

## **Paper 1: Parents' Broad Math Support Concurrently and Longitudinally Predicts Preschoolers' Broad Math Knowledge and Skills**

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Research on home math experiences focuses primarily on how parents' numeracy support predicts child numeracy development (e.g., Zippert, Rittle-Johnson, in press). Broader perspectives, however, suggest spatial and pattern skills are also critical to broad mathematical development (Mix & Cheng, 2012; Rittle-Johnson et al., 2015; Sarama & Clements, 2004). Thus, the current study examined how parents provide spatial and pattern support compared to numeracy support, and how each support type relates concurrently and longitudinally to preschoolers' corresponding skills and general math knowledge.

Participants were 46 parents (85% mothers) and their preschooler ( $M_{age}=4.57$   $SD_{age}=.31$ , 44% girls) from diverse backgrounds. In the first quarter of the pre-K year, dyads were videotaped playing with three randomly ordered math-related toys for about 5 minutes each (playing cards, Lego Duplo blocks, a bead stringing activity), selected to encourage parent number, spatial, and pattern support. Each support type was interval coded using adaptations of existing coding schemes (e.g., Cannon, Levine, & Huttenlocher, 2007; Ramani et al., 2015; Rittle-Johnson et al., 2015). Children's math, spatial, and patterning knowledge was assessed at two timepoints (beginning and end of the pre-K year). The Research-Based Early Mathematics Assessment–Short Form, containing numeracy and geometry items and 1 patterning item, measured general math knowledge. Spatial skills included Form perception (Developmental Test of Visual Perception-II) and visuospatial working memory (VSWM; Corsi Block Tapping task). Pattern skills were assessed via a validated repeating patterning measure (Rittle-Johnson et al., in press).

See Table 1.1 for definitions of parent support and descriptive statistics. Parents provided more total number support than spatial  $t(45)=6.55$ ,  $p<.01$ ,  $d=.97$  or pattern support  $t(45)=11.34$ ,  $p<.01$ ,  $d=1.77$  and provided more total spatial support than pattern support  $t(45)=5.84$ ,  $p<.01$ ,  $d=.90$ . Most number support involved magnitude comparison, numeral and cardinal value identification, and most spatial support involved locations and directions. Parents also supported extending and identifying patterns, albeit infrequently.

Totals of each support type (number, spatial, pattern) did not significantly correlate with child knowledge, but exploratory analyses suggested that frequency of particular types of support were related. Frequency of parents' number support of counting objects and approximate magnitude correlated negatively with child Time 1 and Time 2 numeracy and general math knowledge  $r(45)$ 's =  $-.331$  to  $-.412$ ,  $p$ 's  $<.03$ . Frequency of parents' pattern identification support was positively correlated with child patterning at Time 1  $r(45)=.344$ ,  $p<.02$  and Time 2  $r(45)=.328$ ,  $p<.03$  and math knowledge at Time 2  $r(45)=.314$ ,  $p<.04$ . Parents' spatial location and direction support correlated negatively to Time 1 form perception  $r(45)= -.348$ ,  $p<.02$  and VSWM at Time 1  $r(45)= -.308$ ,  $p<.04$ , and Time 2  $r(45)= -.300$ ,  $p<.055$ .

Thus, parents broadly support math during play with their preschoolers, although they emphasize numeracy more than other topics. Importantly, particular types of support were related to children's skills for that content area/topic and sometimes to general math knowledge. The relations were positive for patterns, but negative for number and spatial. This suggests that parents provide broad support to both challenge their children in areas of strength and to address children's weaknesses.

Table 1.1 Descriptive Statistics and Definitions for Parent Number Spatial, & Pattern Support Codes

<b>Code Type</b>	<b>Definition</b>	<b>Frequency (of 10s intervals)</b>
<b>Number Support Total</b>		<b>42.35(15.00)</b>
Complex operations	Adds/subtracts two numbers or indicates complex operations	1.50(3.15)
Magnitude Comparison	Compares or matches two numbers/quantities	10.87(9.43)
Numeral Identification	Identifies a written numeral	9.11(7.22)
Cardinal Values	Labels number of elements in a set or asks about quantity in a set	8.57(5.54)
Counting Objects	Parent counts objects, or discusses counting objects as a strategy	2.98(5.06)
Ordinal Relations	Describes order of numbers, asking before or after questions or emphasizing “then” relations	2.26(2.43)
Rote Counting	Counts numbers sequentially	.48(1.80)
Number Other	Makes general number statements “I hope I get an 8!”	.50(.96)
Approximate magnitude	Makes a general statement about quantity	6.09(3.53)
<b>Spatial Support Total</b>		<b>28.30(13.79)</b>
Orientation/Transformation	Relative orientation or transformation of objects and people in space (e.g. upside down, right side up, upright, turn, rotate, flip)	3.43(3.24)
Spatial Dimensions	Size of objects, people, and spaces including volume, capacity, and measure (e.g. big, little, long, short, tall)	3.37(3.34)
Features/Properties	Features and properties of 2D and 3D objects, spaces, people, and the properties of their features (e.g. border, line, round, bent, straight, flat, corner, ends, this side)	2.13(2.35)
Shapes	Standard or universally recognized form of enclosed two- and three-dimensional objects (e.g. square, circle, polygon) and spaces (e.g., hole).	2.35(2.31)
Locations/Directions	Relative position of objects, people, and points in space (e.g. underneath, side, on top of, inside of)	16.91(8.96)
Continuous Amount	Amount (including relative amount) of continuous quantities (including extent of an object, space, liquid, etc.)	.11(.31)
<b>Pattern Support Total</b>		<b>15.70(8.10)</b>
Identify Pattern Unit	Explicitly identifies the pattern unit	.17(.44)
Linking/Abstracting	Links the individual items from one pattern to another pattern	.22(1.47)
Label Items in Order	Says characteristic of at least 2 consecutive items in a pattern	3.15(4.2)
Pattern Identification	Asks what the pattern is or identifies that a pattern is present	3.41(3.16)
Pattern Extension	Asking what comes next/first in the pattern, respond with what’s next	4.93(4.68)
Nonverbal patterning	Creating at least two units of a pattern, without discussing	2.87(4.42)
Gestures to Pattern	Points to or sweeps over their own pattern but does not provide a verbal explanation	.00(.00)
Similarities/diffs.	Determining features that are the same, noticing similarities and differences between objects/images that are present	.93(1.68)

Note. Each code type (number, spatial, pattern) was coded hierarchically and mutually exclusively among the different code options at every 10-second interval. Standard deviations are in parentheses.