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Examining the source and content of children's explanations to promote patterning knowledge

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Research Goals

1. Systematically study young children's knowledge of repeating patterns, specifically pattern abstraction

2. Examine the impact of the *source* of explanations on children's patterning knowledge

3. Examine the impact of the *content* of explanations on children's patterning knowledge

Why Patterns?

Patterning is a common activity that young children spontaneously engage in

(e.g., Ginsburg, Lin, Ness & Seo, 2003)

It is a central component of early math knowledge and consensus documents in math education include patterning as a central algebraic topic

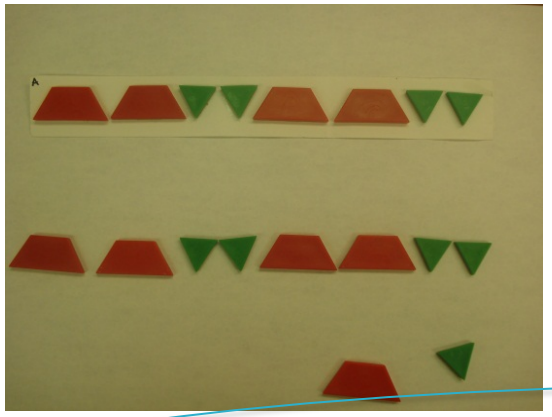
(e.g., National Council of Teachers of Mathematics, 2000)

Knowledge of repeating patterns has been shown to support knowledge in other mathematics domains

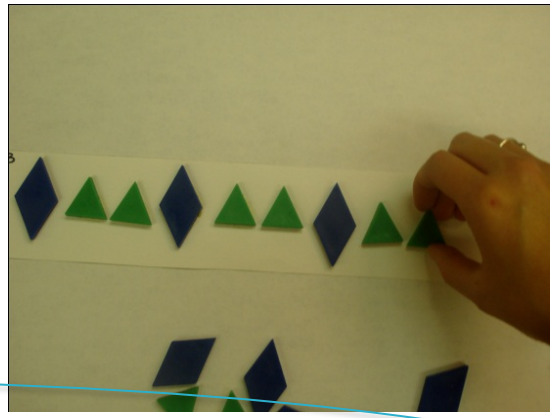
(e.g., Papic, Mulligan, & Mitchelmore, 2011; Warren & Cooper, 2007)

Early Patterning Tasks

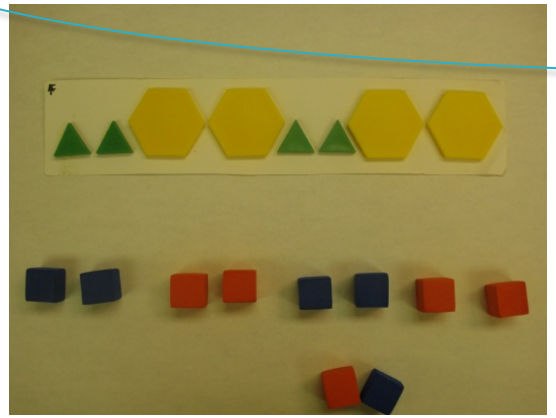
Level 1: Duplication



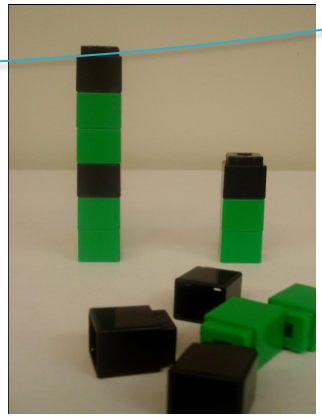
Level 2: Extension



Level 3: Abstraction



Level 4: Unit ID



(e.g., Clements & Sarama, 2009; Klein & Starkey, 2004; Papic et al., 2011; Warren & Cooper, 2006)

Explanation Source

Explanations are a ubiquitous instructional strategy and an important source of knowledge change

Two common types that vary in their source:

- Instructional explanations provided by more knowledgeable others (parents, teachers, etc.)
- Self-explanations generated by the learner spontaneously or in response to a prompt

Instructional Explanation

Instructional explanation: an expert provides an explanation of how or why something works

"This is how you solve it…"

"This works by…"

"This answer is correct because…"

Parents commonly provide explanations, which are associated with greater knowledge in young children

(e.g., Dunn et al., 1991; Ruffman, Slade, & Crowe, 2002)

Self-Explanation

Self-explanation: the learner generates an explanation in an attempt to make sense of new learning material (Chi, 2000)

"How do you think I knew that?"

"What does that mean to you?"

"Why did you use that strategy?"

It was recently identified as one of five evidence-based learning techniques with moderate utility across a variety of conditions

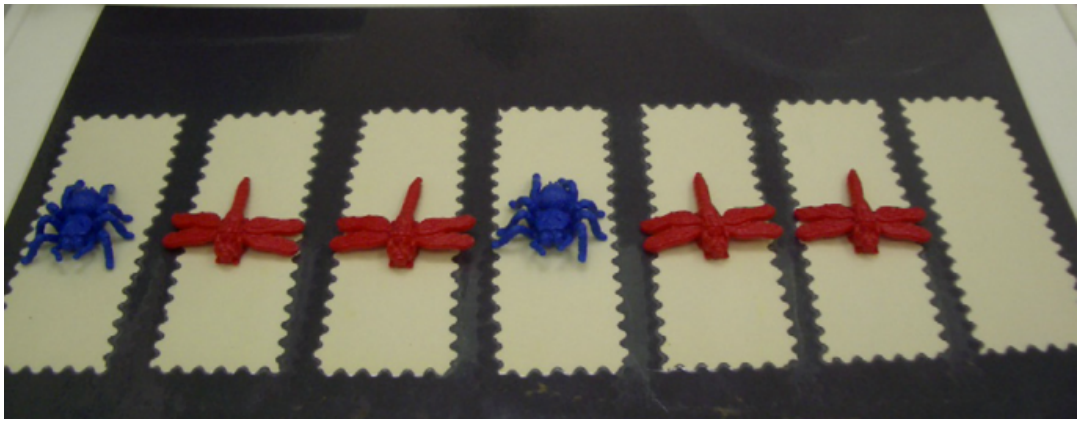
(Dunlosky, Rawson, March, Nathan, & Willingham, 2013)

Self-Explanation

Prompting even young children to explain can improve learning

(e.g., Amsterlaw & Wellman, 2006; Pillow et al., 2002; Rittle-Johnson, 2006)

For example, 4- and 5-year-olds asked to explain patterns exhibited higher problem-solving success than those asked to simply repeat the correct answer (Rittle-Johnson, Saylor, & Swygert, 2008)



Can you explain how to figure out that the blue spider comes next.

Explanation Quality

Although the act of explaining can benefit learning, often the content of the explanation matters (e.g., Chi et al., 1994; Renkl, 1977)

- Frequency of relevant explanations often correlated with outcomes

Elementary-school children who explain math problems in terms of the concept of equality learn more than children who explain math problems in terms of a basic procedure

(Fyfe, DeCaro & Rittle-Johnson, 2014; Matthews & Rittle-Johnson, 2009)

Four-year-olds solving analogy problems generally benefit from prompts to explain, but the few who cannot generate an appropriate explanation fail on transfer problems

(Brown & Kane, 1988)

Explanation Quality

Unfortunately, young children often (though not always) struggle to provide high quality explanations

(e.g., Honomichl & Chen, 2006; Rittle-Johnson et al., 2008)

- Children aged 3 to 4 did not benefit from prompts to explain on a relational reasoning task, in part, because of low-quality responses, but those aged 4.5 to 5 did.

  (Honomichl & Chen, 2006)

- For example, over 25% of explanations in the pattern study were either "I don't know" or "Because I just knew."

  (Rittle-Johnson et al., 2008)

Combining Instructional- and Self-Explanation

One solution is to interleave instructional explanations that contain relevant, correct information.

- This gives children a chance to hear and model a high-quality explanation.

Research on the combination is inconclusive

- Seems instructional explanations often improve the quality of self-explanations
- But, combination not always better than self-explanation alone for overall learning and transfer

(Crowley & Siegler, 1999; Rittle-Johnson, 2006; Rittle-Johnson et al., 2013)

Current Study

We examined the *source* and *content* of children's explanations and its relation to patterning knowledge

Instructional Explanations

Self-Explanations

Self- and Instructional-Explanations

Current Study

Participants

- 124 children attending one of ten preschools in Nashville, TN
- Average age was 4.6 years (*min* = 4.0, *max* = 5.8)
- Approximately 27% were ethnic minorities

Design & Procedure

One-on-one session spanning two days

- Day 1: Pretest and Intervention Part I
- Day 2: Intervention Part II and Immediate Posttest

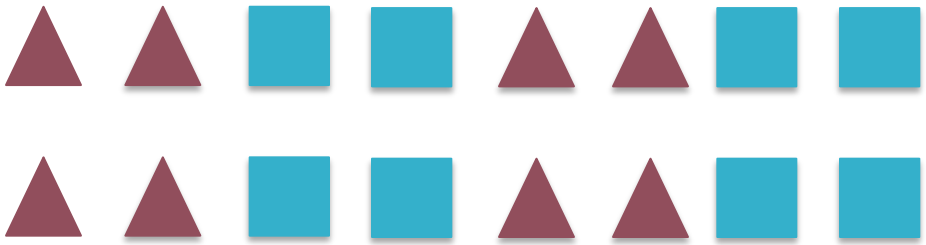
Participated in one of three conditions

- Instructional-explanation only (*n* = 41)
- Self-explanation only (*n* = 41)
- Self- and Instructional-explanation (*n* = 42)

Repeating Pattern Knowledge

Assessed pattern knowledge using four tasks

1. Duplication – make exact copy
2. Extension – identify what comes next
3. Abstraction – recreate pattern using new materials
4. Unit Identification – identify unit of repeat



(Clements & Sarama, 2009; Rittle-Johnson, Fyfe, McLean, & McEldoon, 2013)

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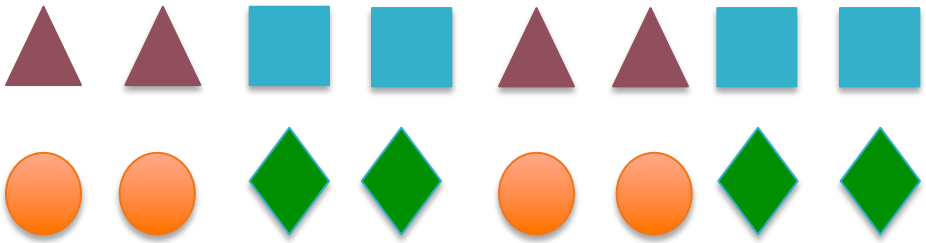

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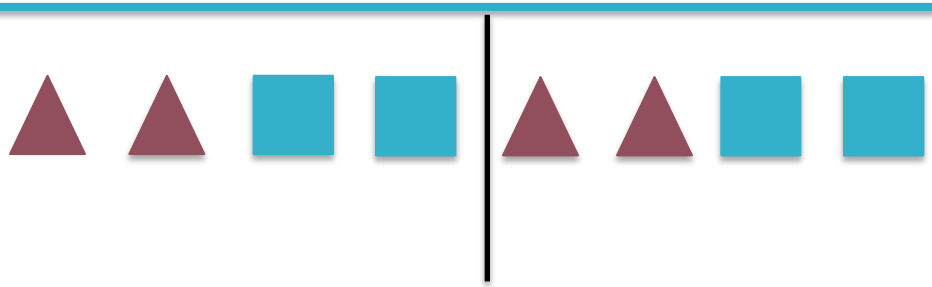
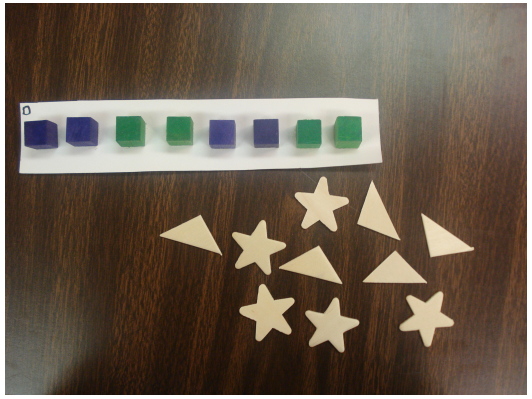


(Clements & Sarama, 2009; Rittle-Johnson, Fyfe, McLean, & McEldoon, 2013)

Pre and Posttest Assessment

Task	Pretest	Posttest
Duplicate	1	1
Extend	2	2
Abstract	2	3
Unit ID	0	2
Total # of Items	**5**	**8**



Intervention

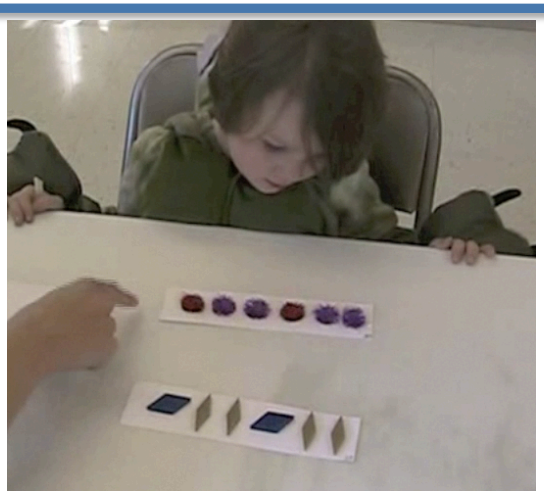
10 examples of abstracting a pattern

- 5 Correct examples
- 5 Solve items with feedback

Self-Explanation: prompted to explain on all 10 trials.

Instructional-Explanation: received instructional explanation on all 10 trials.

Self- and Instructional-Explanation : prompted to explain (5 trials) and received instructional explanations (5 trials)



Correct Example

Solve Item

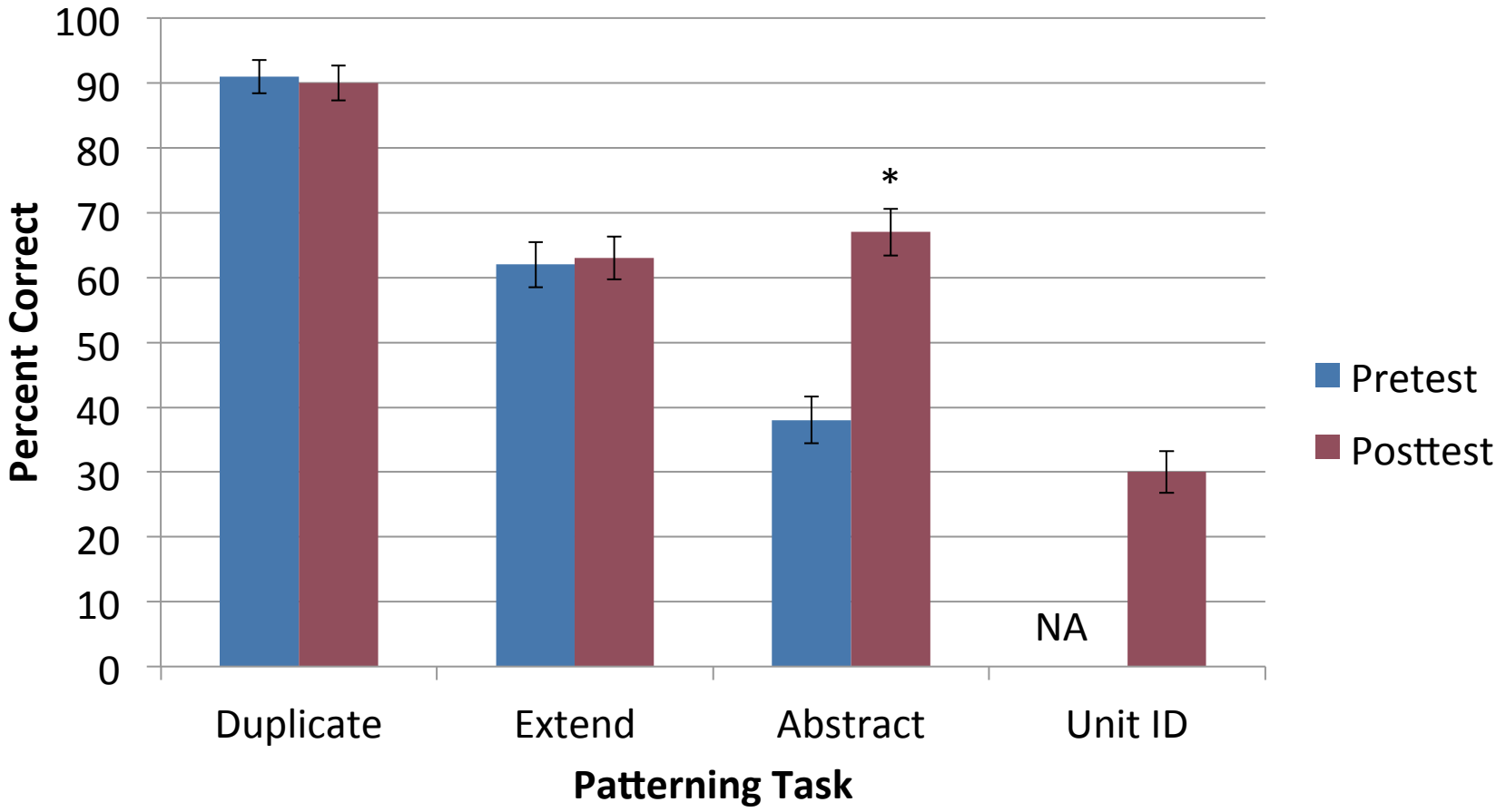
Intervention

Results

Goal 1

Systematically study young children's knowledge of repeating patterns, specifically pattern abstraction

Patterning Performance by Task



Post abstract > Pre abstract; $t = 8.2$, $p < .01$

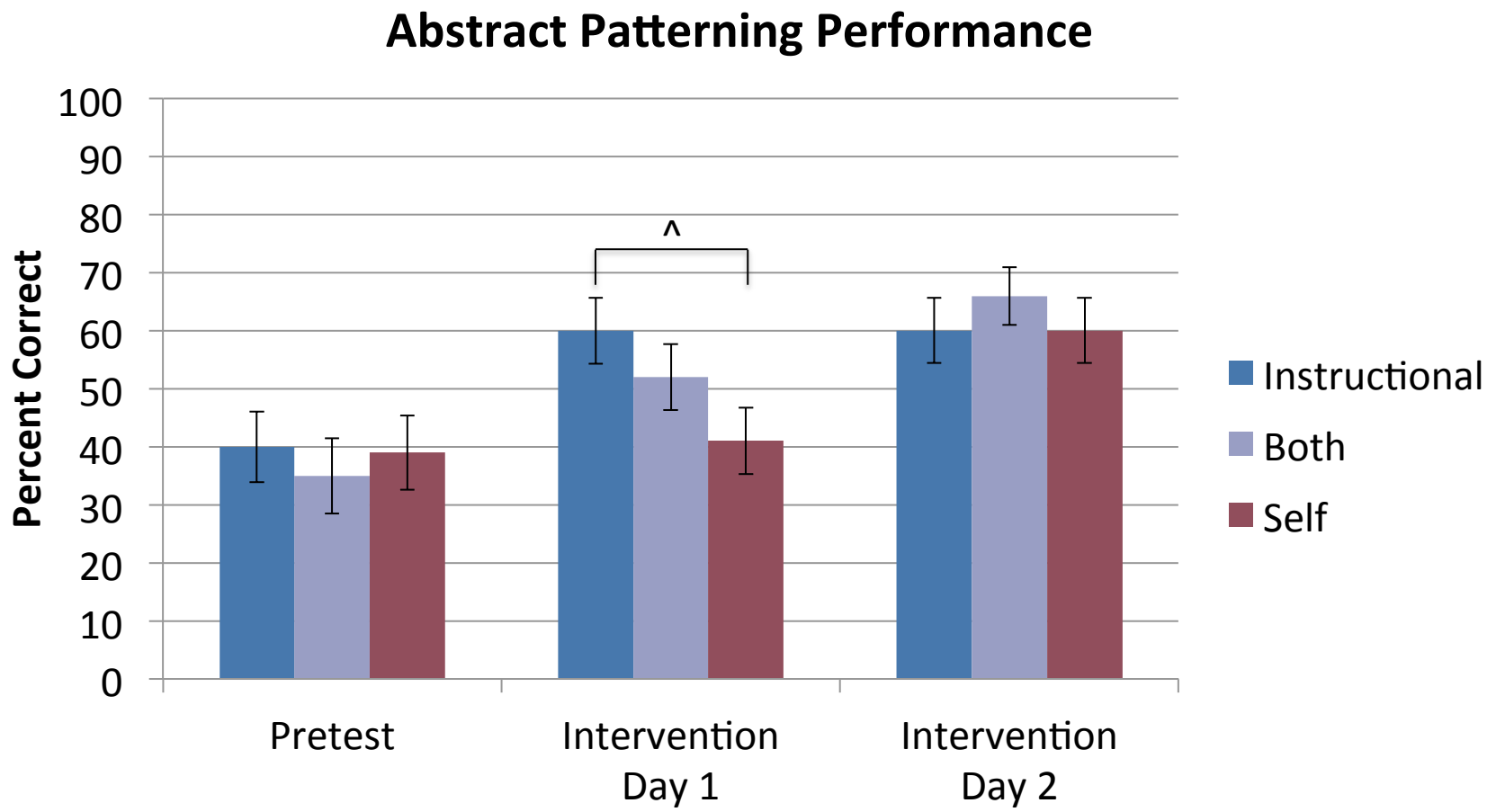
Results

Goal 2

Examine the impact of the *source* of explanations on children's patterning knowledge

Does it matter who provides explanations?

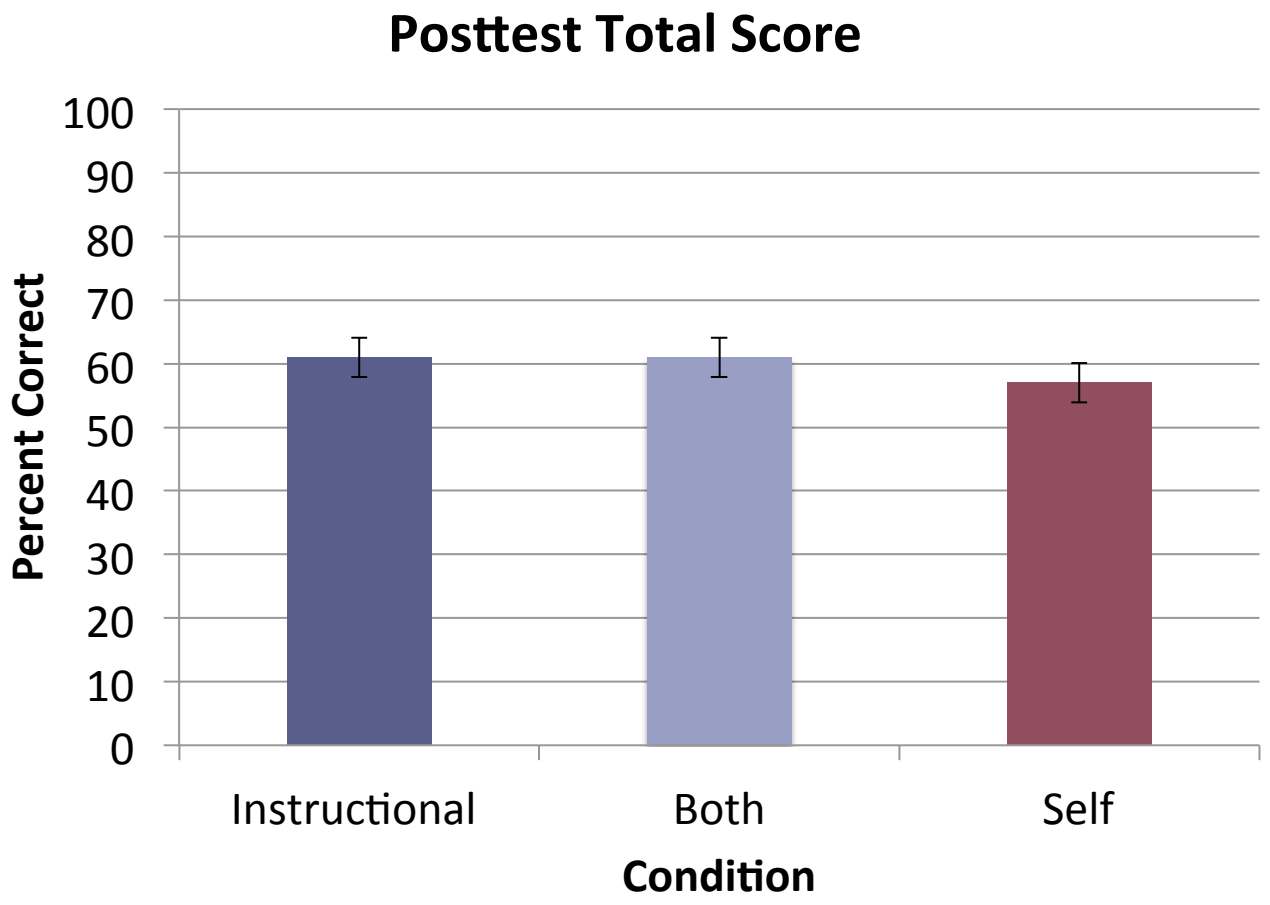
Intervention Accuracy



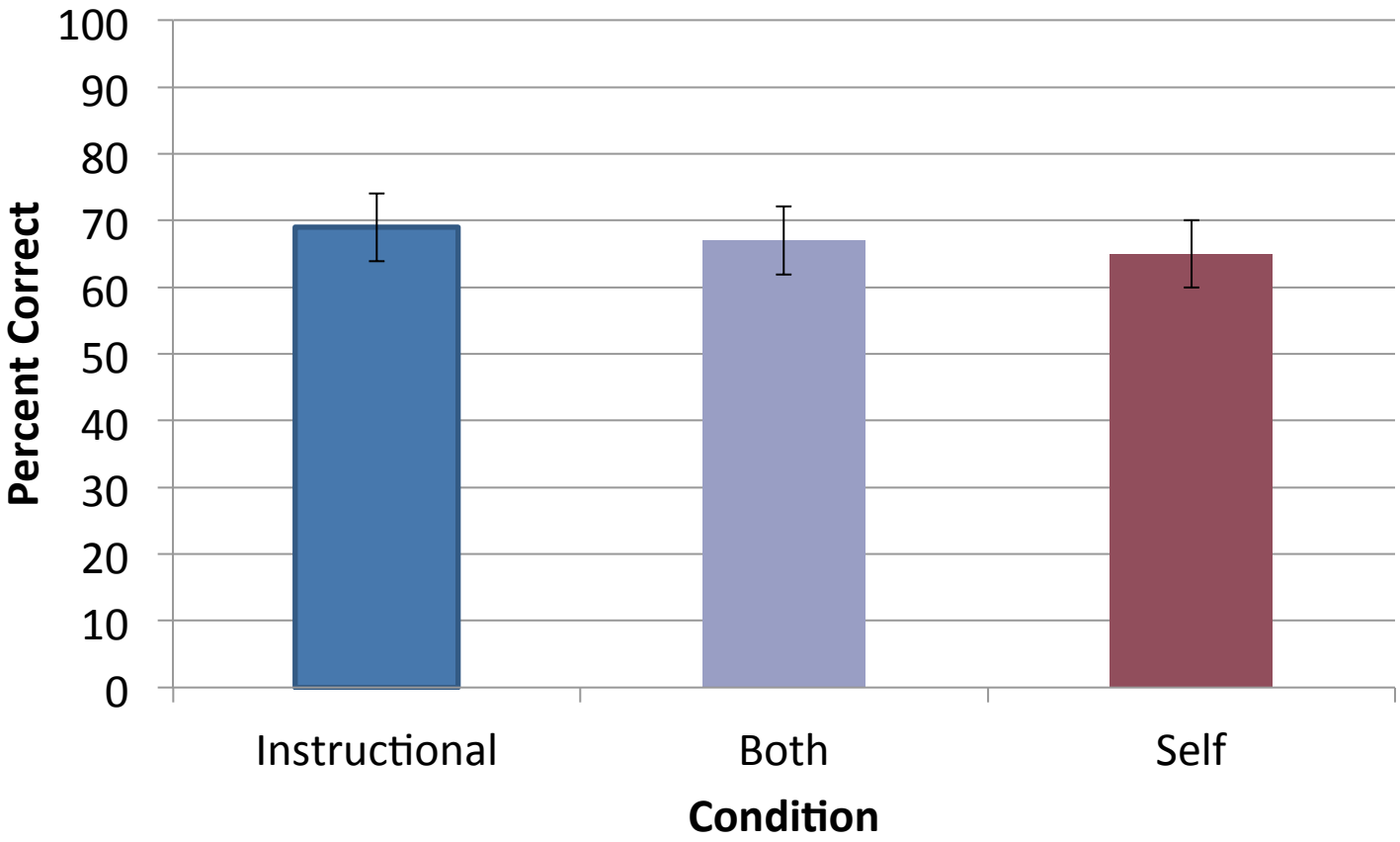
Effect of time; $F = 25.4$, $p < .01$

Int Day 1 Instructional > Self; $F = 2.7$, $p = .08$

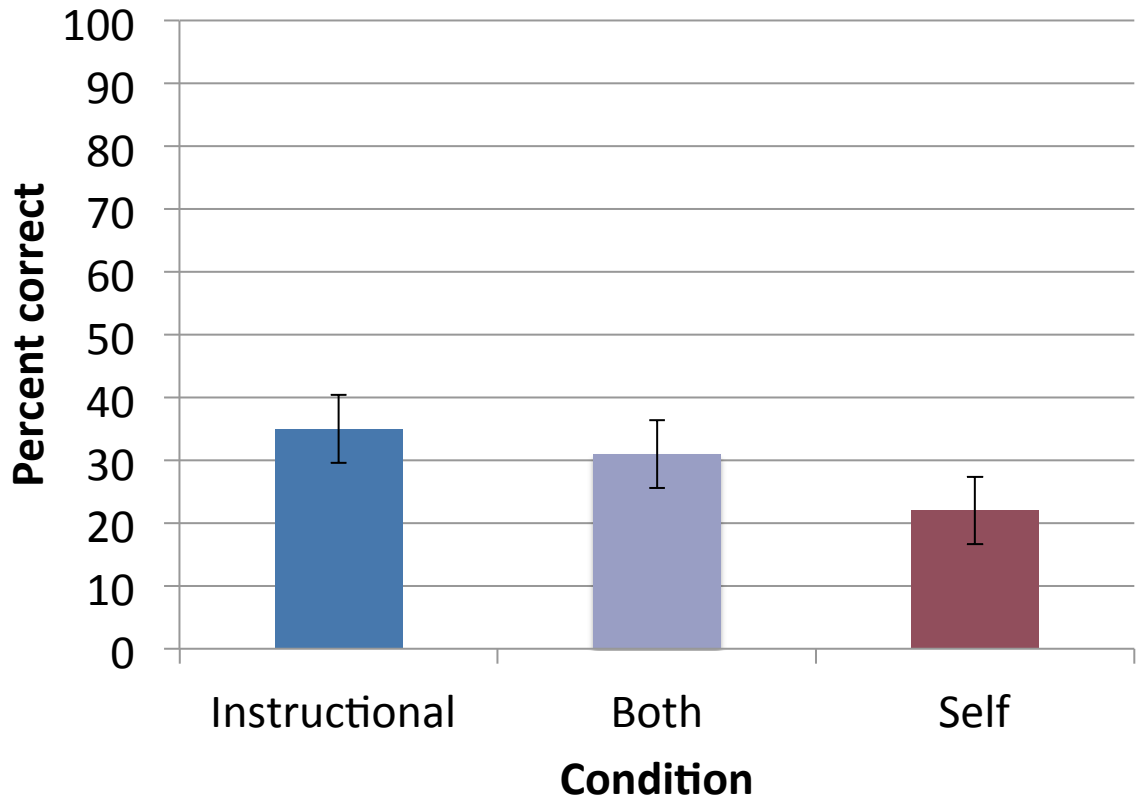
Posttest Results



Abstract Performance



Unit Identification



2 items

Instructional & Both > Self; $p = 0.11$

Summary

Goal 1

- Preschoolers are able to abstract patterns without extensive instruction

Goal 2

- Instructional and self-explanations both benefited children's abstract pattern knowledge similarly
- Combining instructional and self-explanations proved to be equally advantageous as either explanation alone.
- However, instructional explanations may be important for more difficult patterning tasks

Results

Goal 3

Examine the impact of the *content* of explanations on children's patterning knowledge

What is the content of children's explanations?

Do instructional explanations impact the content of children's explanations?

Does the content of children's explanations relate to learning?

Results

Children provided a variety of explanations. We coded their explanations for content into one of nine different categories.

A second rater coded 30% of responses and interrater reliability was high (kappa = .96)

"How is your pattern the same kind of pattern as mine?"

Explanation Code	Description	Example
Links Same/Different	Links the two patterns using same/different language	"Both patterns go same, same, different"
Links Elements	Links elements in both patterns using verbal labels	"Red in mine go with green in yours, blue go with yellow"
Links by Pointing	Links elements in both patterns using gestures only	Points to first three blocks in each pattern.
Same/Different	Uses same/different language in reference to elements in one pattern	"My pattern has one that's different and two the same"
Labels Items in Order	Labels the characteristics of at least three elements of one pattern	"Mine goes red, red, blue, red, red, blue"
Gestures to Pattern	Points to or sweeps over at least three elements of one pattern	Points to each element in one pattern.
Names Characteristics	Names characteristics of pattern elements without reference to position	"Yellow and blue"
Vague	Gives non-pattern response that does not fall into above categories	"Long" "Good"
No Response	Provides no response or provides explanation of uncertainty	Silence or "I don't know"

Content of Explanations Across Conditions

Explanation	% Used Across Trials	% of Children Who Used
Links Same/Different	6	17
Links Elements	15	37
Links by Pointing	5	17
Same/Different	11	30
Labels Items in Order	25	58
Gestures to Pattern	3	13
Names Characteristics	4	12
Vague	25	59
No Response	4	15

Impact of Instructional Explanations

Explanation	% Used Across Trials		% of Children Who Used	
	Self	Both	Self	Both
Links Same/Different	0*	12	0*	33
Links Elements	20^	10	44	31
Links by Pointing	6	3	22	12
Same/Different	1*	21	7*	52
Labels Items in Order	25	23	71*	45
Gestures to Pattern	5	2	17	10
Names characteristics	6	1	17	7
Vague	32	23	66	52
No Response	5	4	20	10

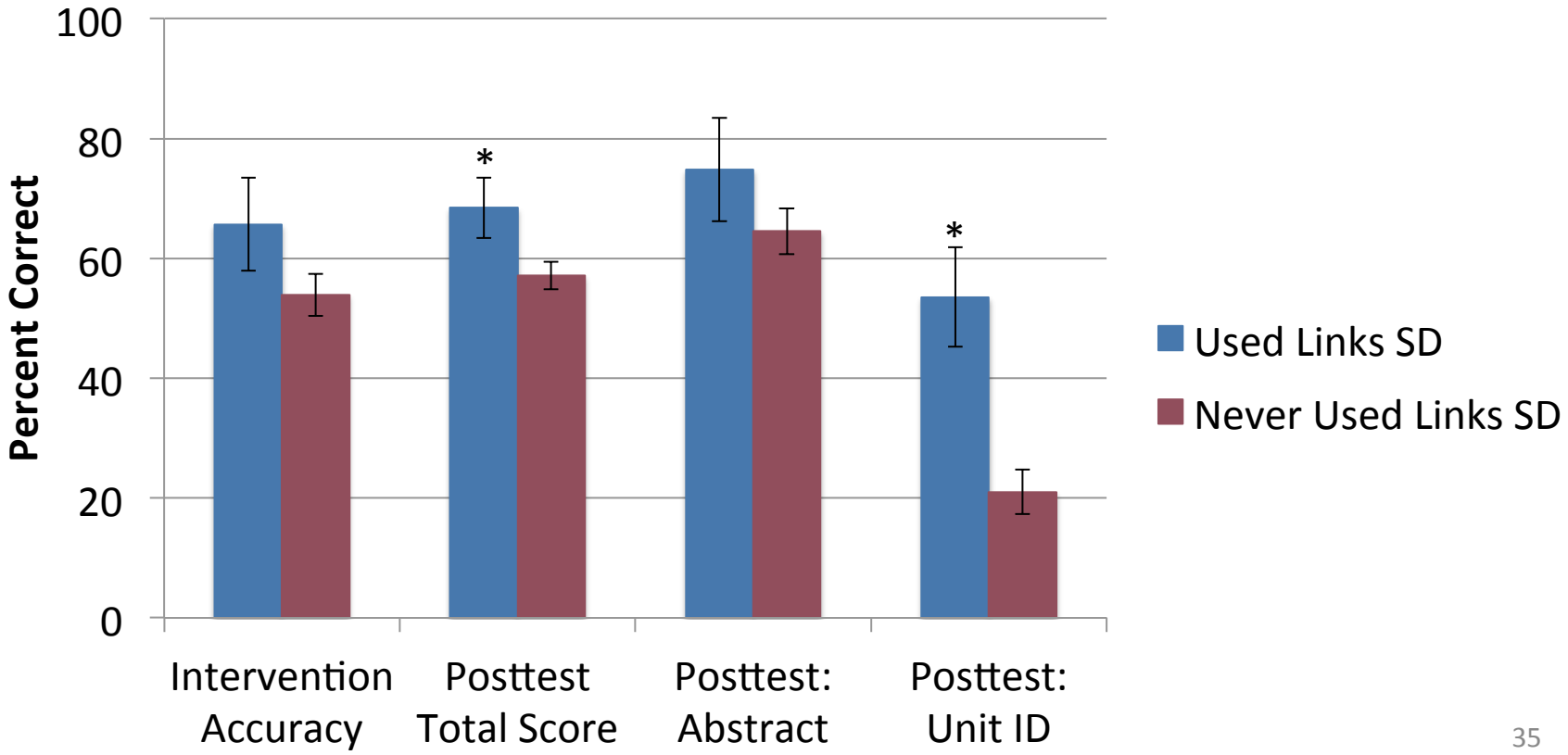
Relation to Learning

Examined whether frequency of Links Same/Different or Links Elements correlated with learning outcomes

	Intervention Accuracy	Posttest Total Score	Posttest: Abstract	Posttest: Unit ID
Link SD Use (Raw)	.26*	.23*	.18	.27*
Link SD Use (Control for Pretest)	.21*	.16	.10	.23*
Link Element Use (Raw)	.26*	.26*	.17	.16
Link Element Use (Control for Pretest)	.10	.09	.00	.04

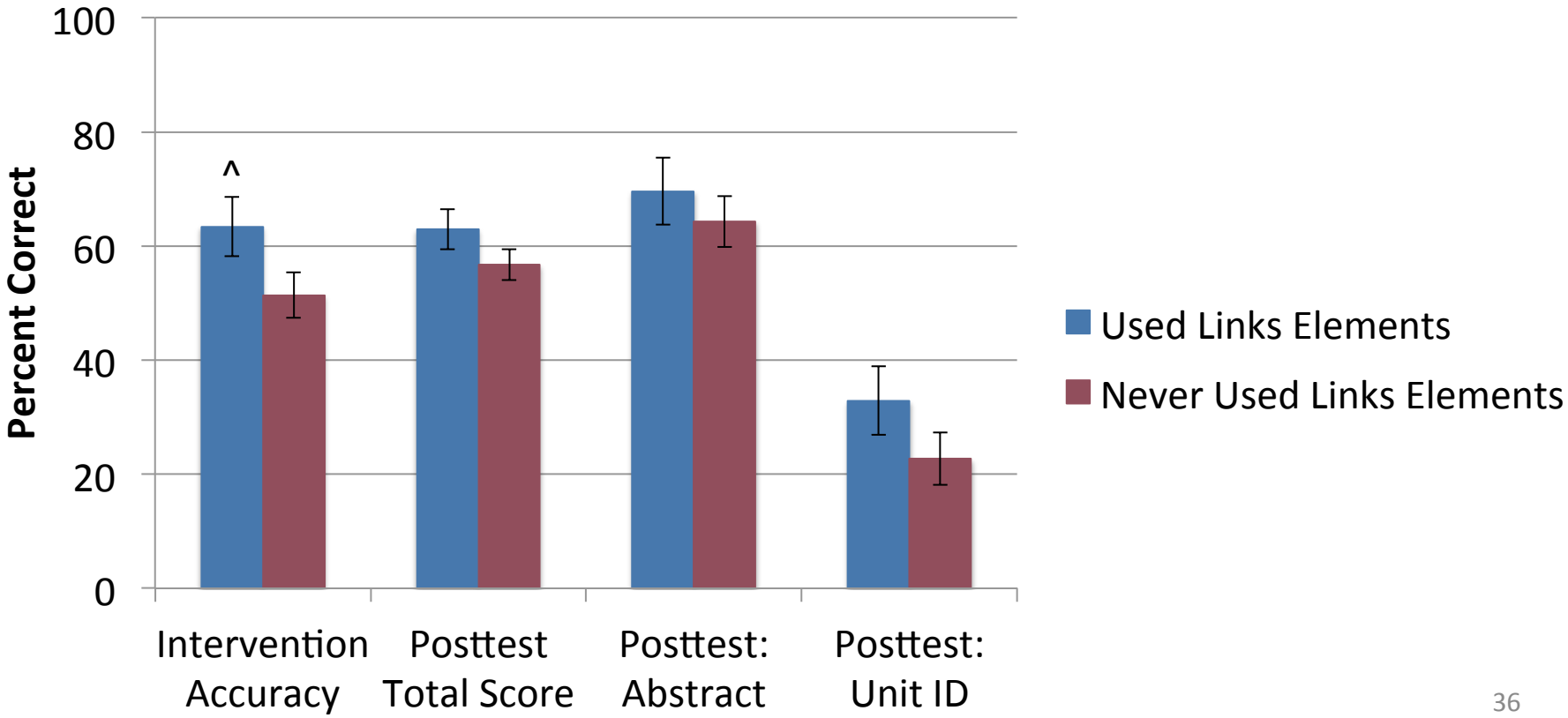
Relation to Learning

Examined whether children who ever used Links Same/Different differed from children who never used it. Fourteen children used it at least once (17% of sample). All of these children were in the self- and instructional-explanation group.



Relation to Learning

Examined whether children who ever used Links Elements differed from children who never used it. Thirty-one children used it at least once (37% of sample). Many were from the self-explanation group (18 out of 31).



Summary

Goal 3: Content of explanations matters!

- Here, frequency of using a link same/different explanation was positively correlated with intervention and posttest performance.
- Further, children who used this high-quality explanation scored higher than those who did not (particularly on difficult posttest items).

Discussion

Children demonstrated substantial pattern knowledge

- Most improved in pattern abstraction and some were even able to identify the unit of repeat
- Encouraging given the importance of repeating pattern knowledge for early algebra (Papic et al., 2011)

Discussion

Quality of explanations matter

- Consistent with prior work showing higher quality explanations relate to higher learning

  (e.g., Chi et al., 1989; Matthews & Rittle-Johnson, 2009)

Source of explanations doesn't matter directly

- Little difference between instructional-explanation, self-explanation, or a combination
- But, instructional explanations can be good source for improving the quality of self-explanations

  (e.g., Crowley & Siegler, 1991; Rittle-Johnson et al., 2013)

Thank You

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