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Alignment Between Children's Numeracy Performance, the Kindergarten Common Core State Standards for Mathematics, and State-Level Early Learning Standards

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The current study examined preschoolers' (N = 801) age-related performance on one measure of verbal counting and two measures of cardinality ("how many" and "give n") aligned with the kindergarten Common Core State Standards for Mathematics (CCSSM) and included in the majority of states' early learning guidelines for mathematics. Children were grouped into five age categories (3, 3.5, 4, 4.5, 5, 5.5), and within-age-group average rates of correct responses for each item within these three measures were calculated. Results demonstrated that the majority of children were already successfully meeting the CCSSM standards for both cardinal number knowledge tasks (86.5% and 53.3%, respectively) prior to kindergarten entry but that only 18.9% of the children were meeting the standard for verbal counting. Findings indicate potential misalignment between children's existing capabilities and the CCSSM standards for cardinality and underscore the need to conduct large, nationally representative studies measuring children's abilities on items that more closely assess the specific mathematics skills included in the CCSSM and early learning guidelines.

Keywords: *Common Core State Standards, cardinality, counting, early learning guidelines, kindergarten, preschool*

As the United States has moved through numerous iterations of education policy initiatives, such as the No Child Left Behind Act (2002); the Good Start, Grow Smart initiative (Executive Office of the President, 2002); and the Every Student Succeeds Act (2015), school accountability—often measured through students' performance on standardized assessments—has become increasingly important. To ensure that children meet rising achievement goals in later years by entering kindergarten "ready for school," all 50 states have now developed and endorsed early learning standards and/or frameworks that guide instruction prior to entry into kindergarten. However, content analyses of these state-level frameworks demonstrate significant variability in the number of standards included and the degree to which they incorporate specific indicators within key school readiness domains (Scott-Little et al., 2006).

In 2010, the Common Core State Standards for Mathematics (CCSSM; Common Core State Standards Initiative, 2010) were released to provide a more centralized and targeted approach to guiding mathematics instruction from kindergarten through high school. Although the development of the CCSSM was motivated in part by the desire to provide high-quality standards for children across the United States, the adoption of the standards is a voluntary, state-level decision. In 2013, 41 states had adopted the CCSSM. Once adopted, states are able to revise, add to, or repeal the standards based on their own priorities (Common Core State Standards Initiative, 2010). Regardless of states' ultimate decisions regarding the adoption of the CCSSM, the standards also influence the content and sequencing of many states' early learning guidelines. With a growing recognition of the importance of linking prekindergarten to kindergarten instruction, the implications of such early learning standards for preparing children for kindergarten entry have gained traction across the nation. However, recognizing the extensive state-level variation among these early learning guidelines (Scott-Little et al., 2006; Table 1), it is particularly important to examine children's performance in relation to more universal standards that may serve as a starting point for states' expectations. Additionally, to ensure that we have developmentally appropriate standards aligned with children's performance, we need to better understand age-related development on mean levels of skills during the early childhood years.

Within the CCSSM, at each grade level, standards (i.e., specific knowledge and/or skills that students should have) are grouped into related domains. For instance, in kindergarten, CCSSM domains include counting and cardinality, operations and algebraic thinking, number and operations in base 10, measurement and data, and geometry—all of which encompass multiple standards (Common Core State Standards Initiative, 2010). One of the key rationales for developing and implementing such a set of national standards was the notion of creating consistent, sequenced, and challenging expectations for students' performance that could be used to guide instruction (Common Core State Standards Initiative, 2010; Porter et al., 2011); however, several analyses of kindergarten instruction have demonstrated that the majority of classroom time spent on mathematics is used to cover skills that over half of the children who entered kindergarten already know, rather than on learning advanced material that the majority of children have not yet mastered (Claessens et al., 2014; Engel et al., 2013).

Across all grade levels, roughly 33% of mathematics content on the CCSSM is related to number sense—the highest percentage for any topic area (Porter et al., 2011). This emphasis complements developmental research, which demonstrates that children's early numeracy skills are the strongest predictors of their later academic achievement (Nguyen et al., 2016). Additionally, research has shown that children's numeracy skills related to numbering, relations, and arithmetic operations develop extensively during the early years, especially when supported by parents and teachers (Ginsburg et al., 2008). As such, it is particularly important that expectations for children's early numeracy performance accurately reflect and build on their developmental capabilities.

Two key early numeracy skills that form the basis for children's ability to understand numerical relations and perform arithmetic operations include their understanding of counting and cardinality (Clements & Sarama, 2014; Purpura et al., 2013). Children's ability to count accurately forms the foundation for their cardinal number knowledge (Krajewski & Schneider, 2009), which encompasses their knowledge of the number of items that belong in a particular set (Sarnecka & Carey, 2008). As demonstrated by prior work, substantial growth in both children's counting and cardinality skills occurs between the ages of 2 and 5 years (e.g., Fuson, 1988; Gelman & Gallistel, 1978; Sarnecka & Carey, 2008). Both counting and cardinality are skills captured by specific standards within the majority of states' early learning guidelines as well as the CCSSM for kindergarten (see Table 1), although evidence suggests that less time is spent on numeracy than other areas (e.g., spatial) in preschool classrooms (Piasta et al., 2014). In the current study, we examine children's performance on standards K.CC.A.1 (K.CC = kindergarten–counting and cardinality) and K.CC.B.5. The standards outline the following skills: by the end of kindergarten, children should be able to count to 100 (K.CC.A.1), determine how many objects are in a group of 20 items (K.CC.B.5), and count out a requested subset of up to 20 items (K.CC.B.5; Common Core State Standards Initiative, 2010).

Although studies have broadly examined alignment between state standards, state assessments, and the CCSSM, as well as investigated relations between students' achievement and the CCSSM (Porter et al., 2011; Schmidt & Houang, 2012), no research has yet examined children's age-related performance on specific numeracy skills aligned with the CCSSM or looked at the alignment between those skills targeted by the kindergarten CCSSM and state early learning standards. Investigating the alignment between children's performance and key mathematics standards would ideally draw on data from a large, nationally representative sample. To date, however, no large national studies have the appropriate item-level data that could be leveraged to do so. The current study takes a first step toward understanding this issue by utilizing an existing dataset sampling over 800 children on measures that closely align with specific items on the CCSSM. Using this sample, the present work addresses the gap in our current knowledge by demonstrating how preschool-age children perform on three measures of counting and cardinality, with components of increasing difficulty, prior to formal kindergarten entry, and whether their performance indicates that the CCSSM may be misaligned with their abilities. Results from this study may inform and encourage future large-scale research investigating whether the current standards effectively build on children's existing skill levels and provide the foundation for appropriately challenging mathematics curricula or whether the standards are below the level of their existing capabilities. Additionally, we map states' early learning standards regarding counting and cardinality onto the CCSSM standards. It is possible that kindergarten instruction may be lower than what children can do (Bodovski & Farkas, 2007; Engel et al., 2013; Engel et al., 2016) because the instruction is aligned with national and state-level standards that are below children's skill levels.

In the current work, we examine cross-sectional data on 3.0- to 5.5-year-old children's performance on one measure of counting and two measures of cardinality to understand precisely when, and how early, children begin to reach milestones aligned with CCSSM expectations for counting and cardinality. Although the CCSSM targets children's end of

TABLE 1

Alignment Between States' Early Learning Standards and the Common Core State Standards for Mathematics

State	Early Learning Standard Document	Verbal Counting	Cardinality—"How Many?"	Cardinality—"Give *n*"
	Common Core State Standards for Mathematics - Kindergarten	*Children should be able to count to 100 by the end of kindergarten (K.CC.A.1)*	*Children should be able to determine how many objects are in a group of 20 items (K.CC.B.5)*	*Children should be able to count out a requested subset of up to 20 items (K.CC.B.5)*
Alabama	Alabama Developmental Standards for Preschool Children (2010)	Show increasing ability to count in sequence to 10 and beyond (4 years)	Demonstrate use of one-to-one correspondence in counting objects and matching numeral names with sets of objects (4 years)	N/A
Alaska	Alaska Early Learning Guidelines (2007)	Count to at least 20 from memory (5 years to kindergarten)	Understand that the last count represents the number of what has been counted (3 to 5 years)	Apply counting to new situations (e.g., counting objects, counting groups; 3 to 5 years)
Arizona	Arizona Early Learning Standards, 4th edition (2018)	Rote count zero to 10 and beyond with increasing accuracy (3 to 5 years)	Count a collection of up to 10 items using the last counting word to tell, "how many?" (3 to 5 years)	N/A
Arkansas	Arkansas Child Development and Early Learning Standards: Birth through 60 months (2016)	Say or sign number words in order accurately with increasing ability to count to five, then up to 10, and finally to 20 and beyond by the end of this age range (37 months to 5 years)	With increasing consistency use the last number counted to represent how many objects are in a group (19 months to 5 years)	Produce a set of a certain number when prompted (e.g., puts five napkins on the table when asked; 37 months to 5 years)
California	California Preschool Learning Foundations (Vol. 1, 2008)	Recite numbers in order to 20 with increasing accuracy (at around 60 months of age)	Understand, when counting, that the number name of the last object counted represents the total number of objects in the group (i.e., cardinality; at around 60 months of age)	N/A
Colorado	Colorado Early Learning & Development Guidelines (2013)	Recite numbers in the correct order (3 to 5 years)	Use the number name of the last object counted to represent the number of objects in the set (3 to 5 years)	N/A
Connecticut	Connecticut Early Learning and Development Standards (2014)	Say or sign the number sequence up to at least 20 (4 to 5 years)	Count up to 10 objects using one-to-one correspondence, regardless of configuration, using the number name of the last object counted to represent the total number of objects in a set (4 to 5 years)	Count out a set of objects up to 5 (4 to 5 years)
Delaware	Preschool Early Learning Foundations (2010)	Recite numbers in sequence (preschool)	Determine quantity or "how many" (preschool)	N/A
District of Columbia	Early Learning Standards (2012)	Count to 20 by ones (pre-K exit)	Count to answer "how many?" questions about 10–20 objects (pre-K exit)	N/A
Florida	Florida Early Learning and Developmental Standards (2017)	Count and identify the number sequence "1 to 31" (4 years to kindergarten entry)	Identify the last number spoken; tells "how many" up to 10 (cardinality; 4 years to kindergarten entry)	Construct and count set of objects (one to 10 and beyond; 4 years to kindergarten entry)
Georgia	Georgia Early Learning and Development Standards (2013)	Recite numbers up to 20 in sequence (4 to 5 years)	With adult guidance and when counting, understand and respond with the last number counted to represent quantity (cardinality; 4 to 5 years)	N/A
Hawaii	Hawaii's Early Learning and Development Standards (2013)	Verbally count to 20 by ones (4 years to kindergarten entry)	N/A	N/A
Idaho	Idaho Early Learning Guidelines (2014)	Count up to 10 from memory in home language without assistance (3 to 5 years)	Begin recognizing that the last number counted represents the "total objects" (for quantities up to 10; 3 to 5 years)	N/A
Illinois	Illinois Early Learning and Development Standards for Preschool (2013)	Verbally recite numbers from one to 10 (3 to 5 years)	Count with understanding and recognize "how many" in small sets up to 5 (3 to 5 years)	Show understanding of how to count out and construct sets of objects of a given number up to five (3 to 5 years)
Indiana	Indiana Early Learning Foundations (2015)	Count the number sequence 1–20 (older preschool)	Recognize the last number name said tells the number of objects counted (older preschool)	N/A
Iowa	Iowa Early Learning Standards, 3rd edition (2018)	Count to 20 verbally (3 to 5 years)	N/A	Make sets of six to 10 objects and describe parts (3 to 5 years)
Kansas	Kansas Early Learning Standards: Building the Foundation for Successful Children (2014)	Count in sequence to 30 (By 5 years)	Count to answer "how many?" questions about as many as 10 things arranged in a line, a rectangular array, or a circle or as many as five things in a scattered configuration (by 5 years)	N/A
Kentucky	Kentucky Early Childhood Standards (2013)	Count in sequence to five and beyond (3 to 4 years)	Realize that the last number counted is the total number of objects (3 to 4 years)	N/A
Louisiana	Louisiana's Birth to Five Early Learning and Development Standards (2013)	Verbally count by ones to 20 (4 to 5 year)	Understand that the last number named tells the number of objects counted for a set of 10 or fewer objects (4 to 5 years)	Count out a specified number of objects from a set of 10 or fewer objects when asked (4 to 5 years)
Maine	State of Maine Early Childhood Learning Guidelines (2005)	Demonstrate an increasing ability to count in sequence to 10 and beyond (3 to 5 years)	N/A	N/A
Maryland	Maryland Model for School Readiness (2009)	Count to 10 (prekindergarten)	N/A	Use concrete materials to build sets zero to 5 (prekindergarten)
Massachusetts	Prekindergarten Standards, Mathematics (2011)	Listen to and say the names of numbers in meaningful contexts (prekindergarten)	N/A	N/A
Michigan	Early Childhood Standards of Quality for Prekindergarten (2013)	Develop an increasing ability to count in sequence up to 10 and beyond, typically referred to as "counting on" (prekindergarten)	N/A	N/A
Minnesota	Early Childhood Indicators of Progress (2016)	Recite number words aloud, forward, up to at least 29 (allow for some mistakes), without objects (4 to 5 years)	N/A	Give five or more items correctly and consistently when asked (4 to 5 years)
Mississippi	Mississippi Early Learning Guidelines (2018)	With prompting and support, recite numbers one to 30 in the correct order (4 years)	Use number name of the last object counted to represent the number of objects in a set, using developmentally appropriate prekindergarten materials (4 years)	N/A

(continued)

TABLE 1 (CONTINUED)

State	Early Learning Standard Document	Verbal Counting	Cardinality—"How Many?"	Cardinality—"Give *n*"
Missouri	Missouri Early Learning Standards (2013)	Count one to 10 or beyond (preschool-age)	Name how many there are in a group (up to five objects; preschool-age)	Count objects with understanding (e.g., hands one to five objects on request; preschool-age)
Montana	Montana Early Learning Standards (2014)	Move from inventive counting to accurate rote counting (emerging through preschool)	Count objects demonstrating one-to-one correspondence and meaning (emerging through preschool)	N/A
Nebraska	Nebraska Early Learning Guidelines (2018)	Count verbally or sign to 20 by ones (4 to 5 years)	Begin to count to answer "how many" questions (understand cardinality; 4 to 5 years)	N/A
Nevada	Nevada Pre-Kindergarten Standards (2010)	Count to 10 (prekindergarten)	N/A	Match the number of objects in a set to the correct numeral zero to five (prekindergarten)
New Hampshire	New Hampshire Early Learning Standards (2016)	Verbally count to 20 (NH Kindergarten Readiness Indicator)	Count to answer "how many" (NH Kindergarten Readiness Indicator)	N/A
New Jersey	Preschool Teaching and Learning Standards (2014)	Count to 20 by ones with minimal prompting (preschool)	Understand the relationship between numbers and quantities (i.e., the last word stated when counting tells "how many"; preschool)	N/A
New Mexico	New Mexico Early Learning Guidelines (2011)	N/A	N/A	N/A
New York	Early Learning Guidelines (2012)	Count to at least 20 from memory (3 to 5 years)	N/A	N/A
North Carolina	North Carolina Foundations for Early Learning and Development (2013)	Rote count in order to 20 with increasing accuracy (older preschool)	Count up to 10 objects arranged in a line using one-to-one correspondence with increasing accuracy, and answer the question "how many?" (older preschool)	N/A
North Dakota	North Dakota Early Learning Guidelines (2010)	Demonstrate the numeracy strategy of rote counting (e.g., from memory; 3 to 5 years)	Demonstrate understanding of the cardinality counting principle (e.g., the last number represents the number of counted objects; ages 3 to 5 years)	N/A
Ohio	Birth Through Kindergarten Early Learning and Development Standards (2012)	Count to 20 by ones with increasing accuracy (3 to 5 years)	Understand that the last number spoken tells the number of objects counted (3 to 5 years)	N/A
Oklahoma	Oklahoma Early Learning Guidelines for Children (2011)	Develop increasing ability to count in sequence to 10 (ages 3 to 5 years)	Recognize the numerical value of sets of objects through five (i.e., name "how many" are in a group of up to five [or more] objects; 3 to 5 years)	Identify and create sets of objects one through five (ages 3 to 5 years)
Oregon	Oregon Early Childhood Foundations (2016)	Count verbally or signs to at least 20 by ones (by kindergarten entry)	Count and answer "how many?" questions for approximately 10 objects (by kindergarten entry)	N/A
Pennsylvania	Pennsylvania Learning Standards for Early Childhood (Pre-Kindergarten; 2014)	Rote count up to 20 (prekindergarten)	State the total number of objects counted, demonstrating understanding that the last number named tells the number of objects counted (prekindergarten)	N/A
Rhode Island	Rhode Island Early Learning and Development Standards (2013)	Verbally count beyond 20 (or in some way indicate a knowledge of words for the numbers from one to 10 in sequence) demonstrating an understanding of the number pattern (5 years)	Understand that the last number counted represents the number of objects in a set (4 years)	N/A
South Carolina	South Carolina Early Learning Standards (2017)	Rote count to 20 with increasing accuracy (4 to 5 years)	Count up to 10 objects arranged in a line using one-to-one correspondence with increasing accuracy, and answer the question "How many are there? (4 to 5 years)	Given a number from zero to 5, count out that many objects (4 to 5 years)
South Dakota	South Dakota Early Learning Guidelines (2017)	Rote count by ones to 20 with increasing accuracy (45 to 60+ months)	Count the number of items in a group of up to 10 objects and know that the last number tells how many (45 to 60+ months)	N/A
Tennessee	Tennessee Early Learning Developmental Standards (2014)	Count forward from one to 30 (4 years))	With guidance and support, count to answer "how many?" questions about as many as 10 things arranged in a line, a rectangular array, or a circle (4 years)	Given a number from one to 10, count out that many objects (4 years)
Texas	Texas Prekindergarten Guidelines (2015)	Use words to rote count from one to 30 (end of prekindergarten)	Count up to 10 items and demonstrate that the last count indicates how many items were counted (end of prekindergarten)	N/A
Utah	Utah's Early Childhood State Standards (2013)	Begin to count to 20 by ones (end of preschool)	Understand the relationship between numbers and quantities; connect counting to cardinality (i.e., develop the ability to respond to the question "how many" after counting the objects in a set; end of preschool)	N/A
Vermont	Vermont Early Learning Standards (2015)	Recite number to 20 in sequence with only occasional errors (4 to 5 years)	Count a group of up to 10 objects and understand that the last number represents the number of objects in the group (4 to 5 years)	N/A
Virginia	Virginia's Foundation Blocks for Early Learning: Comprehensive Standards for 4-year-olds (2013)	Count forward to 20 or more (4 years)	Count the items in a collection of one to 10 items and know the last counting word tells "how many" (4 years)	N/A
Washington	Washington State Early Learning and Development Guidelines (2012)	Count to 20 and beyond (ages 4 to 5 years)	N/A	Count out 10 items (ages 4 to 5 years)
West Virginia	Early Learning Standards Framework for West Virginia Pre-K (2013)	Count in sequence to 10 and beyond (preschool/ prekindergarten)	Count to answer "how many?" questions up to 10 items (preschool/ prekindergarten)	Given a number up to 10, count out that many objects (preschool/prekindergarten)
Wisconsin	Wisconsin Model Early Learning Standards, 5th edition (2017)	May rote count to 100 and may count to 100 by fives and 10s (for children birth through entrance to first grade)	N/A	N/A
Wyoming	Early Learning Foundations (2013)	Recite numbers in the correct order (3 to 5 years)	Use the number name of the last object counted to represent the number of objects in the set (3 to 5 years)	N/A

Note. This table does not include end of kindergarten standards if stated within the state's preschool learning framework. Ages associated with each benchmark are denoted in parentheses. K.CC = kindergarten–counting and cardinality; N/A = not applicable.

kindergarten performance, the current study examines their performance on specific items within these numeracy skills prior to the start of the kindergarten year, as effective standards should be reasonably more advanced than children's initial starting points. Thus, the work provides *initial* insight into whether several key standards within the counting and cardinality domain of the CCSSM effectively build on children's capabilities developed in the years leading up to the transition to kindergarten.

Method

Participants

Data were drawn from six studies across 87 public and private preschools serving a diverse population of families from lower-, middle-, and higher-income households from two states in different regions of the country. These data have been compiled and analyzed in one previous publication (Litkowski et al., 2020) but were used to answer a different research question. Although both states from which the data were collected adopted the Common Core Standards soon after their release in 2010, they have both since developed their own versions of standards. One state began to use their own early learning standards in 2014. The other state adopted the Common Core in 2010 in tandem with additional state-specific standards, but it officially adopted new state standards in 2020. On kindergarten standards addressing counting and cardinality, these state standards do not differ substantially in wording or meaning as compared with the CCSSM.

Data was collected between the spring of 2009 and the spring of 2017. Studies were selected because they all included the same measures of counting and cardinality, followed similar recruitment processes, and used the same training procedures for assessors, the same methods of data collection, and identical scoring procedures. All studies included children in the first and second year of preschool. Participants ($N = 801$) were roughly equally represented in gender (50.3% female), and the entire sample was relatively ethnically diverse (56.3% Caucasian, 18.1% African American, 9.9% Hispanic, 9.5% Asian, and 4.4% multiracial/not reported). Children's age ranged from 3.12 to 5.99 years ($M = 4.63$ years, $SD = 0.68$). Head Start attendance was the only socioeconomic status measure collected across all six studies, and 15.7% of children were enrolled in a Head Start program. Parent demographic data were not consistently collected across all six studies. For one study ($n = 393$), the only demographic data collected was Head Start status; 17.3% of those participants were enrolled in Head Start. However, the state from which these data were collected provided state-funded voluntary prekindergarten to all age-eligible children, which suggests that many of the children who were not in Head Start may have also been from families with low incomes. Additional details regarding the sample characteristics for each of the six studies are reported in Table 2.

In the remaining five studies ($n = 408$), parents reported their highest level of education: 36.3% had some type of postgraduate degree, 15.2% had a bachelor's degree, 38.9% had less than a college degree, 7.8% had a GED or less than a high school degree, and 1.7% did not report their education level. We considered this demographic data in tandem with prior work that collected nationally representative data. For the subsample of participants who reported parental education, percentages for the highest educational attainment group were different from those from nationally representative data such as the Early Childhood Longitudinal Study—Kindergarten Class of 2010–2011 (ECLS-K: 2011), in which 18% of parents reported graduate/professional degree as their highest education attainment, 20% had a bachelor's degree, 32% had completed some college or a vocational degree, and 20% had a high school diploma or equivalent. Nine percent of the ECLS-K: 2011 participants reported a high school diploma or equivalent as their highest level of education (Mulligan et al., 2012).

To determine whether kindergarten expectations are developmentally appropriate, preschool children's performance on the three numeracy subtests was evaluated with regard to average performance rates and age-related differences at 6-month age bands. Age-groups did not significantly differ in terms of gender; however, there were significant differences among age-groups on both ethnicity, $\chi^2(4, N = 786) = 41.64, p = .003$, and Head Start status, $\chi^2(1, N = 126) = 20.32, p = .001$. Only 3.7% of 3-year-olds, 7.2% of 3.5-year-olds, and 11.1% of 5.5-year-olds were enrolled in Head Start programs. For ages 4.0, 4.5, and 5.0 years, enrollment in Head Start programs ranged from 16.9% to 21.1%. This difference is likely due to the nature of Head Start primarily focusing on children in the year before they enter kindergarten. We do not expect such differences to inflate the findings of the current study.

Measures

All children completed a broad battery of numeracy subtests that included measures of counting, relations, and operations (Purpura & Lonigan, 2015). All assessments were administered at the child's preschool by a trained researcher. For the current study, three numeracy measures aligned most closely with the CCSSM were examined: verbal counting (to assess K.CC.A.1), cardinality (how many; to assess the first component of K.CC.B.5), and cardinality (give *n*; to assess the second component of K.CC.B.5). Although in the current study measures for cardinality only reach 16, prior work has demonstrated roughly equivalent item difficulty for cardinal number knowledge of 16 and 20 for both the "how many" and "give *n*" tasks (Purpura & Lonigan, 2015), suggesting that cardinality measures of 16 can be used as a proxy for

TABLE 2
Child Demographics Across Each Study

			Child Gender		Child Ethnicity						Head Start Status	
Study	*N*	Study Year	Male	Female	Caucasian	African American	Hispanic	Asian	Multiracial	Missing	Not Enrolled	Enrolled
Study 1	393	2009	48.3	51.7	55.7	33.8	2.8	7.6	0.0	0.0	82.7	17.3
Study 2	69	2013	53.6	46.4	52.2	0.0	0.0	42.0	1.4	4.3	100.0	0.0
Study 3	125	2013–2014	53.6	46.4	70.4	3.2	3.2	8.0	12.8	2.4	100.0	0.0
Study 4	50	2014–2015	50	50	32.0	10.0	26.0	2.0	24.0	6.0	0.0	100.0
Study 5	119	2015	52.1	47.9	77.3	2.5	5.0	5.0	5.0	5.0	100.0	0.0
Study 6	45	2016–2017	37.8	62.2	0.0	0.0	100.0	0.0	0.0	0.0	82.2	17.8

cardinality measures of 20 because the skills for quantities of 16 and 20 develop at a similar time.

Verbal Counting. Children were asked to count as high as they were able to starting from the number 1. The task ended when they reached 100 or if they made an error without self-correcting. Accurately counting to 5, 10, 15, 20, 25, 40, and 100 were scored as independent items (0 = *incorrect*, 1 = *correct*) as previous research indicates that these breakpoints indicate equidistant levels of difficulty (Purpura & Lonigan, 2015).

Cardinality

How many. This task was embedded within a one-to-one counting task where children were asked to count a set of objects. Immediately following this task (for $n = 3$, 6, and 16), children were asked to indicate how many total dots were on the page. This task had satisfactory reliability ($\alpha = .76$). If the child was not able to respond without recounting, or answered incorrectly, his or her response received zero points.

Give n. In this task, for three items ($n = 3$, 4, 8) the child was provided with a set of 10 blocks and asked to give the researcher a small subset of those blocks (e.g., "give me 4 blocks"). For one item ($n = 16$), the child was given a set of 20 blocks and asked to again give a subset of those blocks (e.g., "give me 16 blocks") to the researcher. This task had satisfactory reliability ($\alpha = .81$). Correct responses received one point.

Procedures

Assessment Procedure. University-level institutional review board approval was obtained prior to any recruitment or data collection. All parents completed a signed consent form prior to their child participating in the research. A trained researcher administered all of the numeracy tasks. Children completed the assessment battery in a quiet location designated by a teacher or a director at each preschool. Across the various waves of data collection, the length of the overall testing batteries varied up to approximately 90 minutes. For these batteries, children were assessed in approximately 3 to 5, 15- to 30-minute sessions. The numeracy portion of the assessments specific to this study took approximately 10 to 15 minutes to administer. Prior to their participation, children were informed about the study procedure and asked to verbally give their assent to take part in the research project. Children were told that they could stop participating at any time.

Analytic Procedure. All analyses were conducted using IBM SPSS Statistics 22. Children were grouped into six age categories, with continuous age rounded down to the nearest half year (e.g., 3 years 0 months to <3 years 6 months = 3): age 3 ($n = 54$), age 3.5 ($n = 111$), age 4 ($n = 147$), age 4.5 ($n = 216$), age 5 ($n = 183$), and age 5.5 ($n = 90$). In this study, we were primarily interested in estimating the mean performance on three numeracy measures across the preschool years. Performance was estimated for specific items that most closely aligned with the Common Core standard. With dichotomous scoring (0 = *incorrect*, 1 = *correct*) for each item, the mean of each item for a particular age-group represents the proportion of children who answered the specific item correctly. Proportions were multiplied by 100 to obtain the reported estimates of the percentage of children within a particular age-group answering each item correctly. Additionally, states' early learning guidelines were compiled through a web-based search process.

Results

Verbal Counting

The first examined CCSSM standard (K.CC.A.1) states that kindergarten children should be able to "count to 100 by ones." Data show that, by age 5 years, nearly all children could count to 10 and the majority of children also could accurately count to 15 and 20 (see Figure 1). Verbal counting to higher numbers (e.g., 40 and 100), however, was still developing through age 5.5 years—likely a result of children still needing to learn the repetitive rule and the decade

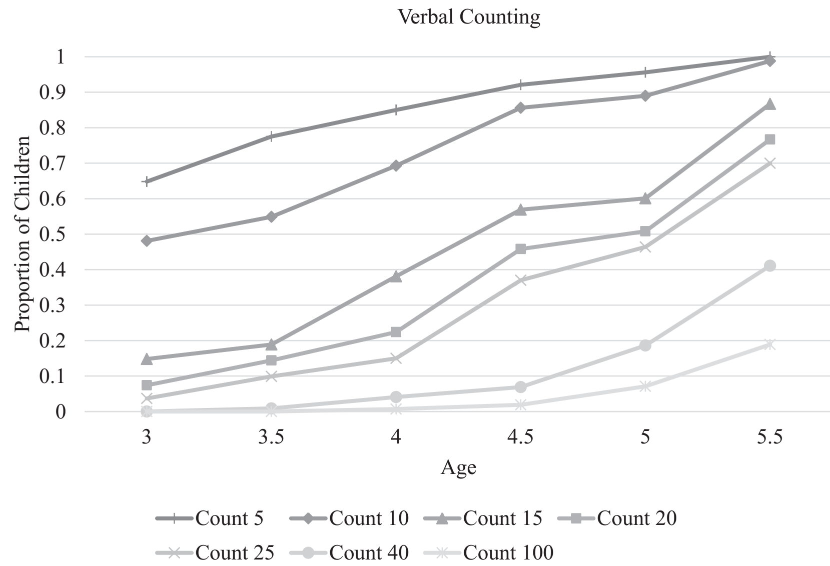

FIGURE 1. *Proportion of children correctly responding to the verbal counting task.*

names. Notably, 18.9% of 5.5-year-olds were able to count to 100.

Cardinality

The second CCSSM standard examined (K.CC.B.5) has two parts. First, the standard states that kindergarten children should be able to "count to answer 'how many?' questions about as many as 20 things . . ." and second, "given a number from 1 to 20, count out that many objects." Data from two tasks (how many and give *n*) in the current study address the two parts of this standard. Results from the "how many" task demonstrate that by age 5 years, nearly all children could correctly answer "how many 3," and the majority of children correctly answered "how many 6" and "how many 16" (see Figure 2). On the "how many" task, 86.5% of 5.5-year-old children had met the first part of K.CC.B.5 prior to kindergarten entry. Children's performance for the "give *n*" task was different. By age 5 years, the majority of children could correctly respond to all items except "give 16" (see Figure 3). Prior to kindergarten entry, 53.3% of 5.5-year-old children had met the second part of K.CC.B.5.

Discussion

To be truly effective at promoting children's mathematics development, the Common Core framework must guide developmentally appropriate expectations and states' early learning standards, as well as inform instruction that accurately reflects children's ability levels throughout the kindergarten year. To examine the two counting and cardinality standards, we make designations of *just right* and *too easy* that are guided by the predicted percentage of children who are able to correctly answer the item most closely aligned with the Common Core standard (<50%—*just right*, ≥50%—*too easy*). These designations indicate whether, prior to kindergarten entry, the majority of children were still in the process of developing the skill or had already developed the skill. This majority cutoff aligns with prior work that defines basic mathematics skills as those that at least 50% of children have already mastered prior to kindergarten entry (Claessens et al., 2014). It is important to note that these designations, indicating alignment or misalignment between children's performance and a specific CCSSM standard, are specific to our sample, and further work should be conducted to examine whether the findings from the current work are applicable across larger, or different, populations. Thus, although we do not infer generalizability from our current sample, it provides a necessary step forward that can inform these future studies.

Historically, although some have refuted the claims (Clements et al., 2017), there have been concerns about the CCSSM being developmentally inappropriate for students because they are too demanding (e.g., Meisels, 2011; Tran et al., 2016); however, findings from the current study demonstrate the converse for the domain of counting and cardinality. The majority of children were already meeting two of the CCSSM standards for counting and cardinality prior to entering kindergarten. Findings indicate that, for the current sample of children, the CCSSM standards may be *just right* for verbal counting, but *too easy* for the "how many" and "give *n*" cardinality tasks. Given that many states use the CCSSM as a framework on which to base their own early learning guidelines, such findings indicate the need for further, nationally representative studies investigating the alignment between both state- and national-level policies and children's early mathematics learning.

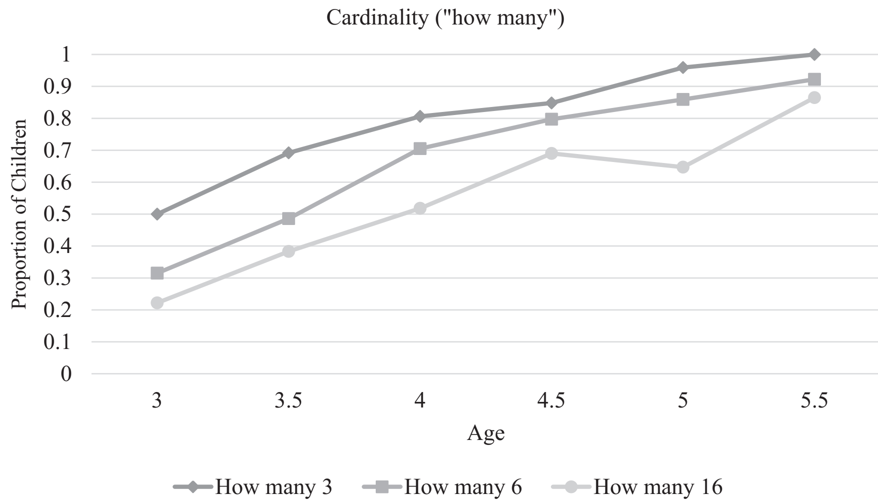

FIGURE 2. *Proportion of children correctly responding to the "how many" cardinal number knowledge task.*

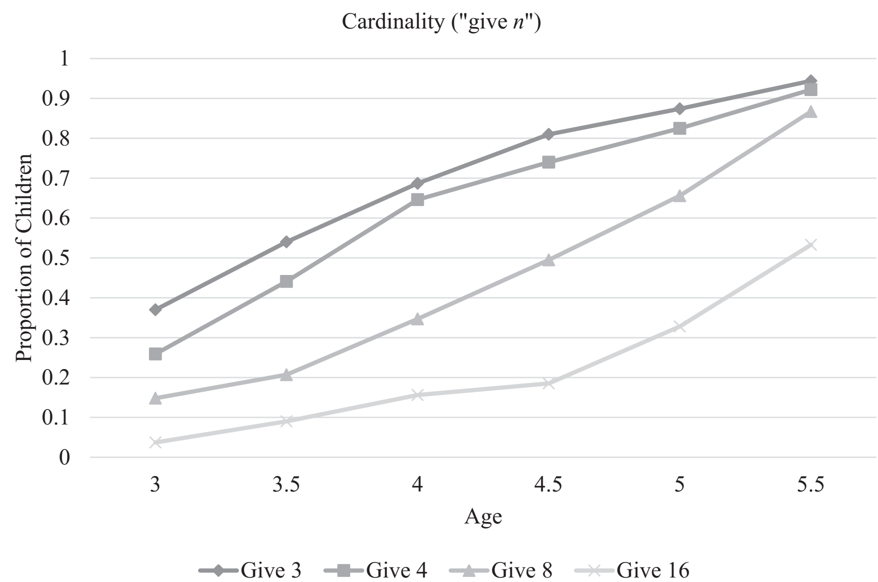

FIGURE 3. *Proportion of children correctly responding to the "give n" cardinal number knowledge task.*

In the current work, only 18.9% of children could accurately count to 100, although the majority of children could accurately count to 20. Prior work outlining general learning trajectories for specific numeracy skills has indicated that counting higher than 20 is a benchmark generally associated with age 5 years (Clements & Sarama, 2014). Verbal counting beyond 20, however, follows a more predictable number-naming pattern than numbers below 20 (Clements & Sarama, 2014), and learning thus likely proceeds more rapidly during the kindergarten year, leading to the conclusion that this goal may be *just right* (Miller et al., 1995). According to the CCSSM, kindergarten children should be able to accomplish both the "how many" and "give *n*" cardinality tasks up to 20 items. On the "how many" task, the majority of children were already able to correctly answer all items (up to 16) by age 4 years and 86.5% of 5.5-year-olds were able to correctly respond. On the "give *n*" task, the majority of 5.5-year-old children (53.3%) answered the highest item (16) correctly. In prior work investigating 2-, 3-, and 4-year-olds' performance on tasks assessing "how-to-count" principles, children's correctness depended both on their age and on the size of the set to be counted. Although the set sizes in this prior work were not equivalent to those within the CCSSM standards, the majority of 3-year-olds were capable of accurately answering "how many" for sets up to four items (Gelman & Gallistel, 1978). In the current work, as a majority of children could correctly answer the most challenging items on each task (and the item most well-aligned with the standard) prior to entering kindergarten, we conclude that both the "how many" and "give *n*" components of the Common Core standard for cardinal number knowledge may be *too easy*.

Prior work has shown that mathematics content provided during kindergarten often focuses on basic content that children have already mastered and may hinder children's mathematics achievement growth (Engel et al., 2013; Engel et al., 2016). Findings from the current study provide initial evidence that some preschoolers may be entering kindergarten already meeting two of the Common Core standards. Standards may need to be modified to more accurately represent children's existing capabilities, such that they continue to challenge students in accordance with their original purpose (Common Core State Standards Initiative, 2010). Although states may make adjustments to items after adopting the CCSSM, recommendations for national standards should set the precedent for state early learning standards to follow.

As illustrated in Table 1, there is significant variation across states with regard to their expectations for children's early counting and cardinality performance. In fact, states' prekindergarten standards demonstrate significant variability and do not always align with the CCSSM. Table 1 provides a reference for how states' early learning standards *just prior to kindergarten entry* address each of the three Common Core standards related to verbal counting and cardinality. Many of these standards purport to be research-based; however, there is significant variability across the individual items in these standards and in their alignment with the three Common Core standards under examination. Although the majority of states include items related to verbal counting, guidelines may vary in the specific quantities that are tied to particular items. For example, some standards state that children's counting should reach 10, 20, 30, or 100—or they may make no recommendations as to what number should be reached (e.g., "recites numbers in sequence"). Additionally, few states refer to both the "how many" and "give *n*" components of cardinality—despite the fact that both components of the CCSSM kindergarten cardinality standards may be too easy for children.

As PK–3 movements that emphasize the alignment of state preschool standards with kindergarten standards progress (Stipek et al., 2017), it will become increasingly important for developmental research to closely examine and evaluate children's performance on state- and national-level standards in order to determine their appropriateness. Realigning the Common Core standards to reflect children's ability levels for the "how many" and "give *n*" components of cardinality may provide the impetus for states to follow suit and create more consistent and appropriate standards for these key early numeracy skills. Findings from the current work should thus be used to encourage additional descriptive work on children's performance levels that can be used to confirm the appropriateness of existing standards and guidelines.

It is likely that there will be natural, individual differences in children's performance levels. Skill development does not always occur at a consistent rate, and children's early experiences in the home and classroom greatly shape their development (Kagan & Scott-Little, 2004). However, findings from the current study demonstrating the developmental trajectories of children's verbal counting and two components of cardinality can inform educators' expectations and subsequently guide differentiated instruction during the preschool to kindergarten transition. To this effect, we provide "performance benchmark" tables in the online Supplemental Appendix A. Tables provide a visual depiction of children's performance at each age across items aligned with each of the two examined Common Core standards, with predicted proportions rounded to the nearest quartile. Tables may provide educators with an accessible visual aid to utilize in the classroom that can help guide and differentiate their early mathematics instruction and may provide policymakers with potential benchmarks for shaping early learning standards.

Limitations and Future Directions

The current study addresses only two of the kindergarten Common Core standards for counting and cardinality. In total, there are seven standards within this specific domain, as well as four other mathematics domains. Findings demonstrate the importance of employing this same fine-grained approach to evaluate children's performance on the remainder of the Common Core standards in order to determine whether the majority of children are already meeting additional standards prior to kindergarten entry. If, when using this approach, other standards are found to be too easy, it may be necessary to revise additional standards guiding the kindergarten mathematics curricula.

It is important to note that findings from this work are limited by the generalizability of the sample, the cross-sectional nature of the data, and the lack of data on these same numeracy measures during the kindergarten year. Although there are some differences between the two states and across the individual studies, the combination of these different datasets provides a far more robust sample than any one site alone. However, the data were not systematically collected in the manner that would be necessary to draw conclusions generalizable across populations. Additionally, it was not the purpose of the current work to examine cross-group differences. Rather, we aim to mirror what the Common Core are intended to do—that is, provide general benchmarks for children's performance that could be used to guide future early learning frameworks or early instruction. As can be seen from comparisons of parental education with the nationally representative ECLS-K: 2011 study, parents in the current work reported higher levels of postgraduate degrees. However, across the six studies, data were collected from a broad range of preschool settings, including private, for-profit schools; public schools; and Head Start centers. In this regard, it is a strength of the study that not just one sampling procedure or setting is used, which could provide biased mean performance (i.e., all children in Head Start centers), but rather the overall means are aggregates across different sampling procedures and settings. On the other hand, the multiple samples were not systematically collected in a way to ensure generalizability; thus, all sources of potential bias are not eliminated for the overall means. Some of these schools provided funding for children from lower-income households, including offering a voluntary pre-K program and providing vouchers. All children who participated in the current study, however, were enrolled in formal, center-based care, and thus, their experiences and performance may differ from those of children who are enrolled in home-based care. Future work should collect data from children in a wider range of early care and education experiences—including both those in their first and second year of preschool—using more nationally representative data, to obtain results that are more generalizable.

All data were collected from two states. Future work addressing children's performance should incorporate larger samples for each age-group from multiple states—including both those that had adopted the CCSSM and those that initially adopted the standards, but then repealed or revised them in favor of their own state-specific versions. Additionally, it may be important to explore differences in children's performance across childcare setting type to examine the impact of mathematics instruction and curricula on children's performance. To inform the further development and revision of kindergarten expectations, we call for additional longitudinal work to examine children's performance, from a diverse, nationally representative sample, through the end of the kindergarten year, on early numeracy skills aligned with the Common Core standards.

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