speed or the phonological loop (Kleemans et al., 2012) did not affect the solving of arithmetic problems, and the children could also use memory aids, such as their fingers, to support their counting. However, there was a near-ceiling effect in both tasks among the NLP group, indicating that these calculations were easy for the majority of the NLP children, and some children might have succeeded in more difficult calculations as well.

The NLP group outperformed the children with SLI on number words (i.e., matching spoken and printed multi-digit numbers) and arithmetic reasoning skills (Cowan et al., 2005). The number words task required transcoding between spoken and written numerals, and the arithmetic reasoning task required manipulating number sequences forward and backwards. It seems that the counting skills the children with SLI had acquired during kindergarten were not adequate enough for the first-grade mathematics learning that required verbal processing.

4.3. Limitations

Several limitations in our study should be considered in future studies. The limitations were mainly related to small sample size, the challenges of applying the study design to a population with learning difficulties, the possibility of using various measurements, and fidelity issues. The greatest limitation in our study was the small number of children with SLI. Therefore, the results obtained should be considered with caution. In addition, our study did not include a control group of children with SLI. Applying a preferred randomized design with normal language-achieving age controls and children with SLI is challenging, as the number of children with SLI is low in the population, and these two groups differ greatly in their cognitive profiles. The mathematics measures we used in kindergarten did not include a nonverbal task (cf., Kleemans et al., 2011) because no such standardized measure was available at the time in Finland. In future studies, more cognitive (e.g., working memory) and language measures should be included not only in the pre-test but also in later measurement points to see how gains in cognitive and language skills predict gains in mathematics performance. All instruction conductors were kindergarten teachers, which added ecological validity to our study, but our limited resources affected the fidelity. In this study, we used only indirect measures (Gresham et al., 2000) by collecting logbook information. In future studies, in-classroom observations should be included, in addition to teacher-reported logbooks, to provide more reliable information on the teachers' implementation of the program as intended.

4.4. Conclusions

This pilot study provided a starting point for mathematics instruction studies on children with SLI. Our study showed that the early numeracy skills of children with SLI can be significantly improved in the small classroom setting over one kindergarten year with explicit instruction emphasizing visualization. The results indicated that for successful performance in first grade as well, some children with SLI may need ongoing support even for mathematics topics already practiced.

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Appendix A

Table A1.

Table A1
Descriptions of the research carried out between 1994 and 2012 on mathematics skills of children with specific language impairment.

Study	Year	Age[a]	Participants (*N*)				Study design		Mathematical measures	Outcomes of children with SLI	
			SLI	Age-matched controls	Language-matched controls	Other	Follow-up	Cross-sectional		Positive	Weaknesses
Arvedson, P. J.	2002	4–5	19	19	19			x	Enumeration and numerical reasoning: reproduction of sets (4–7 objects); numerosity of sets (mental representation of the quantity 4–7); add/subtract condition of numerosity of sets (+1/−1); conservation of number	Children with SLI performed very much like their age controls (especially in conservation) and better than controls in language	Prompting children with SLI to use verbal counting resulted in a 50% decline in accuracy, opposite of their controls
Cowan, R., Donlan, C., Newton, E. J., and Lloyd, D.	2005	7–9	55	57	55			x	Oral counting (forward and backwards); basic calculations (+/−) in spoken form (strategy used); story problems (+/−) in spoken form; transcoding multi-digit numbers (reading and writing numbers, matching spoken and printed numbers); magnitude comparison with multi-digit numbers (place value)		Children with SLI performed below their age-matched controls on every skill measured
Donlan, C., Bishop, D. V. M., and Hitch, G. J.	1998	6–7	10		19			x	Comparative number and size judgment (numerals 1–5, canonical dot-patterns 1–5, line drawings of a familiar animal with constant size, line drawings of houses with varied size)	Children with SLI responded more quickly than language-matched controls, and their performance was consistent across stimulus types and distances	
Donlan, C., Cowan, R., Newton, E. J., and Lloyd, D.	2007	8	48	55	55			x	Oral counting (forward and backwards); basic calculations (+/−) in spoken form (accuracy); magnitude comparison with multi-digit numbers (place value); arithmetic principles	Children with SLI had knowledge of arithmetic principles similar to their age-matched peers	Children with SLI performed below their age-matched controls in the production of the count word sequence (40% failed to count to 20), basic calculation, and understanding the place-value system in numerals. They exceeded their language-matched controls in place value
Donlan, C., and Gourlay, S.	1999	7–8	13	13	12			x	Single- and double-digit-judgment; verbal number comprehension (single and double digits)	Children with SLI responded as quickly as their age-matched controls in choosing the greater of two single- or double-digit numerals; they matched spoken numerals (1–9) to written numerals without error, as well as nearly all double-digit numbers	

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Table A1 (*Continued*)

Study	Year	Age[a]	Participants (*N*)				Study design		Mathematical measures	Outcomes of children with SLI	
			SLI	Age-matched controls	Language-matched controls	Other	Follow-up	Cross-sectional		Positive	Weaknesses
Fazio, B. B.	1994	4–5	20	20	20	20[f]		x	Oral counting: object counting (with 3–9 objects), rote counting (from 1 to as high as possible); gestural counting (without number words up to 7, with and without objects)	Knowledge of counting rules (cardinality, one-to-one correspondence); gestural counting was better than oral counting	Object and rote counting (number word sequence errors)
Fazio, B. B.	1996	6–7	14	15	16		x[j]		Object counting (3–20); rote counting (from 1 to as high as possible); counting by tens; counting backwards (from 10 and 20); adding objects (3–20); sorting by set size (3–9); concept of relative magnitude (more); reading numerals (1–50); writing numerals (1–50); addition facts (verbal response); addition calculation (strategy used); written calculation (+/−)	Children with SLI made progress in learning mathematics in two years; knowledge of counting rules; children with SLI performed similarly to their age controls if they were allowed to use objects in counting and it did not go beyond the sequence of numbers they knew well (1–10)	Rote counting (from 10 onwards); counting by tens; counting backwards from 20; addition facts
Jordan, N. C., Levine, S. C., and Huttenlocher, J.	1995	5–6	33[b]	33		21[g] and 21[h]		x	Addition and subtraction calculations (single digit): nonverbal problems, oral story problems and oral number-fact problems	Children with SLI performed better on nonverbal calculations than on verbal calculations (story and number-fact problems)	Age-matched controls performed better than children with SLI on story problems and on number-fact problems after adjusting for the frequency of finger use (children with SLI used fingers more often)
Kleemans, T., Segers, E., and Verhoeven, L.	2011	6	61	111				x	Logical operations (comparison, linking quantities, correspondence, seriation); numeral representations (rote counting, synchronous and shortened counting with objects, resultative counting with objects, applying knowledge of number system); numeral estimations on number line	Numeral estimation	Logical operations and numeral presentations (in all sub-skills)
Kleemans, T., Segers, E., and Verhoeven, L.	2012	7	53	107				x[l]	Basic calculation skills: addition and subtraction fluency (single-digit problems)		Addition and subtraction fluency
Mainela-Arnold, E., Alibali, M. W., Ryan, K., and Evans, J. L.	2011	8–11	17[c]	17					Understanding of mathematical addition equivalence (accuracy, verbal and gestured strategies)	There was no difference in accuracy between the children with expressive SLI and their age peers	Children with SLI showed delays in their knowledge of mathematical equivalence. None of the children with expressive and receptive SLI solved problems correctly; they tended to express incorrect strategies in both gesture and speech. Children with expressive SLI expressed correct strategies in gestures but incorrect strategies in speech

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Table A1 (*Continued*)

Study	Year	Age[a]	Participants (*N*)				Study design		Mathematical measures	Outcomes of children with SLI	
			SLI	Age-matched controls	Language-matched controls	Other	Follow-up	Cross-sectional		Positive	Weaknesses
Mainela-Arnold, E., Evans, J. L., and Alibali, M. W.	2006	7–10	12	17					Piagetian conservation tasks (liquid, number, length, and mass; verbal and gestured explanations for thinking)	Children with SLI produced proportions of internal explanations in gesture comparable to their age peers	Children with SLI exhibited significant difficulty in conservation relative to their age peers. Children with SLI produced proportionately fewer internal explanations in the verbal modality compared with their age peers
Morgan, P. L., Farkas, G., and Wu, Q.	2011	5–10	180	7200		20[i]	x[k]		Adaptive mathematics test: a range of age- and grade-appropriate mathematics skills (e.g., identify numbers and shapes, sequence, add or subtract or multiply or divide, use rates and measurements, use fractions, calculate area and volume)		Children with SLI displayed lower levels of mathematics achievement compared to their age-matched controls in each grade. The gap in mathematics achievement increased from kindergarten to grade one, but then remained fairly constant between the first and fifth grades
Samelson, V. M.	2009 (study 1)	7	15[d]	15					Verbal and nonverbal addition and subtraction word problems	Children with low language skills performed similarly to age peers on nonverbal word problems	Children with low language skills had greater difficulties than their age peers in solving orally presented word problems
	(Study 2)	7	11 and 9[e]						Word problems (addition and subtraction comparison problems) under four scaffold conditions: traditional wording, traditional wording + gesture, rewording, and rewording + gesture	Children with low language skills (not diagnosed with SLI) benefitted from rewording	Children with SLI did not benefit from rewording presented implicitly or gesture scaffolds

Mainela-Arnold et al. (2006).

[a] Age of children with in years.
[b] A group of children with specific language difficulties (not diagnosed with SLI).
[c] Nine children with expressive SLI and eight children with expressive and receptive SLI.
[d] A group of children with low language skills (not all diagnosed with SLI).
[e] A group of children with low language skills (not diagnosed with SLI).
[f] Mildly mentally retarded cognitive-matched group.
[g] A group of children with low spatial but adequate language abilities.
[h] A group of children with general delays.
[i] A group of children diagnosed as having learning disabilities.
[j] A follow-up study by Fazio (1994).
[k] Mathematics skills measured in spring of kindergarten, and of first, third, and fifth grades.
[l] The study applied a longitudinal design; math skills were assessed only once.

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Appendix B

Table A2.

Table A2
Key objectives of mathematics instruction based on the material used.

RightStart Mathematics Kindergarten key objectives	Kindergarten of the little forest mathematics key objectives
Numeration	Classification and seriation
Can count out 31 objects and arrange in groups of tens	With object and pictures
Can recognize quantities 1–100 and represent them on abacus	Number word–quantity–symbol relations
Knows even numbers to 20	In the number range 1–20
Knows odd numbers to 19	Odd and even numbers
Can count by twos to 30	Number word sequences
Can count by fives to 100	Forward and backwards, in the number range 0–20
Can count by tens to 100	Comparison (more, less, equal)
Money	With quantities and numbers in the number range 0–20
Knows name and value of penny, nickel, and dime (or value of coins of cents and euro in the Finnish version)	Addition and subtraction
Place value	Partition numbers 1–10 into parts
Knows 10 ones is 1 ten	Problem solving
Knows 10 tens is 1 hundred	Addition and subtraction word problems
Knows, for example, 37 as 3-ten 7	Introduction to place value 20–100
Addition	Measurement (with nonstandard measure)
Understands addition as combining parts to form whole	Length and mass
Can partition numbers 3–10 into parts	Circle, square, triangle, symmetry
Knows number combinations equal to 10	Time
Knows number combinations up to 10	Clock (hour)
Subtraction	Days of the week
Understands subtraction as missing addend	Months of the year
Understands subtraction as separating	
Problem solving	
Can solve addition problems	
Can solve missing addend problems	
Can solve basic subtraction problems	
Geometry	
Knows mathematical names of triangle, rectangle, and circle	
Knows parallel and perpendicular lines	
Can continue a pattern on the geoboard	
Time	
Knows days of the week	
Knows months of the year	
Can tell time to the hour	
Can tell time to the half hour	
Measurement	
Can determine length with nonstandard measure	
Fractions	
Can divide into halves and fourths	
Knows unit fractions up to 1/16	

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