Importance of Executive Function for Learning About Patterns

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Patterning

- *Repeating patterns* (e.g., ABBABB) are important for children's mathematics development (NCTM, 2000).
- Yet, it remains unclear how pattern knowledge develops in early childhood.

Cognitive Skills

- Understanding relations among pattern elements is likely influenced by a combination of experience and cognitive ability.
- *Analogical reasoning*: drawing comparisons among objects/experiences on the basis of parallel similarities.
- *Executive function (EF)*: cognitive abilities involved in the control of action and thought (working memory, inhibitory control, cognitive flexibility).

Goal

- Clarify the extent to which experience, analogical reasoning, and EF contribute to preschoolers' understanding of repeating patterns.

Pattern Skills

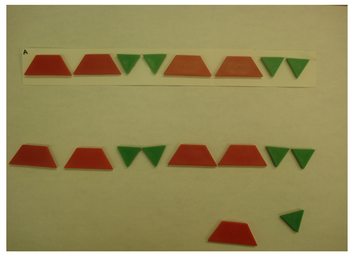
Level	Skill
Level 4: Pattern unit recognition	Identifies the pattern unit
Level 3: Pattern abstraction	Translates patterns into new patterns with same structural rule
Level 2: Pattern extension	Extends patterns at least one pattern unit
Level 1: Pattern duplication	Duplicates patterns

Clements &Sarama (2009); Rittle-Johnson et al. (in press)

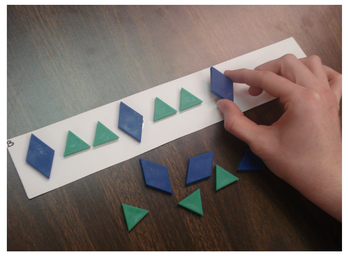
Method

***Participants*:** 124 preschoolers (53 female, *M* = 4.59 years, *SD* = 0.44 years, range: 4.00 to 5.82 years).
Procedure: Day 1: pattern pretest, FIST, Hand Game. Day 2: Backward Digit Span, pattern posttest, Match-to-Sample. Practice on 10 abstract patterns between sessions.
Measures
Pattern Assessment: Rittle-Johnson et al. (2013). 5 items at pretest (Levels 1-3), and 8 items at posttest (Levels 1-4).

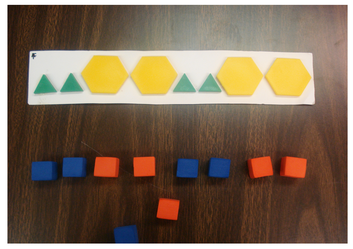
Level 1: Duplicate_AABB



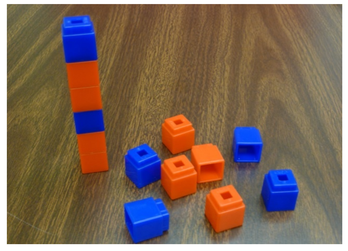
Level 2: Extend_ ABB



Level 3:AbstractColor_AABB



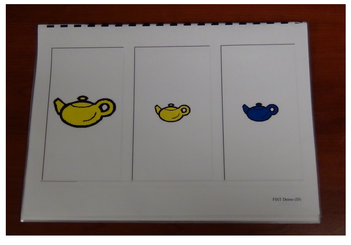
Level 4: SmallestTower_AAB



Working Memory: Backward Digit Span (Wechsler, 2003). Verbally repeat a single-digit number series in reverse order. Correct trials, with 2 trials/digit length, *M*=1.64, *SD*=1.31.

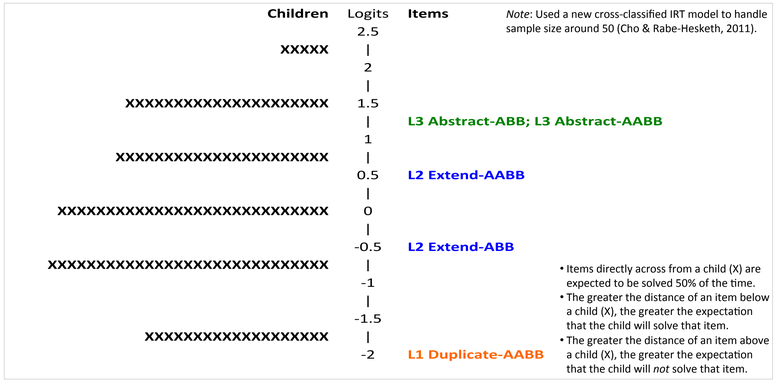
Inhibitory Control: Hand Game (Hughes, 1996). Make a fist when experimenter points finger, and point finger when experimenter makes a fist. 10 trials, *M*=4.83, *SD*=2.31.

Cognitive Flexibility: Flexible Item Selection Task (FIST; Jacques & Zelazo, 2001). Choose two pictures that match one way, and then choose two pictures that match another way. 9 trials, *M*=6.24, *SD*=2.36.



Analogical Reasoning: Match-to-Sample task (Kotovsky & Gentner, 1996). Select the picture that has the same relational rule (A-B-A, A-A-B, or A-B-B) as the top card. 8 trials, *M*=6.51, *SD*=1.56.

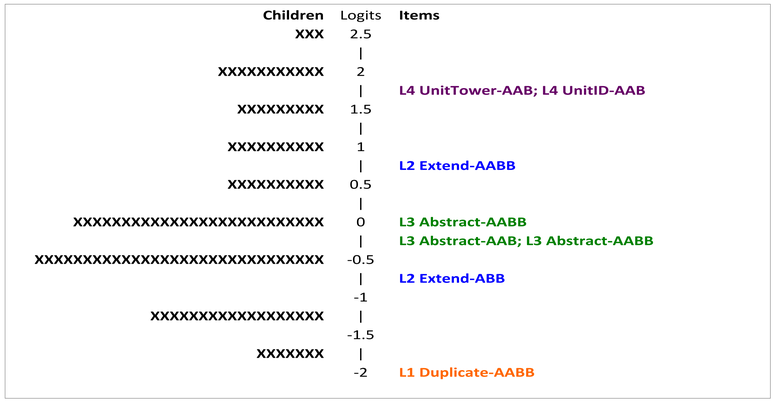
Wright Map – Pretest



Note: Used a new cross-classified IRT model to handle sample size around 50 (Cho & Rabe-Hesketh, 2011).

- Items directly across from a child (X) are expected to be solved 50% of the time.
- The greater the distance of an item below a child (X), the greater the expectation that the child will solve that item.
- The greater the distance of an item above a child (X), the greater the expectation that the child will *not* solve that item.

Wright Map – Posttest



Hierarchical Regression

Variable	*B*	*SE*	ß	ΔR^2
DV: Pattern Pretest				
Block 1				.28
Age	0.72	0.19	.29**	
Block 2				.18
Analogical reasoning	0.14	0.06	.20*	
Working memory	0.22	0.07	.26**	
Inhibitory control	-0.06	0.03	-.13	
Cognitive flexibility	0.14	0.04	.29**	
DV: Pattern Posttest				
Block 1				.47
Age	0.34	0.18	.13	
Pattern pretest	0.40	0.09	.40**	
Block 2				.10
Analogical reasoning	0.07	0.06	.10	
Working memory	0.23	0.06	.26**	
Inhibitory control	0.05	0.03	.11	
Cognitive flexibility	0.06	0.04	.13	

* $p < .05$. ** $p < .01$.

Results

- Preschoolers have a range of repeating pattern knowledge extending across tasks of varying difficulty.
- Analogical reasoning, working memory, and cognitive flexibility all contributed to pretest pattern knowledge.
- Working memory was the only *unique* predictor of posttest pattern knowledge, controlling for age and prior patterning knowledge.

Conclusions

- Increased capacity to consider and manipulate multiple pieces of information likely improves children's ability to identify, recreate, and learn about patterns.
- Findings bring greater awareness to the developmental mechanisms that are important to preschoolers' understanding and learning of patterns.

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