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The Effects of a SFON-Based Early Numeracy Program on Multilingual Children's Early Numeracy and Oral Language Skills

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Abstract

In this quasi-experimental study we examined how the Count How Many (CHM) intervention program can support multilingual children's early numeracy and oral language skills. The program is aimed at promoting Spontaneous Focusing on Numerosity (SFON) and early numeracy skills in 3- to 5-year-old children who attend daycare. We examined the effects of the CHM intervention with existing, but unanalyzed data, of sixteen multilingual children who participated in the intervention, which consists of 6 weeks of intensive training followed by a 5-month rehearsal phase. We matched two monolingual participants with each multilingual participant by age, SFON, and cardinality-related skills for each multilingual child. One of the matched children participated in the CHM intervention, while the other took part in an early literacy program, Let's Read and Talk. Children's early numeracy and oral language skills were measured at pretest, posttest, and delayed posttest. Multilingual children's SFON tendency, cardinality skills, number sequence production abilities, and story comprehension skills developed at a similar rate as monolingual participants during the follow-up period. The results suggest that it is possible to enhance SFON tendency and cardinality-related skills in multilingual children before school age. Furthermore, the time spent supporting early numeracy skills does not take away from language learning. However, more research is needed in larger populations to determine the applicability to broader segments of national and global societies.

Keywords: spontaneous focusing on numerosity (SFON); early numeracy; intervention; early childhood education; multilingual children

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Today's children are exposed to many different languages before entering school. According to Grosjean (2010), more than half of the world's population speaks two or more languages. Recent studies indicate that school-aged, multilingual children consistently show lower mathematical performance levels compared to monolingual children who speak the majority or dominant language of the country (National Center of Education Statistics, 2017; OECD, 2016; Ukkola & Metsämuuronen, 2019). However, there is a paucity of research related to supporting the learning of under school-aged, multilingual children (Arvola, Lastikka, & Reunamo, 2017; McCabe et al., 2013). This gap in empirical research has led to a lack of research-based pedagogical tools to support the academic skills of multilingual children in daycare.

There are numerous children with variable language background participating in the Finnish early childhood education coming from families where Finnish is not the primary language. Often these families consist of immigrant parents and Finland-born children and the parents use their native language at home. Thus, many children are exposed to formal Finnish language for the first time when they enter early childhood education. These are the children that early educators might find the most challenging to support and to find ways to make them feel like a part of the group as well as offer positive learning experiences. In early childhood education, mathematics has traditionally not been something that early educators perceive as important as early language skills (Institute of Medicine and National Research Council, 2015; Phillips & Meloy, 2012). This appears to extend to multilingual children as well. While a variety

of terms have been suggested for referring to the learning of two or more languages (simultaneously or sequentially), we use the term *multilingualism* with a definition adopted by Grosjean (2013) who defined it as the use of two or more languages in everyday life. In the current study, the children whose parents reported that they were using language(s) other than just Finnish at home were considered to be multilingual. If the only language used at home was Finnish, the child was considered as monolingual.

This study is an extension to a larger research project, in which two early numeracy intervention programs (A) Count How Many (CHM) and (B) One, two, how many were developed and empirically tested (see Hannula-Sormunen et al., 2020). Both programs aim to support young children's numerical development and were developed for children who are just learning cardinality recognition and counting skills. Results of a recent intervention with monolingual Finnish-speaking children show that those children who participated in the CHM program improved in their long-term early numeracy skills (Hannula-Sormunen et al., 2020). In the present study, we aim to examine the effects of the CHM intervention on multilingual children's numeracy and oral language skills using previously unanalyzed data of multilingual children who participated in the intervention. This is the first part in a series of studies investigating how to support early mathematical skills in multilingual children. The results of this study will guide the developing of future interventions specially tailored to multilingual children. We therefore aim to determine if multilingual children benefit from the CHM early math intervention or if the intervention needs modification to be beneficial to all children regardless of their language background.

Early Numeracy Development: Cardinality-Related and Counting Skills

Children as young as toddlers are able to recognize the number of items in a small set (such as candles on their birthday cake) without counting; this happens before they are able to determine the exact numerosity of a larger set or understand the cardinal principle (e.g. Bermejo, Morales, & deOsuna, 2004; Mix, Sandhofer, Moore, & Russell, 2012; Wynn, 1990). This recognition is based on subitizing, which can be described as "instantly seeing how many." It is a rapid, accurate, perceptual apprehending of one to four items simultaneously without counting (Clements, 1999; Trick, Enns, & Brodeur, 1996). Subitizing-based enumeration belongs to the first phase in the development of early numeracy skills (Fuson, 1988; Krajewski & Schneider, 2009; Wynn, 1990) as it seems to precede and support the development of counting ability (Le Corre, Van de Walle, Brannon, & Carey, 2006) and understanding the meanings of the first few number words (Benoit, Lehalle, & Jouen, 2004).

Cardinality understanding is an important part of children's cognitive development between the ages of three and five (Bermejo, 1996; Fuson, 1988; 1991). Children's first attempts at counting are often rather random pointing at objects and reciting the number words like a meaningless poem than actually knowing the quantities these words represent (Fuson, 1988; Geary & van Marle, 2016). Learning the cardinal principle means that child understands how the last word of the counting list defines the cardinality of the set (Wynn, 1990) and how in any counting list, the third word always means 3 or the 10^{th} word means 10 regardless of the language used (Sarnecka, Goldman, & Slusser, 2015). The cardinal principle is one of the five counting principles described by Gelman and Gallistel (1978). The other four principles that define accurate counting are one-to-one, stable-order, abstraction, and order-irrelevance principles. Correct counting—and efficiently utilizing counting in particular—require the

integration of these principles. The activities in CHM intervention are aimed to trigger children to practice their early number skills and the adopting of the counting principles not only during the activities but also in everyday situations. The numbers used in the activities are so small that even the children who are not yet able to count, can participate by recognizing small sets through subitizing.

In contrast to the development of early numeracy skills in monolingual children, there is a relatively small body of literature that is concerned with the effects of simultaneously learning two or more languages on children's numeracy development before school age (Bonifacci, Tobia, Bernabini, & Marzocchi, 2016; Cross, Woods, & Schweingruber, 2009; Richards-Tutor, Baker, Gersten, Baker, & Smith, 2016). Existing research suggests that numeracy development in school-age, multilingual children is slower than that of their monolingual peers and in comparison to national norms (Harju-Luukkainen & Mcelvany, 2018; Ukkola & Metsämuuronen, 2019; Xue, Atkins-Burnett, & Moiduddin, 2012). However, when examining the numeracy development of younger children, Bonifacci and colleagues (2016) pointed out that multilingual preschoolers were actually only behind their monolingual peers in the numerical skills with a verbal component. In the purely non-verbal numerical skills, such as quantity comparisons, the monolingual and multilingual groups did not differ.

As there is increasing concern that multilingual children are unable to reach the levels of their monolingual peers in mathematical skills during their school years (OECD, 2016), it would be important to start supporting their skills already in daycare. Despite the importance of mathematics achievement on future academic and economic success (Duncan et al., 2007; NMAP, 2008; Phillips & Meloy, 2012) and the objective of education to provide equal opportunities to succeed for all children regardless of their language background, there is not

much research on multilingual preschool or daycare children's development or the enhancement of cardinality-related and counting skills. This study was designed to increase our understanding of this critical phase in early numeracy development.

Early Numeracy Development: Spontaneous Focusing on Numerosity

The gap between the mathematical skills in multilingual and monolingual children can be seen as early as first grade (Ukkola & Metsämuuronen, 2019). One reason behind the gap may be the informal mathematical experiences young children engage in before formal schooling, as early numeracy skills develop in everyday life (Hannula & Lehtinen, 2005). However, there are great differences in the number of mathematical experiences children have before starting school (Fuson, Clements, & Sarama, 2015). Some children are more aware of numerosities around them than other children; this is also true in situations that are not explicitly mathematical (Hannula & Lehtinen, 2005). This spontaneous focusing on numerosities (SFON) leads to increased self-initiated practice with early numeracy skills, which offers an advantage in learning formal mathematical skills and knowledge at school (Hannula & Lehtinen, 2005; Hannula, Mattinen, & Lehtinen, 2005).

SFON is distinguishable from other cognitive processes, as it is a separate attentional process that refers to a person's self-initiated focusing on the aspect of number and the utilizing of this exact number knowledge in one's action, while SFON tendency is a generalized tendency to spontaneously practice exact enumeration across different situations in natural surroundings. (Hannula, Lepola, & Lehtinen, 2010.) Previous studies of SFON show that this tendency plays an important role in the development of early mathematical skills and later mathematics achievements in school (for a review, see McMullen, Chan, Mazzocco, & Hannula-Sormunen, 2019; Rathé, Torbeyns, Hannula-Sormunen, Smedt, & Verschaffel, 2016).

Hannula (2005) suggested that instead of being only a developmentally relevant disposition or practice of number recognition skills, SFON would also be a relevant sub-process of any counting act. Thus, in addition to the previously described five counting principles, a counting act requires that attention is focused on the aspect of exact numerosity. In other words, in order to be able to recognize exact number, one needs to first focus their attention on the aspect of numerosity rather than other aspects, such as the color or other characteristics of a set of items.

In previous studies, SFON tendency has been shown to be positively related to the development of cardinality recognition, subitizing-based enumeration, object counting, and number sequence skills before school age (Edens & Potter, 2013; Hannula, 2005; Hannula & Lehtinen, 2005; Hannula, Räsänen, & Lehtinen, 2007). The CHM intervention has previously been shown to enhance SFON in monolingual Finnish children, in the present study we aim to examine how this might extend to multilingual children as well.

Supporting Multilingual Children's Early Numeracy Skills

In daycare environments, educators often emphasize children's linguistic skills more than early numeracy skills (Institute of Medicine and National Research Council, 2015; Phillips & Meloy, 2012). This is understandable, especially with children who do not speak the majority language at home and therefore need intensive support to cope with the new environment. Consequently, early educators might have a concern that the time spent supporting children's early numeracy skills might be time away from supporting children's other important skills, such as language and social skills (Clements & Sarama, 2018). However, it seems that playful mathematical interventions might be beneficial to young multilingual children's mathematical and language learning (Fuson et al., 2015).

This view is supported also by Sarama and colleagues (2012) who investigated the impact of Building Blocks mathematics curriculum (Clements & Sarama, 2007) on the oral language and letter recognition skills of 4-year-old children with diverse ethnic backgrounds. The Building Blocks is an intensive pre-kindergarten mathematics curriculum with an approach of mathematizing everyday activities using off- and on-computer activities. In this large-scale randomized trial project, the experimental group participated in the Building Blocks mathematics program whereas the control children received a typical district mathematics instruction. The children in the Building Blocks group performed similarly to the control children in letter recognition and two oral language subtests: sentence length and inferential reasoning. Furthermore, the children in the Building Blocks group outperformed the children in the control group on four language subtests: ability to recall key words, use of complex utterances, willingness to reproduce narratives independently and inferential reasoning. The Hispanic participants in the study, many of whom were learning English as a second language, scored lower than other ethnic groups on letter recognition in both Building Blocks and control group, but there were no impacts on the other language measures. These results challenge the early educators concern of mathematics curriculum's negative impact on early literacy or language skills.

Even though the amount of research is still modest, recent intervention research has begun to provide promising insights into improving multilingual children's mathematical skills already in daycare. These experimental studies conducted in preschool or kindergarten have shown that it is possible to support multilingual children's whole number understanding (Doabler et al., 2019), number sense, arithmetic fluency, and mathematics calculation achievement (Dyson, Jordan, Beliakoff, & Hassinger-Das, 2015) through the use of a number sense

intervention. There are also positive effects on multilingual children's early numeracy skills through interventions using computer-assisted instruction in mathematics in children's home language (Foster, Anthony, Clements, Sarama, & Williams, 2018) and in the instructional language of the kindergarten, that children are not speaking at home (Wang & Woodworth, 2011).

The Count How Many Intervention

As stated before, previous evidence suggests that the One, two, how many and Count, How Many programs were effective in promoting early numeracy in monolingual Finnish-speaking children's (Hannula-Sormunen et al., 2020). One, two how many program was developed for under 3-year-old children who are just learning to recognize their first cardinal numbers without counting, whereas the Count How Many reinforces these early subitizing-based skills and continues to more advanced numerical skills focusing on counting and its sub-skills including cardinality recognition. The CHM program was not developed to specifically cater for children with diverse language backgrounds. However, previous research has established that grouping the multilingual children with children whose home language is the daycare center's instructional language and repeated everyday experiences utilizing children's natural tendency to explore and play supports multilingual children in learning early mathematics (Clements, Sarama, Kutaka, & Banse, 2018). As the CHM intervention uses structured games and meaningful play in various contexts and across different everyday situations to promote children's focusing on numerosity, recognizing and using of exact number recognition and counting skills, we expect it to be beneficial to multilingual children. Additionally, the activities are conducted both in whole-group and in small-group settings, and these groups consist of both multi- and monolingual children.

Furthermore, Count How Many program involves recurring, active, hands-on, "easy-access" mathematics practicing, which could support also multilingual children's mathematical development as the activities give a chance to participate and offer positive learning experiences also with a small vocabulary. This view is supported by Moschkovich (2015) who emphasize the importance of regularity in opportunities to participate in mathematics discourse and paying attention to the mathematics in multilingual children's responses instead of focusing solely on their language abilities.

Count How Many intervention focuses on counting and cardinality related skills, because those skills are necessary in everyday life and a strong basis for later more sophisticated mathematics. Even though a systematic understanding of how childhood's multilingualism effects on skills related to counting and cardinality is still missing, the research shows clear evidence that early mathematical and early literacy skills develop hand-in-hand (Purpura & Napoli, 2015). As the language backgrounds of multilingual children in Finland are extremely diverse, we do not focus on language-specific effects such as how the grammar within a child's home language influences their learning of the cardinal principle (see Le Corre, Li, Huang, Jia, & Carey, 2016). Instead, we investigate in a very naturalistic setting, how multilingual children's numeracy skills develop if they participate in the intervention activities just as any other member of the child group.

The need for this study extends from typical early childhood education practices, where it is often questioned whether children should learn first language skills before they can participate in other activities. However, early mathematical interventions might provide an activity, which allows children who speak more than one language to actively participate despite their possibly weaker language skills in the instructional language used in daycare. The present study

represents an effort to better understand how these practices could be utilized in a daycare's pedagogical practices.

The present study

The aim of the present study was to evaluate the Count How Many program's effect on multilingual children's early numeracy and oral language skills in comparison to two matched monolingual control groups: one group participated in the same CHM intervention as the multilingual children, and another group participated in the Let's Read and Talk (LRT) literacy program. Through the use of structured, playful, hands-on numerical activities, the CHM intervention was expected to be as effective with multilingual children as it is for monolingual children (Hannula-Sormunen et al., 2020).

The present study was designed to address two research questions:

1. Are there differences in the development of SFON, cardinality-related skills, and oral language skills among multilingual children participating in the CHM program, monolingual children participating in the CHM program, and monolingual children participating in the LRT program?
2. How do multilingual children develop in early numeracy, expressive vocabulary, and story comprehension skills during the intervention period?

Method

Participants

The participants were 48 2- to 5-year-old (range from 2 years 11 months to 5 years 9 months) children enrolled in five daycare centers located in a medium-sized city in Finland. Informed consent was obtained from the children's parents before the study began. Because some parents did not speak Finnish, the research permission form was also provided in English

(n = 3), Arabic (n = 2), and Russian (n = 2). The ethical guidelines of the University of Turku were followed and both the ethical board of the University of Turku and the daycare administration gave permission for conducting the study.

The Count How Many intervention was delivered by the early childhood education and care (ECEC) teachers (n = 4) and ECEC childcarers (n = 6) in three daycare centers, whereas the Let's Read and Talk program was delivered by 2 ECEC teachers and 4 ECEC childcarers in two daycare centers. In this study we refer this whole group of ECEC teachers and childcarers as *early educators* (N = 16). Participation was voluntary for all parties. An ECEC teacher in Finland must hold a post-secondary level degree (Bachelor of Education, Master of Education or Bachelor of Social Sciences), and ECEC childcarer must have at least an upper secondary level qualification in social welfare and healthcare (Education Finland, 2018). As all the daycare centers were from the same municipality, they followed the same local curriculum which is based on the on the normative National core curriculum on early childhood education and care (2018) issued by the Finnish National Agency for Education. The National core curriculum includes learning areas, which steer the content of the pedagogical activity of early childhood education. The learning areas are grouped into five entities: (a) A rich world of languages, (b) Many forms of expression, (c) Me and our community, (d) I explore and act in my environment, (e) I grow, move and develop. The entity d includes mathematical, environmental and technology education. The mathematical education aims to support the development of children's mathematical thinking and strengthen a positive attitude towards mathematics through illustrative and playful activities. The early educators have lots of autonomy in planning the pedagogical activities, but regular, mandatory observation-based pedagogical evaluations are

used for developing individual learning plans for all children. (Finnish National Agency for Education, 2020.)

Subgroups

There were 16 multilingual children (4.5 years; *SD* = 9.7 months) in the study from three daycare centers participating in the Count How Many intervention. A total of 14 different home languages were reported among this group of children. These languages included, but were not limited to, English, Swedish, Arabic, Russian, French, and Spanish. Eight parents reported that they spoke Finnish and some other language at home and eight parents reported that they did not speak Finnish at home. The multilingual children were randomly assigned to small groups in each of the 3 daycare centers which implemented the CHM intervention. Thus, in every small group there were both multi- and monolingual children.

Pairwise-matched controls were selected from the group of monolingual children on the basis on their age, scores on tests of SFON tendency and cardinality-related skills at pretest. Two control children were selected for each multilingual child. Half of the control children participated in the Count How Many intervention in the same daycare groups as the multilingual children (CHM-monolinguals, 4.5 years; *SD* = 9.0 months) while other half took part in the LRT early literacy program (LRT-monolinguals, 4.4 years; *SD* = 9.2 months). Information on the children's gender, age and mother's educational level can be found in Table 1.

Table 1

Demographics of the Multilingual and Monolingual Groups

Group	Multilingual Children			CHM Monolinguals			LRT Monolinguals		
	n	*M (SD)*	[Min, Max]	*n*	*M (SD)*	[Min, Max]	*n*	*M (SD)*	[Min, Max]
Gender (girls %)		50%			50%			43,75%	
Age in months at pretest	16	53.94 (9.68)	[39.33, 68.80]	16	53.48 (9.01)	[37.95, 67.15]	16	52.56 (9.25)	[35.12, 68.01]
Mother's educational background		4.44 (1.86)	[1, 7]		4.31 (1.25)	[3, 6]		4.31 (1.45)	[2, 6]

Note. CHM = Count How Many; LRT = Let's Read and Talk; SD = standard deviation. Mother's educational background: 1 = no vocational education; 7 = doctoral degree.

Design and Schedule of the Study

This study consisted of a quasi-experimental, pretest-posttest design with a delayed posttest and two active control groups. Before the interventions, all children participated in the pretest. The posttest was conducted seven weeks after the pretest and the delayed posttest was conducted five months after the posttest. The design, schedule of the data collection, professional development training, and phases of the Count How Many and Let's Read and Talk programs are described in Figure 1. Throughout the interventions, the LRT control group had a similar frequency and overall structure of intervention activities as those in the Count How Many intervention.

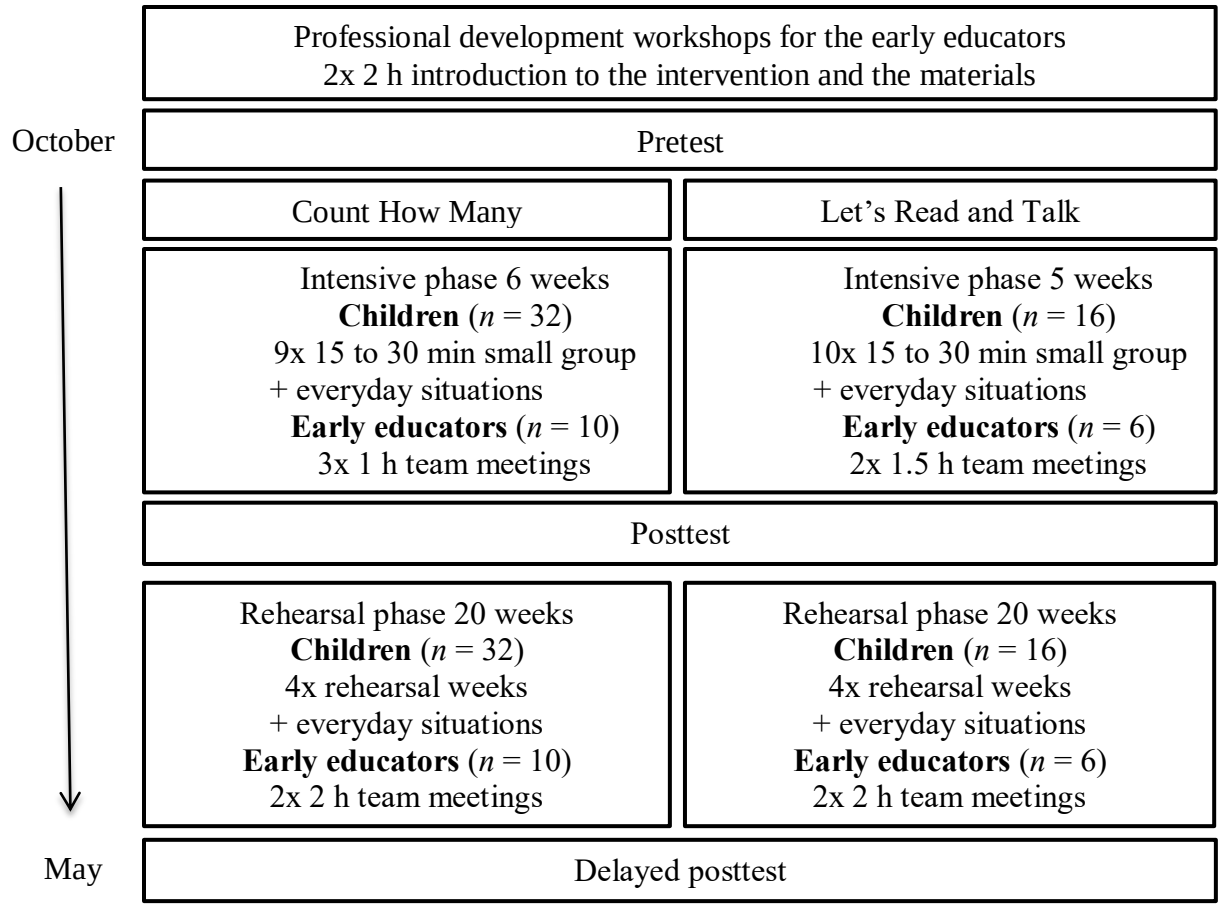

Figure 1. Schedule of the data collection, professional development training, and intervention phases.

Professional Development Training of the Early Educators

The structured small-group activities in both interventions were guided by the early educators who participated in professional development training provided by the researchers as described in the Figure 1. The training focused on pedagogical guidance and early mathematics or early literacy content knowledge. In the numeracy program, the focus was on the enhancement of SFON, cardinality recognition, and counting skills. The literacy program's professional development training emphasized supporting the children's vocabulary and story comprehension skills. The training began with two 2-hour workshops at the university in which the interventions and the designed materials were introduced. In team meetings during the interventions at the

daycare centers, early educators had the opportunity to discuss the activities and guidance together with the researchers. In addition, the early educators video-recorded the last small-group activity of each week. In team meetings, educators and researchers watched these videos and reflected on the well-guided episodes chosen by the researchers.

Count How Many Intervention Program's Design and Activities

The Count How Many intervention began with a 6-week intensive phase. During the odd weeks (1, 3, and 5), children participated in a small-group activity (3 to 7 children) for 15 to 30 minutes, three times a week. During the even weeks (2, 4, and 6), the skills practiced in the small groups were applied to everyday situations at the daycare centers. The intensive phase occurred in autumn and was followed by a spring rehearsal period.

The goal of the rehearsal period was to maintain the integration of the counting activities as well as noticing numerosities in the daily daycare routines. To support the early educators in maintaining the pedagogical mathematical sensitivity in the interactions with the children, the 20-week rehearsal phase included four special weeks. During these weeks**,** one of the guided small-group activities (CHM box, CHM board or Vegetable market, see "Structured activities") was implemented twice a week. The purpose was to make numerical focusing and enumeration training a regular, everyday behavior of all children, not only during the intervention, but also over the longer term. The methods to support the numerical focusing and enumeration training in the small-group activities and during everyday activities were e.g. how many questions, counting, recounting, comparing, increasing and decreasing the number of objects in the activities and in the environment and asking the children to find the same number of objects in the environment. The environment was made more "countable" by placing SFON baits around the daycare for children to discover. The early educators encouraged children to use fingers to

count and express the numerosity and to generate numerosities in various manners such as by clapping and bumming. The activities progressed from adult-modeled activities to the active participation of children. The intervention was delivered in Finnish.

Structured activities. Each small-group session consisted of a playful activity with structured guidelines for early educators to enhance and trigger focusing on numerosity. The methods of triggering and enhancing the focusing on numerosity in the structured activities are described in Figure 2. There were three different small-group activities. The same activity with different variations was repeated three times a week. A SFON bait, which is the fourth activity described in Figure 2 was present throughout the intervention phases in both small group and whole group settings.

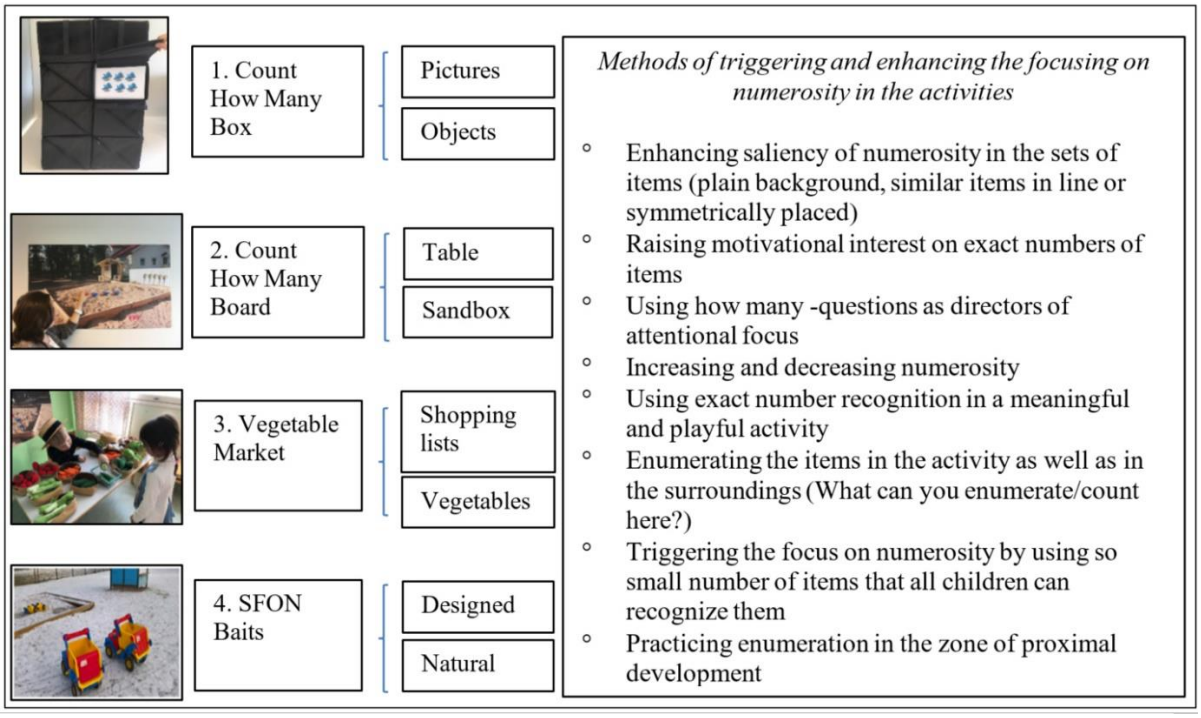

Figure 2. Structured, adult-guided activities in the Count How Many intervention program (modified from Hannula-Sormunen et al., 2020).

1) *The Count How Many box* is a light drawer cabinet with eight boxes with doors. In every box, there is a different picture of objects (or later, real objects) in differing numbers. Children's attention is guided toward the exact number of objects before and after opening the door. The objects are picked up one by one from the box on the table while simultaneously counting. In addition, children are guided to find the same number of objects in their surroundings. Later, each child gets their own counting box for their own play.

2) *The Count How Many board* is a large photo of either a table or a sandbox. Photographs of similar everyday items closely cut out along their outlines are placed on the board. The children's attention to the number of items is captured by asking how many items there are and by increasing and decreasing the number of items together with the children. Children are also asked to find out how many similar items there are in the actual daycare environment.

3) *The Vegetable Market* is a structured, adult-guided, role-play activity in which children act as customers, salespersons, drivers, and warehouse workers. The customer has a shopping list with a picture of one to seven similar vegetables and the child is asked to find out how many vegetables they need to buy. The child needs to memorize the number of vegetables and then ask the salesperson at the market to give them the vegetables. When arriving back home, the children are asked to recount them to make sure they have the same number as in the shopping list.

To make the focusing on numerosity and counting objects present outside the small-group sessions, early educators are encouraged to provide opportunities for children to practice their number recognition skills in everyday situations. One prompting method involves the use of a SFON bait.

4) *A SFON bait* is made of similar toys or everyday materials arranged in a symmetric manner that separates the set of toys from the surroundings and makes numerosity more salient and easier to focus on as a target. During the intensive phase and occasionally during the rehearsal phase, early educators place the baits around the daycare center. By arranging the similar toys side-by-side in a row on a plain background, the likelihood of exact number recognition and/or counting behavior increases. If the child does not focus on the numerosity of the items in the SFON bait, the early educators explicitly guide the child's attention by asking how many items there are or by taking away or adding items.

Everyday activities. In addition to placing SFON baits around the daycare environment, early educators are instructed to be especially sensitive to children's enumeration initiatives and to encourage noticing numerosities, enumeration, and counting in the daycare's typical routines such as eating, getting dressed, crafting, waiting in line, and playing outside. As a consequence of these little counting moments, enumeration and counting practice becomes a frequent and typical activity in a daycare day.

Let's Read and Talk Intervention Program

The Let's Read and Talk intervention program included reading the picture book by dialogic reading (Whitehurst et al., 1988) and by supporting children's vocabulary and listening comprehension skills in everyday activities. The main principle of dialogic reading is to teach children become a storyteller instead of passively listening to the story. The child is asked open-ended and enlivening questions that encourage and guide the child to tell the story content broadly. In other words, early educators favour what, where and why questions and avoid ones that the child can answer simply yes or no. Reading activities are adapted to the child's development. This means that as a child's skills develop, the child is guided to do more

conclusions about the events of the story and the emotional states of the characters. In the program, children are helped using these methods of dialogic reading to understand the meanings of the words in the stories, the plot structure of the story, and to draw conclusions about the events of the story and the emotional states of the characters in the story. These key components of listening comprehension were also practiced in the context of day-to-day activities by discussing things that the child is interested in or in situations that in themselves provide a good opportunity for joint reflection.

The intervention began with a 5-week intensive phase. During this phase, one Onni-boy story (Pelliccioni, 2015) per week was read with the children. Each story included everyday situations, bridged to the children's own experiences. The story was read in three parts; thus there were 3 small-group (3 to 7 children) sessions (15 to 30 minutes) per week. The early educators were guided to discuss, ask questions, and embrace verbal initiatives of the children by giving encouraging and formative feedback, which was framed for the children with the intention of children noticing the difference between their own answer and the correct one. During the 20-week rehearsal phase, children's vocabulary and story comprehension skills were supported by applying the principles of dialogic reading to other reading moments and to the natural interaction between children and adults. Every fifth week of the rehearsal phase there was a special week. Twice during the week, an Onni-boy story was re-read and the methods from the small-group activities used in autumn were especially emphasized. The purpose of these review weeks was to remind and maintain the principles of dialogic reading in daycare's everyday activities also after the intensive phase of the intervention.

Testing Procedure and Measurements

All the test situations were video-recorded and presented in a quiet, familiar room in each of the daycare centers. The children participated in the test situations one at a time. Two testers collected all the data from the children in all measurement points. Both testers were extensively trained in following strict verbal and non-verbal testing procedures by using video-recording and joint reflection. The same person tested the child in the pretest and delayed posttest, but in order to keep the situation as novel as possible, the other tester completed the posttest. Thus, tester A tested half the children on the pre-test and delayed post-test, these children were tested by tester B at the post-test. The other half of the children were tested by tester B at the pre- and delayed post-tests and tester A at the post-test. Scoring was based on video recordings. A careful analysis of the recordings showed that all testing procedures were correctly followed. Each test situation lasted, on average, 20 minutes. This included seven tasks and two short breaks in the following order at every measurement point: 1) SFON imitation task with disappearing objects; 2) vocabulary task; 3) short break; 4) SFON selection task; 5) story comprehension task; 6) short break; 7) SFON imitation task with visible objects; 8) give-a-number task; and 9) number sequence production task. The breaks included simple, relaxing, and joyful activities (e.g. let's fly like butterflies) to ensure the spontaneity of the next SFON assessment. The testers praised each child after completing each task, but no specific feedback was given. Children's responses were scored from the videos by two observers. The inter-rater reliability of all tasks varied from 0.96 to 1.0, indicating very high reliability.

SFON tasks (Hannula, Mattinen, & Lehtinen, 2005). In the SFON tasks, different model activities were presented to the children. All instructions or contextual hints about numerosity were carefully avoided, so it was up to the children as to whether they regarded exact numerosity

as a relevant aspect of the task. SFON tasks included small numbers and simple visual instructions so that if the children focused on numbers in the task, they were capable of proceeding according to their numerical focusing target.

The child's responses were scored from 0 to 1. One point was given if the child spontaneously focused on numerosity. That is, the child either put the same number of items as the experimenter did in the task, or the child presented verbal or nonverbal quantifying acts. The following quantifying acts were scored as 1 point: utterances, including number words (e.g. I'll give him two berries); the use of fingers to express the number of objects; counting acts (e.g. whispering a number word sequence or indicating counting by fingers and/or head); and comments related to quantities or counting (e.g. "Oh, I miscounted them" [Hannula-Sormunen, 2015; Hannula et al., 2005]). The maximum score on individual SFON tasks at the pre-, post-, and delayed posttests was 3. Due to our interest in children's general SFON tendencies across different task contexts, we used the sum score of the SFON tasks. Thus, the pre-, post-, and delayed posttest SFON scores described how many times out of 9 each child focused on numerosity. The average measures of intraclass correlation for all three SFON tasks were .577 in the pretest; .763 in the posttest; and .796 in the delayed posttest.

All SFON tasks included three trials: an imitation task with disappearing objects; a selection task; and an imitation task with visible objects. A parallel version of the tasks was used in every measurement point. The procedure was similar in all the parallel versions, only the materials used in the tasks were changed. Materials used in the imitation task with disappearing objects were a toy parrot and berries in the pretest; a post box and envelopes in the posttest; and a toy puppy and biscuits in the delayed posttest. In the selection task, the materials were a brown paper creature and shoeboxes (pretest); a red paper house and window boxes (posttest); and a

green caterpillar and sock boxes (delayed posttest). The materials used in the imitation task with visible objects were a truck and a box with gravel (pretest); a toy hen together with a spoon, a plate and a box full of grains (posttest); and a tractor and shovel with a trailer (delayed posttest). The following is a brief description of the pretest versions of these tasks.

The imitation task with disappearing objects (Hannula & Lehtinen, 2005). The materials of the imitation task at the pretest were a toy parrot and a plate of eight red glass berries. The experimenter began the task by introducing the materials and saying, "Look (child's name), this is Vaakku bird and here are berries for Vaakku. Watch carefully what I'm doing and then you do exactly as I did. Look, I'm doing it now." The experimenter put two berries, one at a time, into the parrot's mouth. The berries disappeared into the parrot's stomach with a bumping sound. Then the child was told, "Now you do exactly like I did." The number of berries was 2, 1, and 2.

The selection task (Hannula et al., 2005). The materials at the pretest were either a one- or two-legged paper creature and four shoeboxes. On the covers of the boxes, there were different numbers of shoes (3, 1, 2, and 4). The boxes were completely covered by a tablecloth at the beginning of the task. The experimenter started the task by lifting the creature from the bag and saying, "Look (child's name), here is a creature but it feels cold. Here are shoeboxes under the cloth." The experimenter revealed and presented each shoebox, one at a time, by pointing to it with her hand and saying, "Here is this kind of shoebox, here is this kind of shoebox, etc. For this creature, give it its very own box of shoes." The number of legs was 2, 1, and 2.

The imitation tasks with visible items (Hannula et al., 2005). The experimenter placed a truck and a box full of gravel on the table in front of the child. The experimenter started the task by introducing the materials and then said, "Look, I'll now put gravel onto the truck's loading

platform." The experimenter loaded two handfuls of gravel and said, "Now you put gravel onto the loading platform." The number of handfuls was 2, 1, and 2.

Give-a-number task. Cardinality-related skills were measured by an applied version of the give-a-number task (Wynn, 1990). The task was similar in all measurement points. In this task, the child was advised to place a certain number of small objects onto a table. For example, the experimenter asked the child to "Take two strawberries from this box and put them on the table. How many strawberries will you put on the table?" If the child answered with a wrong number, did not answer at all, or showed the number with his or her fingers, the child was advised, "You were supposed to take two. How many will you put onto the table?" After ensuring that the child heard and repeated the correct number, the box was given to him or her so the child could put the strawberries onto the table. The numbers requested were 2, 3, 4, 5, 7, 9, 13, 19, 23, and 32. The total number of items in a box in each case was 10 more than the correct answer. The maximum score was 10. The task was discontinued after two consecutive wrong answers. Cronbach alphas for the give-a-number task were .83 in the pretest, .87 in the posttest, and .88 in the delayed posttest.

Number sequence production task. Children's verbal counting skills were tested with the number sequence production task. The children were asked to count from one onward, as high as they could. The counting was stopped at 50, which was the maximum for the task. The score was the highest number reached without making any mistakes.

Expressive vocabulary task. The WPPSI-III vocabulary task (Wechsler, 2009) is a standardized verbal task that was used in this study. Each child was asked to name five familiar objects in pictures presented to them and then explain the general meaning of 10 to 35 concepts (the number of presented questions was dependent on the success of the participant because three

consecutive questions resulting in 0 points ended the task). The maximum score was 61. The vocabulary task was repeated similarly at all measurement points.

Story comprehension task. Story comprehension skills were tested with the standardized NEPSY II task introduced by Korkman, Kirk, and Kemp (2008). In this task, the experimenter showed a picture and read a short story related to the picture. Parallel versions for each of the measurement points were used. The children were encouraged to tell as many aspects about the story as they remembered. If the children were not able to begin the retelling, they were encouraged with two hint questions. In the second phase, guided questions were posed about the aspects that remained unmentioned in the first free recall phase. The maximum score was 24.

Results

Analysis was carried out using IBM SPSS Statistics 25 (IBM, Armonk, NY). To examine whether the multilingual children and monolingual children differed in pretest and background variables we conducted a series of preliminary analyses. The analyses revealed no differences among the groups' ages, genders, or their mothers' educational backgrounds (see Table 1). There were also no differences among any of the pretest variables, which included SFON [$F(2, 45) = .091$, $p = .91$]; cardinality skills [$F(2, 45) = .264$, $p = .77$]; number sequence production [$F(2, 45) = .341$, $p = .71$]; expressive vocabulary abilities [$F(2, 45) = .429$, $p = .65$]; and story comprehension skills [$F(2, 45) = 1.070$, $p = .35$]. Therefore, the only difference among the groups was the children's home language.

To investigate the differences in the development of SFON, cardinality-related skills, and oral language skills among multilingual children participating in the CHM program, monolingual children participating in the CHM program, and monolingual children participating in the LRT

program, we analyzed each skill using a 3 (time) x 3 (group) univariate analysis of variance (ANOVA) with repeated measures from the pretest, posttest, and delayed posttest. All children's SFON tendency [$F(1.497, 67.370) = 4.248$, $p = .028$, $\eta^2 = .086$], cardinality skills [$F(1.678, 75.497) = 10.528$, $p < .001$, $\eta^2 = .190$], number sequence production abilities [$F(2, 86) = 12.031$, $p < .001$, $\eta^2 = .219$], and story comprehension skills [$F(2, 90) = 9.287$, $p < .001$, $\eta^2 = .171$) increased across the three tests, resulting in significant main effects of time. Expressive vocabulary did not statistically differ across the three measurement points: $F(1.691, 76.094) = 2.424$, $p = .057$, $\eta^2 = .065$. There was no statistically significant effect of the interaction between time and group for any of the skills measured. In other words, the results in Table 2 show similar development of mathematical skills and oral language skills in all three groups.

Table 2

Descriptives and Repeated Measures ANOVA: Group x Time Interaction Effects by Multilingual, CHM Monolingual, and LRT Monolingual Groups

Variables	Group	Pretest *M (SD)*	Posttest *M (SD)*	Delayed Posttest *M (SD)*	Group x Time Interaction *F(df)*	*p*	η^2
SFON (max. 9)	Multil.	3.06 (1.84)	3.56 (1.09)	3.81 (1.76)	.342 (2.99, 63.37)	.795	.015
	CHM-Monol.	3.63 (1.50)	4.56 (2.78)	4.69 (2.93)			
	LRT-Monol.	3.63 (1.54)	3.75 (2.236)	4.31 (2.60)			
Give-a-number (max. 10)	Multil.	3.25 (3.61)	3.81 (3.39)	4.63 (3.70)	.325 (3.36, 75.50)	.829	.014
	CHM-Monol.	4.00 (3.10)	5.25 (2.96)	5.88 (2.45)			
	LRT-Monol.	3.56 (2.53)	3.94 (2.82)	4.94 (3.15)			
Number seq. production (max. 50)	Multil.	15.87 (15.83)	22.44 (16.32)	21.87 (16.27)	1.695 (4, 86)	.159	.073
	CHM-Monol.	17.60 (13.20)	21.47 (17.16)	25.53 (16.76)			
	LRT-Monol.	14.00 (5.210)	13.93 (7.363)	23.07 (14.21)			
Expressive vocabulary (max. 61)	Multil.	12.94 (11.56)	11.19 (8.64)	12.00 (8.04)	2.424 (3.38, 76.09)	.065	.097
	CHM-Monol.	16.19 (9.78)	18.75 (8.19)	20.94 (7.32)			
	LRT-Monol.	16.31 (9.86)	20.56 (11.43)	19.63 (10.31)			
Story comprehension (max. 24)	Multil.	4.81 (5.53)	6.25 (4.89)	6.19 (6.06)	.718 (4, 90)	.582	.031
	CHM-Monol.	6.31 (4.74)	8.00 (4.68)	9.06 (5.43)			
	LRT-Monol.	4.31 (3.4)	7.44 (3.43)	8.19 (5.05)			

Note. ANOVA = analysis of variance; CHM = Count How Many; LRT = Let's Read and Talk; SD = standard deviation; SFON = spontaneous focusing on numerosity.

The low power in this study, due to its small sample size and large within-group variation, suggests that there is a possibility that the intervention effects may have not been captured using summary statistics. Given that both the multilingual and control groups improved in all skills except vocabulary, we then aimed to more directly examine how the children's language backgrounds were related to their gains from the Count How Many program. In order to investigate how the intervention supports the multilingual children, we examined the multilingual children in two groups. *Multi Finn* -group consisted of children (n=8) who had Finnish as one of their home languages. *Multi No Finn* -group (n=8) consisted of children whose first exposure to formal Finnish language was at the daycare as they did not have Finnish as one of their home languages.

There were clear differences in children's vocabulary mean scores between the Multi No Finn and Multi Finn groups (Figure 3), along with the large within-group variation. Even though there were no effects of vocabulary from the numeracy intervention (as expected), the low language proficiency level at the pretest did not hinder the children from participating in the activities and developing in the numeracy measures.

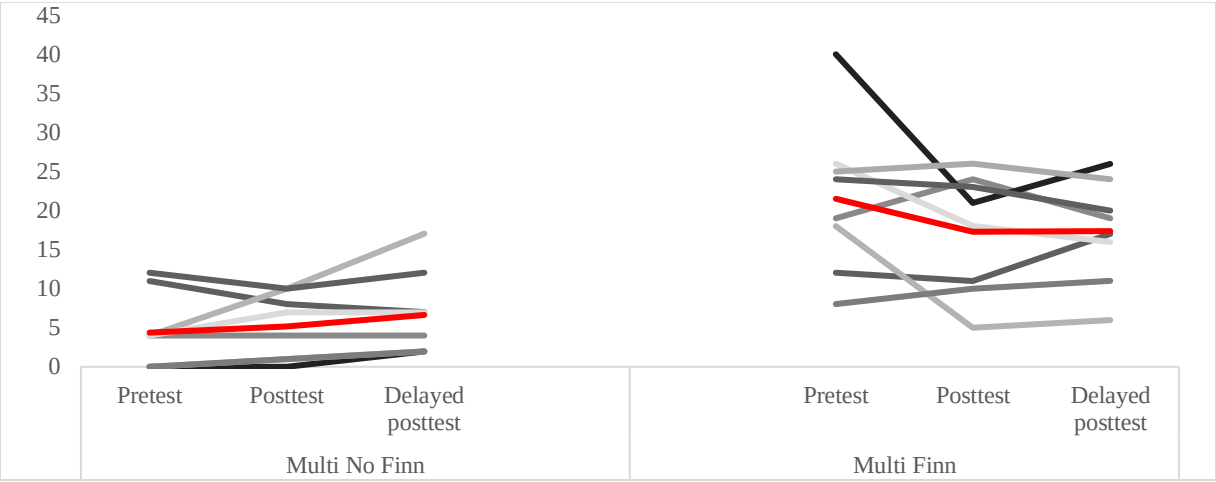

Figure 3. Proportion of pre-, post- and delayed posttest expressive vocabulary scores by the multilingual group. Gray scale lines represent one participant; red lines represent the means for the groups.

The Multi No Finn group was able to succeed at a nearly similar level at the pretest as the Multi Finn group on the SFON measures, with both groups modestly increasing their SFON scores during the intervention (Figure 4). These results indicate that SFON measures are not particularly dependent on language skills.

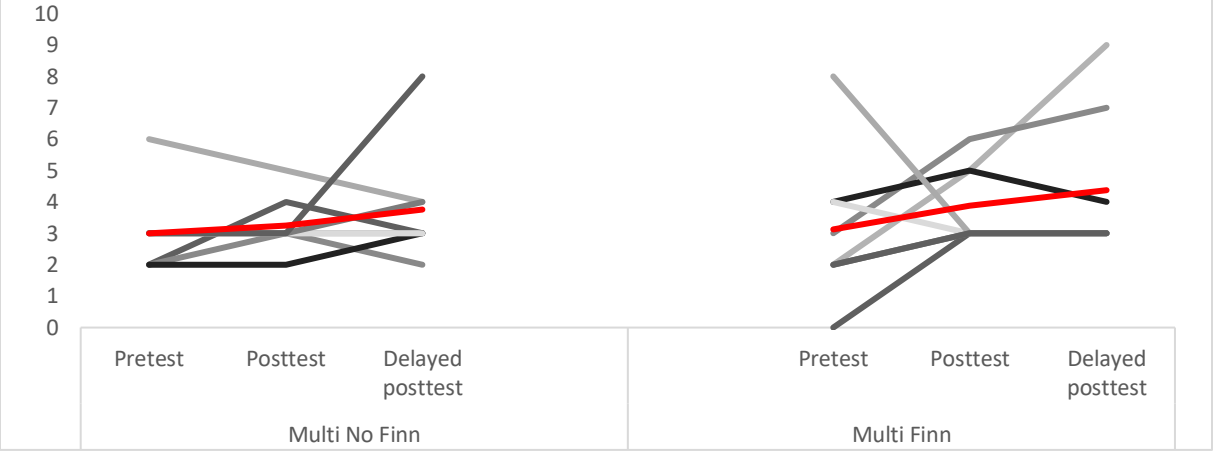

Figure 4. Proportion of pre-, post- and delayed posttest SFON scores by the multilingual group. Gray scale lines represent one participant; the red lines represent the means for the group.

The Multi No Finn scores on the give-a-number task were lower than those of the Multi Finn group (see Figure 5). When examining the individual scores of the Multi No Finn group, there were three children who gained 0 points in all three measurement points. These children also showed the lowest levels of expressive vocabulary on the pretest, gaining 0 points. While on the pretest, two of these children could not count any numbers in Finnish and one of them was able to count to three, all three were able to count to 10 on either the posttest or the delayed posttest.

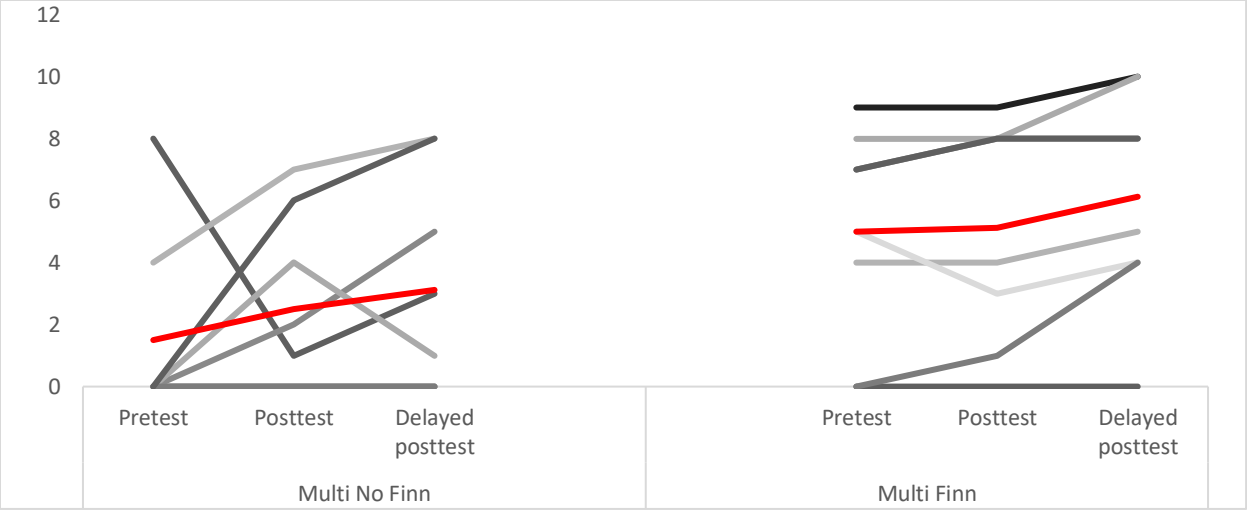

Figure 5. Proportion of pre-, post- and delayed posttest give-a-number scores by the multilingual group. Gray scale lines represent one participant; the red lines represent the means for the group.

These three children typified the general positive development for the Multi No Finn group in number sequence production (see Figure 6). While the Multi Finn group was fairly stable from pretest to posttest, they already had relatively high scores in the pretest and were able to develop their number sequence production skills during the rehearsal phase, as can be seen from the delayed posttest mean score.

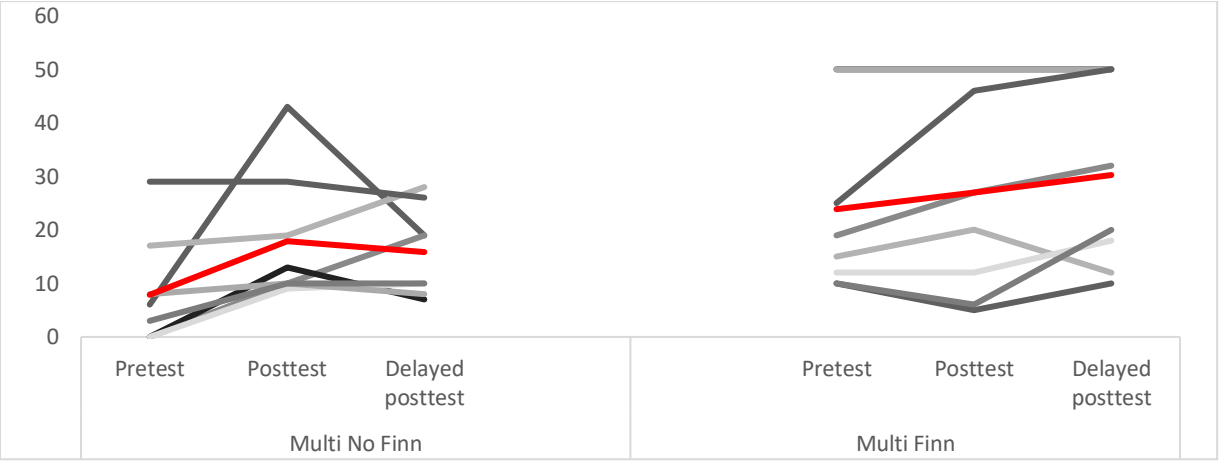

Figure 6. Proportion of pre-, post- and delayed posttest number sequence production scores by the multilingual group. Gray scale lines represent one participant; red lines represent the means for the group.

Even though children's vocabulary scores did not develop significantly during the follow-up period, the Multi No Finn group appeared to develop their story comprehension skills, which was the other language-related measure in this study (see Figure 7). All children in the No Finn Group were able to show positive development from pretest to delayed posttest, whereas the mean of the Multi Finn group remained fairly stable during the follow-up period. However, there still appeared to be a great deal of variation in individual children's development of story comprehension skills.

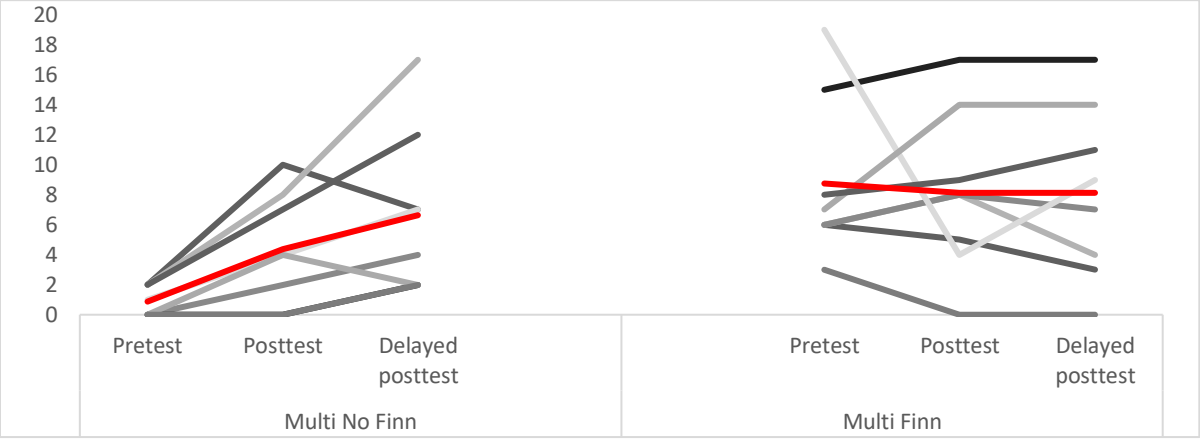

Figure 7. Proportion of pre-, post- and delayed posttest story comprehension scores by the multilingual group. Gray scale lines represent one participant; red lines represent the means for the group.

Discussion

The Count How Many intervention has previously been shown to be effective in promoting early numerical and oral language skills in monolingual children (Hannula-Sormunen et al., 2020). The present study aimed to examine the effects of the intervention on multilingual children using previously unanalyzed data from this intervention study. Results show similar development of mathematical skills and oral language skills in the multilingual group in comparison to matched monolingual groups of children. This indicates that it may be possible to support multilingual children's early numeracy skills through early numeracy training similar to

monolingual children. In line with the findings from Sarama et al. (2012), we found no evidence that early math training would negatively affect children's language skills.

To provide more in-depth information about the multilingual children's development during the intervention period, we further divided the group into those who do not have Finnish as one of their home languages (Multi No Finn group) and children who speak Finnish and some other language(s) at home (Multi Finn group). The Multi No Finn group showed a similar skill level as the Multi Finn group and the monolingual control groups on a measure of SFON at the pretest, whereas the Multi No Finn group's scores on the give-a-number task were lower than those of the Multi Finn group. One possible explanation for this is that the children were able to perform the SFON task using completely non-verbal actions, whereas in the give-a-number and number sequence production tasks, verbal comprehension of number words was required. This finding is consistent with that of Bonifacci and colleagues (Bonifacci et al., 2016) who stated that the difference between multilingual and monolingual children is clearest in the numeracy tasks with a verbal component, suggesting that "linguistic weaknesses may lead to poorer performance with numeracy but not to impaired numerical abilities" (p.12).

For the children with the lowest vocabulary pretest level, the give-a-number task seemed to be too challenging due to the floor effect at every measurement point. However, in the number sequence production, these children showed great positive development. They were able to count to 10 in the posttest or delayed posttest, even though their pretest vocabulary level and number sequence production level was close to 0. This result seems to suggest that learning number words could be something to begin with when children with low language proficiency enter daycare. It might provide them with positive learning experiences, opportunities to actively participate in the mathematical activities, and practice with mathematical discourse (see

Moschkovich, 2015). Overall, these results indicate that SFON tendency, cardinality-related, and story comprehension skills of those multilingual children in the CHM intervention developed at a similar rate as monolingual children in the intervention.

Limitations

Our intervention and control groups were pairwise matched in their pretest cardinality skills and SFON, but the small sample size and great variability reduced the chances of detecting statistically significant results in group comparisons. Thus, these results need to be taken cautiously and replicated with larger samples, taking into account also the variability at the group level. Yet, considering the small number of studies in the field, we consider that this study opens fruitful and novel avenues of research on multilingual children's early numeracy development. In addition, our multilingual group was rather heterogeneous in the languages they spoke at home, as well as in their Finnish skills. Even though this diversity may have influenced the effects of the intervention, this naturalistic nature of the sample was a good representation of the diversity of children's language skills in today's daycare centers. Thus, it increases generalizability of the results.

In this study a child was categorized as multilingual if the parents reported that they did not speak Finnish at home or if they spoke Finnish and some other language(s) at home. This method is limited in its capability of differentiating broader linguistic or cultural aspects of the family.

Future research

Even though promising results have been established in how early mathematical interventions develop not only monolingual but also multilingual children's skills before school age (Doabler et al., 2019; Foster et al., 2018; Hassinger-Das, Jordan, & Dyson, 2015; Pasnak,

Savage Greene, Ferguson, & Levit, 2006; Sarama et al., 2012; Wang & Woodworth, 2011), the academic success among multilingual children in school is less than that of their monolingual peers (NCES, 2017; OECD, 2016; Ukkola & Metsämuuronen, 2019). There is a need for research-based practices and pedagogical tools for early educators to support multilingual children and to provide an equal starting point for their future school paths.

The CHM intervention and the assessments were originally planned to be implemented with monolingual children. In future studies, it would be good to supplement vocabulary and comprehension measures with tests that are more sensitive in measuring language learners' linguistic skills. In addition, it would be interesting to include measures in the native language of each child, both in numerical and linguistic skills. Nevertheless, as can be seen from the results, at least the CHM intervention had similar effects on multilingual and monolingual children's early numeracy and language-related skills. However, the lack of significant effects in comparison to monolingual children in the comparison condition suggest that some of the activities and assessments could be improved in order to take into account language diversity.

Even though the CHM intervention appears to hold promise as being beneficial to multilingual children's numeracy skills, we see that there are possibilities to improve the intervention. Especially professional development training could be improved to better inform the early educators (a) how research-based methods in the activities can also support multilingual children, (b) how early numeracy training does no harm to multilingual children's language skills and (c) how numeracy training with small numbers and regular opportunities to actively participate in the mathematical discussions could be something to begin with the children who do not speak the daycare's instructional language at home.

Conclusions

This study is the first empirical investigation of enhancing SFON and cardinality-related skills in multilingual children through the use of an early numeracy intervention in daycare. The most important implication of this study is that it shows the possibility of enhancing SFON tendency and cardinality-related skills in multilingual children before school age.

The Count How Many program uses playful, hands-on activities with minor verbal language requirements to support early numeracy skills. The evidence from this study suggests that enhancing and practicing the noticing and recognition of exact numerosities might be a useful pedagogical tool when multilingual children are entering daycare, especially with the children who do not speak the daycare's instructional language at home. In addition to learning early math, the program may function as a tool to engage multilingual children in daycare groups by providing opportunities to participate and gain positive learning experiences, even with a limited vocabulary.

References

Arvola, O., Lastikka, A.-L., & Reunamo, J. (2017). Increasing Immigrant Children's Participation in the Finnish Early Childhood Education Context. *The European Journal of Social & Behavioural Sciences*, *20*(3), 2538–2548. https://doi.org/10.15405/ejsbs.223

Benoit, L., Lehalle, H., & Jouen, F. (2004). Do young children acquire number words through subitizing or counting? *Cognitive Development*, *19*(3), 291–307. https://doi.org/10.1016/j.cogdev.2004.03.005

Bermejo, V. (1996). Cardinality development and counting. *Developmental Psychology*, *32*(2), 263–268. https://doi.org/10.1037/0012-1649.32.2.263

Bermejo, V., Morales, S., & deOsuna, J. G. (2004). Supporting Children's Development of Cardinality Understanding. *Learning and Instruction*, *14*(4), 381–398.

Bonifacci, P., Tobia, V., Bernabini, L., & Marzocchi, G. M. (2016). Early Literacy and Numeracy Skills in Bilingual Minority Children: Toward a Relative Independence of Linguistic and Numerical Processing. *Frontiers in Psychology*, *7*, 1020. https://doi.org/10.3389/fpsyg.2016.01020

Clements, D. (1999). Subitizing: What is it? Why teach it? *Teaching Children Mathematics*, *5*, 400–405.

Clements, D., & Sarama, J. (2007). Effects of a Preschool Mathematics Curriculum: Summative Research on the "Building Blocks" Project. *Journal for Research in Mathematics Education*, *38*(2), 136–163.

Clements, D., & Sarama, J. (2018). Myths of early math. *Education Sciences*, *8*(2). https://doi.org/10.3390/educsci8020071

Clements, D., Sarama, J., Kutaka, T., & Banse, H. (2018). *Supporting Dual Language Learners*

(DLLs) and English Learners (ELs) in Early Math. Retrieved from https://learningtrajectories.org/documents/1571674858177.pdf

Cross, C. T., Woods, T. A., & Schweingruber, H. (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity*. National Academies Press.

Doabler, C. T., Clarke, B., Kosty, D., Smolkowski, K., Kurtz-Nelson, E., Fien, H., & Baker, S. K. (2019). Building number sense among English learners: A multisite randomized controlled trial of a Tier 2 kindergarten mathematics intervention. *Early Childhood Research Quarterly*, *47*, 432–444. https://doi.org/10.1016/J.ECRESQ.2018.08.004

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., … American Psychological Association DC., W. (2007). School Readiness and Later Achievement. *Developmental Psychology*, *43*(6), 1428–1446.

Dyson, N., Jordan, N. C., Beliakoff, A., & Hassinger-Das, B. (2015). A Kindergarten Number-Sense Intervention With Contrasting Practice Conditions for Low-Achieving Children. *Journal for Research in Mathematics Education*, *46*(3), 331–370. https://doi.org/10.5951/jresematheduc.46.3.0331

Edens, K. M., & Potter, E. F. (2013). An Exploratory Look at the Relationships Among Math Skills, Motivational Factors and Activity Choice. *Early Childhood Education Journal*, *41*(3), 235–243. https://doi.org/10.1007/s10643-012-0540-y

Education Finland. (2018). Early childhood education and care. Retrieved from: https://www.educationfinland.fi/what-we-offer/early-childhood-education-and-care

Finnish National Agency for Education. (2020). National core curriculum for ECEC in a nutshell. Retrieved from: https://www.oph.fi/en/education-and-qualifications/national-core-curriculum-ecec-nutshell

Foster, M. E., Anthony, J. L., Clements, D., Sarama, J., & Williams, J. J. (2018). Hispanic dual language learning kindergarten students' response to a numeracy intervention: A randomized control trial. *Early Childhood Research Quarterly*, *43*, 83–95.

Fuson, K. (1988). *Children's counting and concepts of number.* Retrieved from https://psycnet.apa.org/record/1987-98811-000

Fuson, K. (1991). Children's early counting: Saying the number-word sequence, counting objects, and understanding cardinality. In K. Durkin & B. Shire (Eds.), *Language and mathematical education* (pp. 27–39). Milton Keynes, GB: Open University Press.

Fuson, K., Clements, D., & Sarama, J. (2015). Making early math education work for all children. *Phi Delta Kappan*, *97*(3), 63–68. https://doi.org/10.1177/0031721715614831

Geary, D. C., & van Marle, K. (2016). Young children's core symbolic and nonsymbolic quantitative knowledge in the prediction of later mathematics achievement. *Developmental Psychology*, *52*(12), 2130–2144. https://doi.org/10.1037/dev0000214

Gelman, R., & Gallistel, C. R. (1978). *The child's understanding of number*. Cambridge, MA: Harvard University Press.

Grosjean, F. (2010). *Bilingual: Life and reality.* Harvard University Press. https://doi.org/https://doi.org/10.4159/9780674056459

Grosjean, F. (2013). Bilingualism: A Short Introduction. In F. Grosjean & P. Li (Eds.), *The Psycholinguistics of Bilingualism* (pp. 5–25). New York: Wiley-Blackwell.

Hannula-Sormunen, M. (2015). Spontaneous focusing on numerosity and its relation to counting and arithmetic. In A. Dowker & R. Cohen Kadosh (Ed.), *The Oxford handbook of numerical cognition* (pp. 275–290). Oxford, UK: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199642342.013.018

Hannula-Sormunen, M., Nanu, C., Luomaniemi, K., Heinonen, M., Sorariutta, A., Södervik, I., &

Mattinen, A. (2020). Promoting spontaneous focusing on numerosity and cardinality-related skills at day care with one, two, how many and count, how many programs. *Mathematical Thinking and Learning*, 1–20. https://doi.org/10.1080/10986065.2020.1818470

Hannula, M. (2005). *Spontaneous focusing on numerosity in the development of early mathematical skills*. (Doctoral dissertation). University of Turku, Finland, Painosalama.

Hannula, M., & Lehtinen, E. (2005). Spontaneous focusing on numerosity and mathematical skills of young children. *Learning and Instruction*, *15*(3), 237–256. https://doi.org/10.1016/j.learninstruc.2005.04.005

Hannula, M., Lepola, J., & Lehtinen, E. (2010). Spontaneous focusing on numerosity as a domain-specific predictor of arithmetical skills. *Journal of Experimental Child Psychology*, *107*(4), 394–406. https://doi.org/10.1016/j.jecp.2010.06.004

Hannula, M., Mattinen, A., & Lehtinen, E. (2005). Does social interaction influence 3-year-old children's tendency to focus on numerosity? A quasi-experimental study in day care. In M. L. Verschaffel, E. De Corte, G.Kanselaar, & Valcke (Ed.), *Powerful environments for promoting deep conceptual and strategic learning* (pp. 63–80). Leuven: Leuven University Press.

Hannula, M., Räsänen, P., & Lehtinen, E. (2007). Development of Counting Skills: Role of Spontaneous Focusing on Numerosity and Subitizing-Based Enumeration. *Mathematical Thinking and Learning*, *9*(1), 51–57. https://doi.org/10.1080/10986060709336605

Harju-Luukkainen, H., & Mcelvany, N. (2018). Immigrant Student Achievement and Education Policy in Finland. In & O. B. L. Volante, D. Klinger (Ed.), *Immigrant Student Achievement and Education Policy: Cross-Cultural Approaches* (pp. 87–102). Springer. https://doi.org/10.1007/978-3-319-74063-8_6

Hassinger-Das, B., Jordan, N. C., & Dyson, N. (2015). Reading Stories to Learn Math: Mathematics Vocabulary Instruction for Children with Early Numeracy Difficulties. *Elementary School Journal*, *116*(2), 242–264.

Institute of Medicine and National Research Council. (2015). *Transforming the Workforce for Children Birth Through Age 8: A Unifying Foundation : Health and Medicine Division*. Retrieved from http://www.nationalacademies.org/hmd/Reports/2015/Birth-To-Eight.aspx

Korkman, M., Kirk, U., & Kemp, S. (2008). *NEPSY II: Lasten neuropsykologinen tutkimus [NEPSY-II: A developmental neuropsychological assessment] (2nd ed.)*. Helsinki: Psykologien Kustannus Oy.

Krajewski, K., & Schneider, W. (2009). Early development of quantity to number-word linkage as a precursor of mathematical school achievement and mathematical difficulties: Findings from a four-year longitudinal study. *Learning and Instruction*, *19*(6), 513–526. https://doi.org/10.1016/j.learninstruc.2008.10.002

Le Corre, M., Li, P., Huang, B. H., Jia, G., & Carey, S. (2016). Numerical morphology supports early number word learning: Evidence from a comparison of young Mandarin and English learners. *Cognitive Psychology*, *88*, 162–186. https://doi.org/10.1016/j.cogpsych.2016.06.003

Le Corre, M., Van de Walle, G., Brannon, E. M., & Carey, S. (2006). Re-visiting the competence/performance debate in the acquisition of the counting principles. *Cognitive Psychology*, *52*(2), 130–169. https://doi.org/10.1016/j.cogpsych.2005.07.002

McCabe, A., Bornstein, M. H., Guerra, A. W., Kuchirko, Y., Páez, M., Tamis-LeMonda, C. S., … Mendelsohn, A. (2013). Multilingual Children: Beyond Myths and Toward Best Practices and commentaries. *Social Policy Report*, *27*(4), 1–37. https://doi.org/10.1002/j.2379-

3988.2013.tb00077.x

McMullen, J., Chan, J. Y.-C., Mazzocco, M. M. M., & Hannula-Sormunen, M. (2019). Spontaneous Mathematical Focusing Tendencies in Mathematical Development and Education. In Norton A & Alibali M (Eds.), *Constructing number. Research in Mathematics Education.* (pp. 69–86). Springer International Publishing. https://doi.org/10.1007/978-3-030-00491-0_4

Mix, K. S., Sandhofer, C. M., Moore, J. A., & Russell, C. (2012). Acquisition of the cardinal word principle: The role of input. *Early Childhood Research Quarterly*, *27*(2), 274–283. https://doi.org/10.1016/j.ecresq.2011.10.003

Moschkovich, J. N. (2015). Academic literacy in mathematics for English Learners. *Journal of Mathematical Behavior*, *40*, 43–62. https://doi.org/10.1016/j.jmathb.2015.01.005

NCES. (2017). *NAEP Mathematics: National Student Group Scores and Score Gaps. Washington, DC: NCES.* Retrieved from https://www.nationsreportcard.gov/math_2017/nation/gaps?grade=4

NMAP. (2008). Foundations for Success: The Final Report of the National Mathematics Advisory Panel. In *US Department of Education*. Washington DC: U.S. Department of Education.

OECD. (2016). *Immigrant background, student performance and students' attitudes towards science, in PISA 2015 Results (Volume I): Excellence and Equity in Education, OECD Publishing, Paris.* https://doi.org/10.1787/9789264266490-11-en

Pasnak, R., Savage Greene, M., Ferguson, E., & Levit, K. (2006). Applying Principles of Development to Help At-Risk Preschoolers Develop Numeracy. *The Journal of Psychology*, *140*(2), 155–173.

Pelliccioni, S. (2015). *Onni-poika*. Helsinki: Etana Editions.

Phillips, D. A., & Meloy, M. E. (2012). High-Quality School-Based Pre-K Can Boost Early Learning for Children with Special Needs. *Exceptional Children*, *78*(4), 471–490.

Purpura, D. J., & Napoli, A. R. (2015). Early Numeracy and Literacy: Untangling the Relation Between Specific Components. *Mathematical Thinking and Learning*, *17*(2–3), 197–218. https://doi.org/10.1080/10986065.2015.1016817

Rathé, S., Torbeyns, J., Hannula-Sormunen, M., Smedt, B. De, & Verschaffel, L. (2016). Spontaneous focusing on numerosity: A review of recent research. *Mediterranean Journal for Research in Mathematics Education*, *15*, 1–25.

Richards-Tutor, C., Baker, D. L., Gersten, R., Baker, S. K., & Smith, J. M. (2016). The Effectiveness of Reading Interventions for English Learners. *Exceptional Children*, *82*(2), 144–169. https://doi.org/10.1177/0014402915585483

Sarama, J., Lange, A. A., Clements, D., & Wolfe, C. B. (2012). The impacts of an early mathematics curriculum on oral language and literacy. *Early Childhood Research Quarterly*, *27*(3), 489–502. https://doi.org/10.1016/j.ecresq.2011.12.002

Sarnecka, B. W., Goldman, M. C., & Slusser, E. B. (2015). How counting leads to children's first representations of exact, large numbers. In R. Cohen Kadosh & A. Dowker (Eds.), The Oxford Handbook of Numerical Cognition, 291–309. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199642342.013.011

Trick, L. M., Enns, J. T., & Brodeur, D. A. (1996). Life span changes in visual enumeration: The number discrimination task. *Developmental Psychology*, *32*(5), 925–932. https://doi.org/10.1037/0012-1649.32.5.925

Ukkola, A., & Metsämuuronen, J. (2019). *Alkumittaus – Matematiikan ja äidinkielen ja*

kirjallisuuden osaaminen ensimmäisen luokan alussa. Retrieved from https://karvi.fi/app/uploads/2019/07/KARVI_1719.pdf

Wang, H., & Woodworth, K. (2011). *Evaluation of Rocketship Education's Use of DreamBox Learning's Online Mathematics Program*. Retrieved from http://www.dreambox.com/wp-content/uploads/downloads/pdf/DreamBox_Results_from_SRI_Rocketship_Evaluation.pdf

Wechsler, D. (2009). *WPPSI-III - Wechsler Preschool And Primary Scale Of Intelligence - Third Edition*. Helsinki: Psykologien Kustannus Oy.

Whitehurst, G. J., Falco, F. L., Lonigan, C. J., Fischel, J. E., DeBaryshe, B. D., Valdez-Menchaca, M. C., & Caulfield, M. (1988). Accelerating Language Development Through Picture Book Reading. *Developmental Psychology*, *24*(4), 552–559. https://doi.org/10.1037/0012-1649.24.4.552

Wynn, K. (1990). Children's understanding of counting. *Cognition*, *36*(2), 155–193. https://doi.org/10.1016/0010-0277(90)90003-3

Xue, Y., Atkins-Burnett, S., & Moiduddin, E. (2012). *Informing the Perfomance-Based Contract Between First 5 LA and LAUP: Child Progress in the 2011−2012 Program Year: Final Report.* Washington, DC: Mathematica Policy Research.

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