Chapter 5
Ecuadorian Kindergartners' Spontaneous Focusing on Numerosity Development: Contribution of Numerical Abilities and Quality of Mathematics Education

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Abstract Young children's spontaneous focusing on numerosity (SFON) predicts their later mathematical competencies. In this study we investigated the development of SFON in Ecuadorian kindergartners as well as the contribution of early numerical abilities and the quality of mathematics education to this development. The participants were 100 kindergartners drawn from 10 classrooms. Children received two SFON tasks, one at the beginning and one at the end of the school year, and an early numerical abilities achievement test at the beginning of the school year. The quality of mathematics education was assessed twice via the COEMET instrument. Results demonstrated limited SFON development during the kindergarten year, with large individual differences in and highly consistent SFON performances. Additionally, children's SFON development during the kindergarten year was predicted by their SFON tendency and early numerical abilities at the start

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I. Elia et al. (eds.), *Contemporary Research and Perspectives on Early Childhood Mathematics Education*, ICME-13 Monographs,
https://doi.org/10.1007/978-3-319-73432-3_5

of the year. The quality of mathematics education did not contribute to children's SFON development. The scientific and practical implications of these results are discussed.

Keywords SFON · Early numerical abilities · Quality of math education
Kindergarten

5.1 Introduction

Worldwide, scholars agree that early numerical competence is an important predictor of later mathematics achievement and of children's future professional career and life success. However, while most authors focus on children's early numerical *abilities* (i.e., their early numerical knowledge and skills; e.g., the ability to count, the ability to compare numerical magnitudes, the ability to decompose numbers, or the ability to approximate or estimate numerosities) (Andrews and Sayers 2015; De Smedt et al. 2009; Duncan et al. 2007; Geary 2011; Jordan et al. 2009), an increasing number of others is focusing on children's early numerical *dispositions* (e.g., the inclination to make sense of numerical situations, or the inclination to spontaneously focus on the numerical characteristics of daily-life situations) (Bojorque et al. 2016; Hannula and Lehtinen 2005; Mulligan et al. in press). This increasing interest into the dispositional side of numerical competence is in line with Perkins et al.'s (2000) definition of general thinking competence as consisting of abilities (e.g., the ability to consider hidden options, to search for evidence, to relate new information to old one) and dispositions (e.g., the inclination to be curious, to be open-minded, to pay attention to evidence). So, throughout this chapter, the following three different terms are used along the same lines: (a) *early numerical abilities*, to refer to children's early numerical knowledge and skills only; (b) *spontaneous focusing on numerosity* (*SFON*), to refer to children's early disposition to attend to numerosities only; and (c) *early numerical competencies*, to refer to both children's early numerical abilities and their SFON.

Given the growing number of studies providing empirical evidence on the importance of children's early numerical competencies for their further mathematical development (Aunio and Niemivirta 2010; De Smedt et al. 2009; Duncan et al. 2007; Geary 2011; Hannula-Sormunen et al. 2015; Jordan et al. 2009), it is surprising that empirical information on the development of early numerical competencies in Ecuadorian preschoolers and kindergartners is extremely scarce. However, studies with older Ecuadorian elementary and secondary school students indicate that they poorly perform in both national (Ministerio de Educación 2012) and international (UNESCO 2015) assessments in the domain of mathematics. Against this background, we aimed at investigating the development of Ecuadorian kindergartners' SFON during the kindergarten year, with special attention for the contribution of early numerical abilities and the quality of early mathematics education to this development. In the following, we first discuss prior research on

SFON and the relation between SFON and early numerical abilities. We next focus on the associations between the quality of mathematics education and children's mathematical development, and more specifically SFON. We end with our major research goals and questions.

5.1.1 Spontaneous Focusing on Numerosity

SFON refers to a process of spontaneously (i.e., in a voluntary way not prompted by others) focusing attention to the exact number of a set of items or incidents in daily life (e.g., noticing that there are two cats on the roof or that there are three cookies on the plate) when exact numerosity is utilized in action (Hannula and Lehtinen 2005; Hannula et al. 2007). According to Hannula and Lehtinen (2005), this attentional process is needed for eliciting exact number recognition and for using the recognized exact number in action because exact number recognition is not a totally automatic process that would occur every time a child is confronted with something to enumerate. SFON tendency is considered an indicator of the amount of a child's unguided or spontaneous practice in using exact enumeration in natural situations that are not explicitly numerical (Hannula and Lehtinen 2005) and differs from more general attention processes, enumeration skills or perceptual skills. Previous SFON studies revealed large inter-individual differences in young children's SFON tendency (Hannula and Lehtinen 2005; Hannula et al. 2005, 2007, 2010). According to Hannula and Lehtinen (2005), these individual differences are not due to children's lack of enumeration skills since SFON tasks involve only numbers within the children's enumeration capacity. These authors found that, although young children already possess some enumeration skills that enable them to count collections of up to three items, some children do not spontaneously focus on the aspect of number when confronted with novel, not explicitly numerical, tasks that involve such small collections. Furthermore, these authors showed that there is within-subject stability in children's SFON tendency across different task contexts and years of time. For instance, Hannula-Sormunen et al. (2015) reported stability in SFON tendency from the age of six to the age of 12 years.

Children's SFON has been measured with different tasks. The most commonly used SFON tasks for children aged five (e.g., Hannula and Lehtinen 2005) are the Parrot Imitation task and the Mailbox Imitation task. Both tasks involve small quantities (i.e., up to three) and are introduced to the child as new pretend-play situations. The materials involved in the Parrot Imitation task are glass berries and a toy parrot. On each of four trials the experimenter introduces a given number of berries into the parrot's beak and then asks the child "to do exactly the same". In the Mailbox Imitation task, the experimenter posts some letters into a toy mailbox and then asks the child to do the same. The aim of these tasks is to obtain a reliable indicator of a child self-initiated focus on exact numerosity. Therefore, when presenting the task, the experimenter should not use any phrase that can suggest that the task is numerical or quantitative in nature (Hannula and Lehtinen 2005; Hannula et al. 2007).

Using different versions of these SFON tasks, Hannula and colleagues demonstrated that preschoolers' individual differences in SFON predicted both their concurrent early numerical abilities (Hannula et al. 2007) and their later school mathematics achievement (Hannula et al. 2010). Accordingly, findings of previous SFON studies reported a unique contribution of children's SFON to the development of their early numerical abilities, including subitizing-based enumeration, object counting, cardinality recognition, number sequence, and arithmetic competencies (Edens and Potter 2013; Hannula and Lehtinen 2005; Hannula et al. 2010, 2007; see Hannula-Sormunen 2015; Rathé et al. 2016). Furthermore, SFON tendency in kindergarten was demonstrated to be a significant, domain-specific predictor of arithmetical skills assessed at the end of grade 2 (Hannula et al. 2010). Kindergartners' SFON tendency also predicted their mathematical performance in grade 5 (Hannula-Sormunen et al. 2015), and it was even positively related to the development of numerical competencies up to the end of primary school (Hannula-Sormunen 2015). Regarding the mechanisms underlying the reported predictive relation between SFON and later mathematical performance, as summarized in Rathé et al. (2016), some authors have argued that children's cognitive factors such as their working memory, inhibition, language, and symbolic fluency play an important role in early mathematical development and thus also may be influencing the relationship between SFON and mathematical performance. Other authors explain this relation based on environmental factors such as children's spontaneous self-initiated practice in exact number recognition in daily situations. Finally, as reported in the next section, young children's SFON tendency can be enhanced through guided focusing activities (e.g., Hannula et al. 2005).

5.1.2 Quality of Early Mathematics Education

Studies that evaluate the quality of mathematics education are becoming increasingly important, as early numerical competencies predict later academic achievement (Kilday and Kinzie 2009). To the best of our knowledge, only one study previously addressed the influence of early mathematics education on the development of SFON. In a quasi-experimental study of Hannula et al. (2005), the personnel of a day care center was guided to create rich learning experiences with a view to intentionally direct three-year old children's attention towards variations in small numbers of objects or incidents in everyday situations and in structured games. An example of activities embedded in everyday situations is guiding the children to pay attention to (a small number of) slides of bread during lunchtime; an example of structured games is a board with removable animals that were changed in numerosity during the morning in the context of a singing game and then again secretly along the day. The authors found that children in the experimental group increased not only their SFON but also their counting skills compared to children in the control group. These findings suggest that it is important to give a central place to this feature of children's early numerical development in mathematics education at school, as SFON enhancement is possible and might help to prevent and overcome learning difficulties in mathematics (Hannula-Sormunen 2015).

More generally, the quality of mathematics education is shown to significantly influence students' school achievements (Hiebert and Grouws 2007), already at the kindergarten level (Fuson 2004). Children who attend high-quality pre-school programs make more substantial gains in their mathematical competencies than their peers who do not attend these programs (Sarama and Clements 2009a; Fuson 2004; Griffin 2004). Clements et al. (2013) found that low-SES children who participated in a high-quality, research-based mathematics intervention program from pre-school to grade 1, developed stronger early numerical competencies than their peers who did not participate in that program. It is important that these findings on the association between the quality of mathematics education and children's mathematical development are extended to other settings, and more specifically to children's acquisition of SFON.

5.1.3 The Ecuadorian Context

In Ecuador, the Ministry of Education is responsible for the organization of primary and secondary education. The Ecuadorian educational system comprises three levels, i.e., (1) Beginning level, involving pre-school, and intended for children up to four years; (2) Basic education, from grade 1 up to grade 10; with grade 1 referring to kindergarten; basic education is intended for students aged five to 14 years; and (3) High school, or the last three years of schooling, for students aged 15–17 years. Education is compulsory for all students in primary and secondary education (i.e., basic education and high school) but not for pre-school children (i.e., beginning level). Around 73% of Ecuadorian children attend public schools (39% attend public urban schools; 34% attend public rural schools), 21% attend private schools; the remaining 6% of the children attend municipal schools or schools financially assisted by both government and private sources (Ministerio de Educación 2013).

Kindergarten education is aimed for children aged five years. After one year of kindergarten, children are promoted to the first year of basic elementary school (for children aged six years). Kindergarten education is regulated by a mandatory national curriculum that prescribes the minimum requirements that students should master by the end of the school year. At this level, children attend school five days per week from 7:30 till 12:30.

5.2 The Present Study

All previous studies on the development of SFON have been conducted in developed countries, mainly in Finland, and thus it is not possible to generalize previous findings on children's SFON development to other, less developed countries such as Ecuador (United Nations 2016) that differs in its cultural and educational characteristics from Finland. Given the influence of SFON to young children's concurrent and later mathematical achievement, and the problematic poor performance of Ecuadorian children in the area of mathematics compared to their international peers (UNESCO 2015), our first goal was to examine Ecuadorian five to six-year olds' SFON development throughout the kindergarten year, focusing on both individual differences and stability in children's SFON development. Our second goal was analyzing the relationship between kindergartners' SFON development and their early numerical abilities. Finally, to complement current findings on the contribution of the quality of mathematics education to young children's SFON development, our third goal was to explore whether the quality of mathematics education Ecuadorian kindergartners receive at school is associated to the development of their SFON tendency.

Consistent with our three goals, we addressed three research questions:

(1) Does Ecuadorian kindergartners' SFON develop between the start and the end of the kindergarten year?
(2) Do Ecuadorian kindergartners' early numerical abilities at the start of the school year contribute to their SFON tendency at the end of the kindergarten year?
(3) Does the quality of early mathematics education in the Ecuadorian kindergarten contribute to Ecuadorian kindergartners' SFON tendency at the end of the kindergarten year?

5.3 Method

5.3.1 Participants

Participants were 100 kindergartners, with an average age of 5 years 3 months (SD = 3.7 months) at the start of the study. About 10 children were randomly selected from a convenient sample of 10 different schools of the three major school types in Ecuador (public urban, public rural, private). These schools were selected in view of their willingness to participate in the project. The inclusion of different school types was considered important in order to guarantee the representativeness of the sample. Table 5.1 shows the composition of the sample.

Table 5.1 Number of children and schools per school type

School type	Number of schools	Children			Mean age (SD)
		Boys	Girls	Total	
Public urban	3	14	15	29	5y 1 m (4.1)
Public rural	3	15	17	32	5y 3 m (3.2)
Private	4	23	16	39	5y 4 m (3.3)
Total	10	52	48	100	5y 3 m (3.7)

5.3.2 Measures and Procedure

Child measures *SFON Imitation tasks* (Hannula and Lehtinen 2005). Children's SFON tendency was measured using the Spanish version of two SFON Imitation tasks, namely, the Parrot Imitation task (Test 1) at the start of the school year and the Mailbox Imitation task (Test 2) at the end of the school year. We used these two SFON Imitation tasks given that they both were designed to capture young children' spontaneous attention for exact numerosity in non-mathematically focused situations and that they both are characterized by exactly the same task requirements and procedures, except from the concrete materials used and the overall context. These two SFON tasks were used in prior SFON studies with children aged four to six years (e.g., Hannula and Lehtinen 2005).

(1) The Parrot Imitation task consists of a toy parrot capable of swallowing different-colored small glass berries. The examiner starts the task by placing a case of eight red glass berries on the left, and a case of eight blue glass berries on the right, in front of the parrot, and by introducing the materials saying: "This is Elsi bird, she likes berries. Here are red berries and here are blue berries (pointing to the cases). Now, look carefully, what I do, and then you do exactly like I did". In the first trial the examiner puts two red berries and one blue berry into the parrot's beak, one at a time, and they drop into the parrot's stomach, making a bumping sound. Then the child is told: "Now you do exactly like I did". The number of berries in the second item is three green and two yellow; in the third item, two white and three brown; and in the fourth item, one transparent and two light-blue.
(2) The Mailbox Imitation task, consists of a mailbox to post different-colored envelopes. For the first trial, a pile of eight red envelopes is placed on the left, and a pile of eight blue envelopes is placed on the right, in front of the mailbox. The examiner starts with the task by saying: "This is a mailbox, and here are red envelopes and here are blue envelopes (pointing to the piles of envelopes). Now, please look carefully what I do, and then you do exactly like I did". The examiner puts two red envelopes and one blue envelop into the mailbox. Then s/he says to the child: "Now you do exactly like I did". For the second item, the examiner puts three green and two yellow envelopes, for the third item, two white and three brown envelopes, and for the last item, one orange and two light blue envelopes.

Each of the SFON tasks was administered in accordance with the procedure of Hannula and Lehtinen (2005). The examiner made sure that the child's attention was fully on the task while the trial was performed. She avoided the use of any phrases or other contextual hints that could have suggested that the task was somehow quantitative. The tasks included only very small numbers of items (i.e., 1–3). The child received a score of 1 if s/he responded by putting in the correct exact number of berries/envelopes and/or if s/he was observed doing any quantifying acts. By contrast, in each trial, the child received a score of 0 if s/he did not respond by putting in the correct exact number of berries/envelopes and did not present any quantifying act. Each child received a total score out of four. Both tests were administered individually and were checked for the quality of the task administration on the basis of the video recordings. Cohen's Kappa inter-rater reliability (on 10% of the data) of SFON scores was $K = 0.96$, $p < 0.001$ at Test 1; at Test 2, we obtained a perfect match.

Test of Early Number and Arithmetic (TENA) (Bojorque et al. 2015). Children's early numerical abilities at the start of the school year were measured using the TENA. The TENA is the only reliable and valid test available in Ecuador for assessing Ecuadorian kindergarten's early numerical abilities. This test was developed based on the Ecuadorian National Standards for kindergarten number and arithmetic. It consists of 54 items distributed among nine subscales (with six items per subscale), namely (a) quantifiers, (b) one-to-one correspondence, (c) order relations more than/less than, (d) counting, (e) quantity identification and association with numerals, (f) ordering, (g) reading and writing numerals, (h) addition, and (i) subtraction. The test is organized in two parts: an individual part with 29 items and a collective part with 25 items. Items are scored dichotomously: for each item, a score of 1 is assigned for a correct answer and a score of 0 for an incorrect answer (maximum score = 54). Cohen's Kappa (on 10% of the data) for the TENA scores revealed strong inter-rater reliability, $K = 0.92$, $p < 0.001$.

Classroom measures

Classroom Observation of Early Mathematics Environment and Teaching (COEMET; Sarama and Clements 2009b). The quality of mathematics education in children's classrooms was evaluated twice via the COEMET. We used this instrument for two reasons. First, the absence of valid observation instruments to assess the quality of early mathematics education in Ecuador. Second, the COEMET is the only evaluation instrument that focuses on the quality of *early mathematics* education without being linked to any specific curriculum (Kilday and Kinzie 2009). The COEMET was developed on the basis of research about the characteristics and teaching strategies of effective teachers in early childhood mathematics. The COEMET is a half-day administration instrument, specifically designed to assess the quality of mathematics education in early education settings by means of determining teaching strategies, mathematics content, clarity and correctness of mathematics teaching, and quality of student/teacher interactions. It has 28 items addressing the quality of the Classroom Culture (CC) (nine items) and the Specific Mathematical Activities (SMA) (19 items) on a five-point Likert scale (ranging from "strongly disagree" to "strongly agree"). Dimensions of the CC section are (a) environment and interactions and (b) teacher's personal attributes. An example of a CC item is: "The environment showed signs of mathematics: Materials for mathematics, including specific math manipulatives, were available and mathematics was enacted and/or discussed around them". With respect to the SMA, the COEMET distinguishes among seven dimensions, namely (a) mathematical focus, (b) organization, teaching approaches, interactions, (c) expectations, (d) eliciting children's solution methods, (e) supporting children's conceptual understanding, (f) extending children's mathematical thinking, and (g) assessment and instructional adjustment. An example of a SMA item is: "The teacher began by engaging and focusing children's mathematical thinking (i.e., directed children's attention to, or invited them to consider, a mathematical question, problem, or idea)". At each observation moment, two observers spent a half-day in each classroom from the beginning of the activities until lunch time, including the observation of a mathematics lesson. The observers took field notes and completed the COEMET scoring form after the observation on the basis of both their field notes and the videos of the lessons. The inter-rater reliability (on 10% of the data) of COEMET scores was $K = 0.88$, $p < 0.001$.

5.3.3 Data Analyses

The descriptive and inferential statistical analyses were conducted via IBM SPSS Statistics version 20.0. Due to the small number of schools included in this study, we used a non-parametric test, i.e., Spearman rank-order, to correlate the quality of early mathematics education between the two observations. Given that our SFON data do not follow a normal distribution, we calculated Wilcoxon signed-rank test between SFON scores at the start and the end of the school year to examine children's SFON development. Finally, to take into account the nested structure of our data (i.e., children nested within classrooms), we conducted multilevel analyses using the Mixed Models technique (Hayes 2006) as to analyze the contribution of children's early numerical abilities and the quality of early mathematics education to SFON development.

5.4 Results

We first present the descriptive statistics and analyses of the SFON, TENA, and COEMET scores. Then, we report the results concerning our three research questions.

5.4.1 Descriptive Statistics and Initial Analyses

The descriptive analysis of the data displayed in Table 5.2, first revealed that there were clear individual differences in children's SFON tendency both at the beginning and at the end of the school year. They also indicate a rather low SFON tendency of Ecuadorian children at both measurements. Moreover, only 37% of the kindergartners made progress in their SFON tendency throughout the kindergarten

Table 5.2 Means, standard deviations, and range of SFON, TENA, and COEMET scores

Measure	M	SD	Range
SFON (max. score = 4)			
Test 1	1.24	1.37	0–4
Test 2	1.66	1.61	0–4
TENA (max. score = 54)	25.42	9.30	8–49
COEMET			
Classroom culture (max. score = 45)	17.5	4.55	12–24
Specific math activities (max. score = 95)	41.85	5.56	34–51
Total COEMET (max. score = 140)	59.35	9.75	47.63–74.5

year; 44% of the children did not make any progress, whereas 19% of them decreased in SFON scores from Test 1 to Test 2. Furthermore, the correlation between children's SFON scores at the two measurement points was statistically significant (*Spearman's rho* = 0.40, $p = 0.01$), providing evidence for the consistency of the SFON construct. Second, regarding children's early numerical abilities, children's TENA scores were also low, again with large differences between individual children. Third, with respect to the quality of early mathematics education, it can be deduced from Table 5.2 that the quality of the mathematics education offered to the children tended to be low in the observed classrooms (i.e., only half of the maximum score per subscale as well as for the COEMET as a whole), with rather small differences between the participating classes. Typically, teachers' approach involved mainly whole-class and teacher-centered instruction supported by paper-and-pencil work sheets, with scarce individual teacher-child or child-child interactions, thought-provoking discussions or child-initiated activities. As mentioned above, teachers' classroom activities were observed twice throughout the kindergarten year. We found a highly significant positive correlation (*Spearman's rho* = 0.80, $p = 0.01$) between the COEMET scores on the two observation moments, supporting the stability of the COEMET construct.

5.4.2 Analyses Concerning Our Three Research Questions

To analyze whether Ecuadorian kindergartners' SFON develops between the start and the end of the kindergarten year (research question 1), we conducted a Wilcoxon signed-rank test on children's SFON scores at the start (Test 1) and the end (Test 2) of kindergarten. The results of this analysis indicated that SFON scores were significantly higher at the end of the school year (*Mdn* = 1.50) than at the beginning (*Mdn* = 1.00), $z = -2.415$, $p = 0.02$, meaning that there was development in Ecuadorian kindergartners' SFON tendency throughout the kindergarten year.

To examine whether children's early numerical abilities and the quality of early mathematics education contributed to children's SFON development throughout kindergarten (research questions 2 and 3), we conducted multilevel analyses. We evaluated the adequacy of three models for predicting SFON at Test 2, namely, (a) SFON Test 1 (Model 1); (b) SFON Test 1 and TENA (Model 2); (c) SFON Test 1, TENA, and COEMET (Model 3) (all children from the same class received the same COEMET score).

The outcome of the multilevel analyses presented in Table 5.3 indicates that children's SFON scores at Test 1 significantly and positively predicted their SFON scores at Test 2. Children's initial SFON scores accounted for 17% of the variance in their SFON score at the end of the school year. In addition, children's early numerical abilities accounted for a significant 20% of variance in SFON scores at Test 2 (Model 2), indicating that children's early numerical abilities at the beginning of the school year predict their SFON tendency at the end of the school year even when children's SFON score at the start of the school year is statistically controlled for. When adding the quality of mathematics education as the third predictor to the analyses (Model 3), the increase in the amount of explained variance in SFON scores at Test 2 was rather small (i.e., R^2 = 2%). The contribution of this predictor variable was not significant indicating that the quality of mathematics education children received did not predict their SFON tendency at the end of the kindergarten year. However, the increase in explained variance in the model cannot be used as the sole indicator of the importance of a variable. To compare the relative contribution of the different independent variables standardized betas (Everitt and Dunn 2001) were used. These indicated that children's early numerical abilities at the start of the school year are most predictive for their SFON tendency at the end of the school year, compared to children's SFON tendency at the start of the school year and the quality of mathematics education during the school year.

Table 5.3 Multilevel model of predictors of SFON scores at the end of the school year

Model	Predictor	Coeff	SE	Sig.	Stand. Beta	-2LL
1	Intercept	1.667	0.275			349.651
	SFON test 1	0.429	0.098*	***	0.366	
2	Intercept	−0.822	0.434			326.203
	SFON test 1	0.224	0.097**	*	0.191	
	TENA	0.087	0.017*	***	0.503	
3	Intercept	−2.161	1.157			324.783
	SFON test 1	0.223	0.097**	*	0.190	
	TENA	0.081	0.017*	***	0.468	
	COEMET	0.025	0.020		0.142	

Note R^2 = 0.17 (Model 1); R^2 = 0.37 (Model 2); R^2 = 0.39 (Model 3); *p < 0.05, **p < 0.01, ***p < 0.001

In sum, these results indicate that kindergartners with higher early numerical abilities and with higher SFON at the start of the school year develop higher SFON throughout the school year. The quality of the mathematics education received throughout kindergarten did not add to the prediction of children's SFON score at the end of the year. The latter result might be due to the generally low quality of early mathematics education as well as the small variance in observed quality in the participating classes (see above). However, given the small number of classrooms included in our study, we cannot make strong statements about the impact of the quality of the early mathematics education on the development of children's SFON tendency.

5.5 Discussion

5.5.1 Implications for Understanding Young Children's Early Numerical Competencies and Development

A first goal of our study was to examine Ecuadorian kindergartners' SFON development throughout the school year, focusing on both individual differences and stability in children's SFON development. First, our results demonstrate large inter-individual differences in SFON tendency among Ecuadorian kindergarteners, as well as consistency in their SFON tendency throughout the school year. These results are in line with previous findings in Finnish children (Hannula and Lehtinen 2005; Hannula et al. 2007, 2010). The similarities between our and Hannula and colleagues' findings suggest that the same structures and mechanisms underlie children's SFON development across different cultural and educational contexts. Second, we found that children's SFON scores were noticeably low at both the start and the end of the school year. Remember from prior findings that SFON contributes to children's mathematical performance in elementary school (Hannula-Sormunen et al. 2015; Rathé et al. 2016), thus it might be hypothesized that the low SFON tendency of Ecuadorian children may have a negative impact on their mathematics achievement during the elementary school years. As this is the first study on Ecuadorian kindergartners' SFON development, future studies are required to validate and refine our findings. Moreover, as we did not follow children's early numerical and later mathematical development during and after the kindergarten year, future studies need to longitudinally follow up kindergartners' SFON acquisition and its relation with their concurrent and later numerical and mathematical achievement at elementary school.

Our second goal was analyzing the relationship between kindergartners' SFON development and their early numerical abilities. Our results revealed a positive relation between children's early numerical abilities at the start of kindergarten and their SFON tendency at the end of kindergarten. Thus, the higher children's score on the early numerical abilities test at the start of kindergarten, the more children spontaneously focused on numerosity at the end of kindergarten. Importantly, this relationship was significant, even after controlling for SFON at the start of the school year. Moreover, the contribution of children's early numerical abilities to SFON development was stronger than the contribution of their initial SFON tendency. These results provide additional evidence for the relations between early numerical abilities and SFON (e.g., Hannula et al. 2010; Hannula-Sormunen 2015; Hannula-Sormunen et al. 2015; Rathé et al. 2016). As such, and as already stated for the first major research question, the highly similar results in Finnish and Ecuadorian kindergartners seem to indicate that SFON development relies on analogous developmental structures and processes in children coming from countries largely differing in cultural and educational characteristics. This study constitutes a first attempt to examine young children's SFON tendency in a developing country, i.e., Ecuador, however, further investigations are needed, to address the processes underlying Ecuadorian children's rather low SFON scores, and, to replicate and refine this study in other European and South-American samples, differing in general cultural and educational context, to allow more general conclusions.

5.5.2 Implications for Optimizing Early Mathematics Education

Our study did not only add to the theoretical understanding of SFON competencies and development in Ecuadorian children, but also offers new insights into the relation between SFON and the quality of mathematics education in current Ecuadorian kindergarten. Indeed, as outlined in our third research goal, we also aimed at examining the relationship between the quality of early mathematics education received in the kindergarten year and Ecuadorian children's SFON development throughout that school year. Surprisingly, our results revealed that the quality of early mathematics education that the Ecuadorian kindergartners received did not contribute to their SFON tendency at the end of the kindergarten year.

To the best of our knowledge, this is the first study that directly addresses the relation between children's SFON development for a one-year-time period and the quality of early mathematics education. As discussed above, Hannula et al. (2005) tried to stimulate (Finnish) children's SFON development via a focused intervention study and concluded that young children's SFON tendency can be enhanced through purposeful activities that guide their attention to the aspect of number. Our results are not in line with Hannula and colleagues' conclusions, taking into account the lack of contribution of the quality of mathematics education to SFON development throughout the kindergarten year. However, it should be noted that the teachers participating in our study were not trained to focus on enhancing children's SFON development, as was the case in the study of Hannula and colleagues. Moreover, as indicated by the rather low COEMET scores, children's early mathematics education did not only miss a focus on SFON enhancement but was also generally characterized as being of rather low quality, with teachers' approaches characterized as providing mainly whole-group teaching followed by individual work, with limited interactions and discussions between peers or between children and the teachers. These differences between this study and the previous studies of Hannula and colleagues might explain the observed differences. Additionally, the low number of schools included in this study, may also account for the lack of a relation between SFON and quality of mathematics education, thus urging the need for replication and extension in large-scale studies, not only in Ecuador but also other South-American and, more generally, other countries worldwide.

Although our results on the relation between children's SFON development and quality of mathematics education need to be confirmed and refined in future studies, they offer important building blocks for optimizing educational policy and practice in the domain of kindergarten mathematics in Ecuador. A first topic that requires considerable attention concerns the generally rather low quality of kindergarten mathematics education in Ecuador, as reflected in the low COEMET scores obtained by the participating classrooms when compared to previous studies conducted in the US, in which the authors reported COEMET scores of (about) 108 in experimental classrooms and scores of (about) 99 in control classrooms (Clements et al. 2011; Sarama et al. 2012). The low quality of early mathematics education in the participating classrooms might be due to the characteristics of current teacher training in Ecuador, with only marginal attention for both the core structures and processes involved in young children's mathematical development and the defining elements of powerful learning environments to effectively stimulate this development. Although the consistency in our classroom observations and the high inter-rater reliability in the COEMET instrument indicate a valid description of the educational practices in the participating classrooms, these observations need to be complemented with further observation studies. These may include more frequent classroom observations, teacher interviews, and fine-grained qualitative analyses of interactions during schooling and testing to provide a more detailed description and understanding of current educational practices in early mathematics education in Ecuador. The results of the presented study and of these future studies may allow us to make informed decisions in future educational reforms in Ecuador. Furthermore, the observations via the COEMET allow us to pinpoint both strengths and weaknesses in current educational practices; an overview of these strengths and weaknesses will enable focused reforms to address current weaknesses in both kindergarten classes and pre-service and in-service teacher training and, consequently, increase the quality of kindergarten mathematics education in Ecuador.

A second challenge for future studies on the role of early mathematics education on Ecuadorian children's SFON development refers to the contribution of the quality of mathematics education in the three major school types (i.e., public urban, public rural, private). There are some indications that the quality of mathematics education differs among these school types with children attending private schools having better educational opportunities than children attending public rural schools

(PREAL 2006). However, given the small number of schools per school type included in our study, it was not possible to reliably address the effect of school type on the quality of mathematics education in the different classrooms and children's SFON development during the kindergarten year. Therefore, further efforts that include a larger number of schools per school type and a larger sample of children are necessary to describe in more detail children's SFON tendency within schools as well as between school types in relation to the quality of early mathematics education. In these future studies, the complex interplay between the type of school children attend, the quality of the early mathematics education received and children's acquisition of SFON and early numerical abilities, requires careful consideration.

A third topic that needs further consideration relates to nonexistent contribution of the quality of Ecuadorian early mathematics education to Ecuadorian kindergartners' SFON development. A first hypothetical explanation for the absence of the assumed relation between children's SFON development and the quality of early mathematics education refers to the general low quality of mathematics instructional practices in the participating classrooms (see above). A second hypothetical explanation concerns the fact that the teachers in our study did not focus on enhancing their children's SFON development (cf. study of Hannula et al. 2005). Therefore, future intervention studies aiming at enhancing both general numerical abilities and SFON tendency in Ecuadorian kindergartners are needed. The implementation of the TRIAD/Building Blocks early childhood mathematics program (Clements and Sarama 2013) that has proven to be effective in North American countries provides a fruitful avenue for these future intervention studies. Moreover, it seems worthwhile to complement the TRIAD/Building Blocks program with guided activities that focus on directing children's attention to the aspect of number via structured games organized by the kindergarten teachers and also in everyday situations (Hannula et al. 2005). Our results and the results of these future intervention studies will offer important information for educational policy regarding the content of effective mathematics education in Ecuadorian kindergarten and for current educational practice in Ecuador with respect to the effective stimulation of young children's early numerical competencies.

Finally, in this study we used two instruments developed in Finland, namely the two SFON Imitation tasks, and one instrument developed in the US, namely the COEMET to assess the quality of early mathematics education in Ecuador. In this respect, one may question the fairness of analyzing Ecuadorian children's SFON tendency as well as Ecuadorian classroom practices with, respectively, a Finnish and US lens. Regarding the two SFON tasks being used in this study, namely the Parrot Imitation task and the Mailbox Imitation task, we argue that the contexts wherein these tasks are presented to the children, i.e., feeding a parrot and posting letters into a mailbox, respectively, are also closely familiar to Ecuadorian children and, thus, children easily became acquainted to them.

Moreover, meanwhile, these instruments have been successfully used in several different cultural settings (see Rathé et al. 2016). Regarding the use of the COEMET, we argue that this instrument was developed and based on vast international research literature about good early childhood mathematics teaching practices (Sarama and Clements 2009b) and can be used to measure the quality of early mathematics instruction in any classroom given that it "is not connected to any curriculum" (Clements and Sarama 2008, p. 461). We therefore reasoned that it might also be suitable for the Ecuadorian context. Moreover, the first authors' personal experience with early mathematics education in Ecuador allows to conclude that there is a good fit between the COEMET items and what is considered as good teaching practices in early mathematics education in Ecuador. Still, we are well aware of possible subtle influences of the cultural and educational context of the US on the development of the COEMET instrument. Consequently, it is important to conduct a more systematic evaluation of the suitability of the COEMET for the evaluation of the Ecuadorian early mathematics education teaching practice.

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