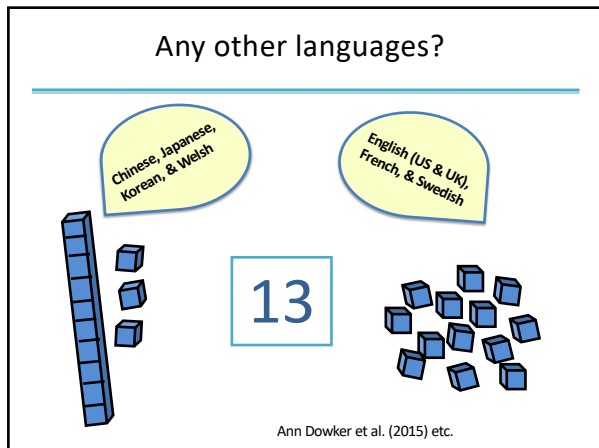
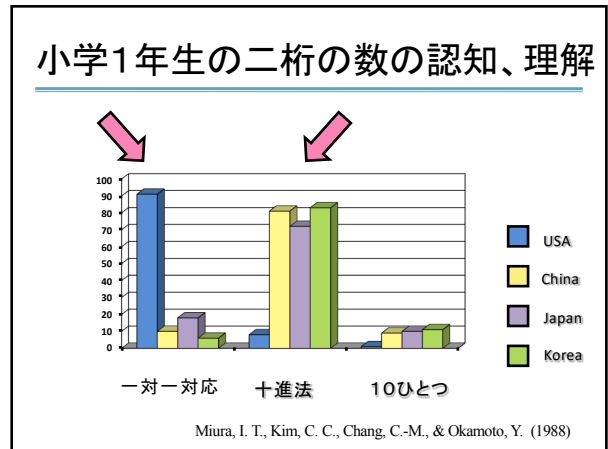
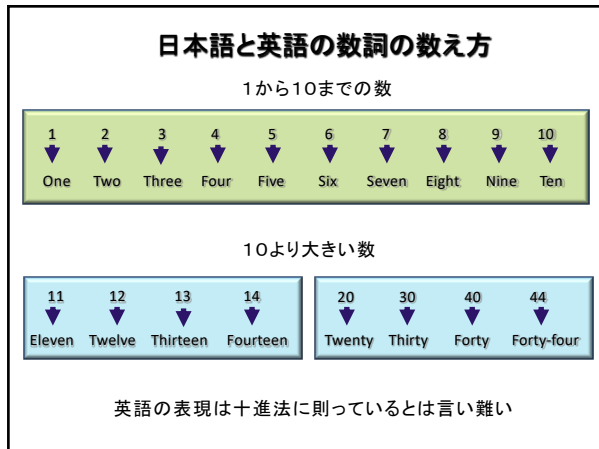


子どもはどのように数学力を身につけていくか  
 一数言語、数直線、および空間思考の役割—

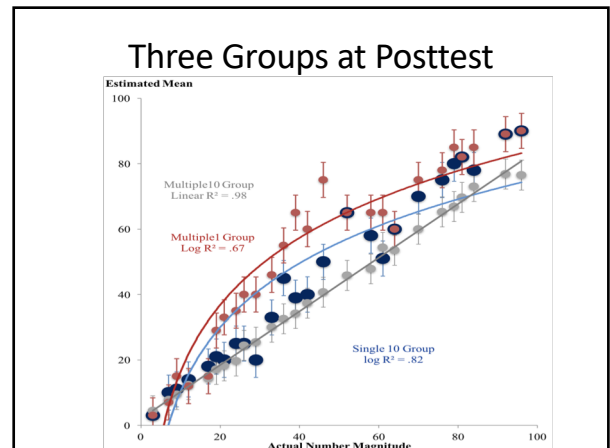
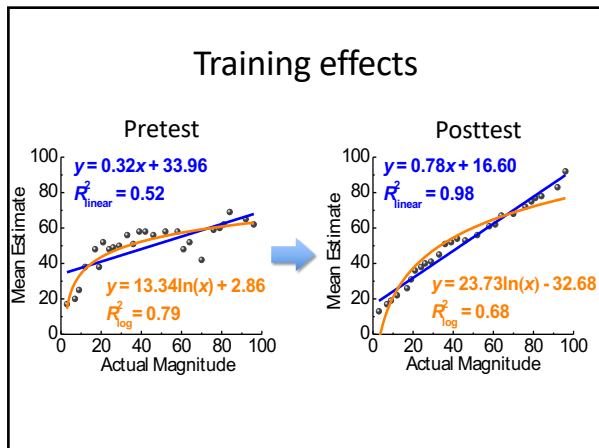
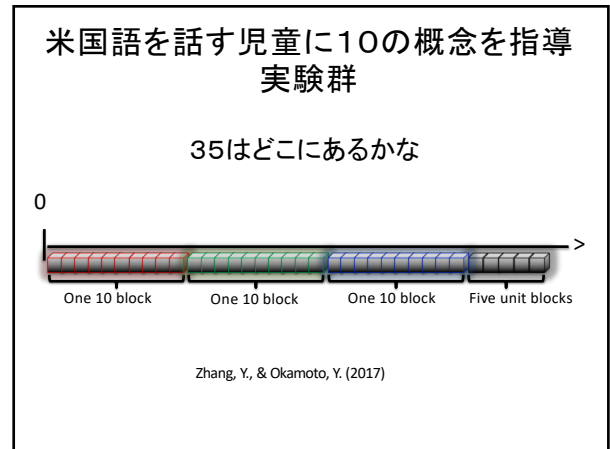
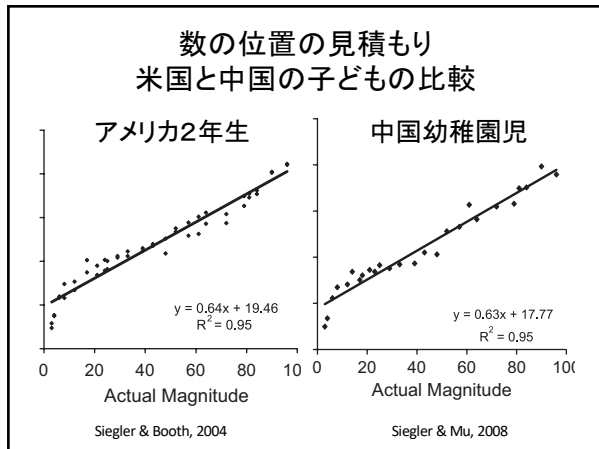
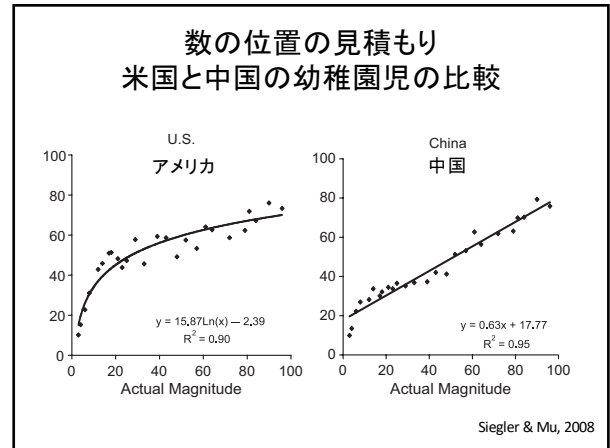
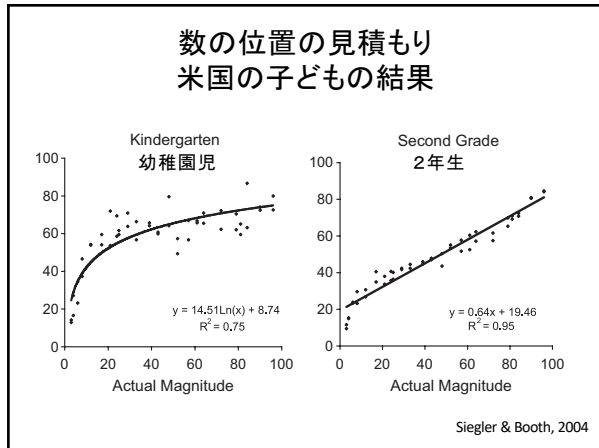
カリフォルニア大学サンタバーバラ校  
 教育学博士 岡本ゆかり

主な研究分野

- 認知発達 (新ピアジェ派)
  - Okamoto, Y. (1996). Modeling children's understanding of quantitative relations in texts: A developmental perspective. *Cognition and Instruction*, 14(4), 409-440.
- 言語と数学力との関係
  - Okamoto, Y. (2015). Mathematics Learning in the USA and East Asia: Influences of Language. In R. Kadosh & A. Dowker (Eds.), *Oxford Handbook of Numerical Cognition*. UK: Oxford University Press.
- 授業実践の国際比較 (数学、理科)
  - Roth, K. J., Druker, S. L., Garnier, H., Lemmens, L., Chen, C., Kawaka, T., Okamoto, Y., Rasmussen, D., Trubacova, S., Warvi, D., Gonzales, P., Stigler, J., & Gallimore, R. (2006). Teaching Science in Five Countries: Results from the TIMSS 1999 Video Study of Eighth-grade Science Teaching. U.S. Department of Education.
- 有理数 (分数、割合)
  - Siegler, R., Carpenter, T., Fennell, F., Geary, D., Lewis, J., Okamoto, Y., Thompson, L., & Wray, J. (2010). *Developing effective fractions instruction for kindergarten through 8th grade: A practice guide*. National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.
- 数直線的思考の利点
  - Zhang, Y., & Okamoto, Y. (2017). Encoding "10ness improves first graders' estimation of numerical magnitudes. *Journal of Numerical Cognition*, 2, 202-219.
- 空間思考
  - Evans, G., & The Spatial Reasoning Study Group. (2015). *Spatial reasoning in the early years: Principles, assertions, and speculations*. New York: Routledge.
- Biology/health science curriculum for Latino children from low-income families
- プログラミング、空間理解、数学力
  - Francis, K., Bruce, C., Davis, B., Drefs, M., Hallowell, D., Hawes, Z., McGarvey, L., Moss, J., Mulligan, J., Okamoto, Y., Sinclair, N., Whiteley, W., & Wootcott, G. (2017). Multidisciplinary perspectives on a video case of children designing and coding for robotics. *Canadian Journal of Science, Mathematics and Technology Education*, 17(3), 165-178.



- どういった利点があるか
- 10をベースにした考え方
  - 筆算のやり方
  - 数の位置の見積もり



### 考察

- 短期の介入で米国の1年生は2年生のような理解をしめた。
- 数学言語に関する研究をふまえた授業介入で、子どもの数学力に影響を及ぼすことが可能である。

### 言語と数学力との関係

- 位取りの概念の理解
- 10をベースにした考え方
- 筆算のやり方
- 数の位置の見積もり

### 日本語は最適？

- 欠点 classifier system
- 日本語も韓国語も2つの数詞の数え方がある

### 韓国語の数詞の数え方

1から10までの数

	1	2	3	4	5	6	7	8	9	10
I-K	hana	dool	set	net	dasut	yusut	ilgop	yudulp	ahop	yul
S-K	il	ee	sam	sah	oh	yook	chil	pal	goo	shib

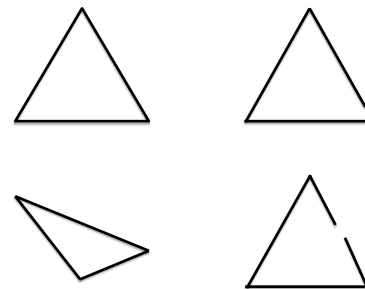
10より大きい数

	11	12	13	14	20	25	35	45
I-K	yul-hana	yul-dool	yul-set	yul-net	sumul	sumul-dasut	sulheun-dasut	maheun-dasut
S-K	shib-il	shib-ee	shib-sam	shib-sah	ee-shib	ee-shib-oh	sam-shib-oh	sah-shib-oh

S-K 十進法に則っているが、I-Kの表現は20以降はそうでない

### 図形の名称と図形の特徴の理解

- 三角形 — triangle
- 正方形 — square
- 長方形 — rectangle
- 台形 — trapezoid
- 五角形 — pentagon
- 三角柱 — triangular prism
- 四角錐 — square-based pyramid



### 空間思考と数学力

Canada  
 University of Calgary  
 University of Toronto  
 University of Alberta  
 University of Victoria  
 Simon Fraser University  
 Trent University  
 Wilfrid Laurier University  
 York University

Australia  
 Macquarie University  
 Southern Cross University

USA  
 UC Santa Barbara

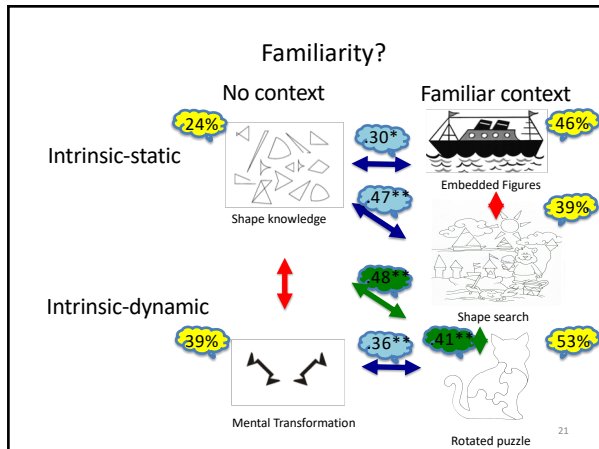
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### Preschoolers' Intrinsic Spatial Reasoning

- 45 children (22 girls)
- 4 years 6 months
- 5 measures

- ✓ How do children do on the 5 measures (relations)?
- ✓ Is familiarity a factor?
- ✓ Any demographic factors?

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### Demographic Factors?

- Only gender difference
  - Girls > Boys on the Puzzle task
- Only maternal education difference
  - Graduate School > High School on the Embedded Figures Test
- Age of preschool entry
  - Earlier > Later on all measures

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### Preschoolers' Intrinsic Spatial Reasoning

- ✓ How do children do on the 5 measures (relations)?
  - Mostly expected but some unexpected
- ✓ Is familiarity a factor?
  - Context matters
- ✓ Any demographic factors?
  - Early entry to preschool matters

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### 空間理解と数学力

“The relation between spatial ability and mathematics is so well established...”  
 (Mix & Cheng, 2012, p. 206)

例えば...

- メンタル回転 -> SAT-M (Casey, Nuttall, Pezaris, & Benbow, 1995)
- 空間メカニカル思考 -> 数学力テスト (Casey, Nuttall, & Pezaris, 2001)
- メンタル回転 -> 数の位置の見積もり-> 概算 (Gunerson, Ramirez, Beilock & Levine, 2012)

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### アメリカのカリキュラム Common Core State Standards 幾何

- 幼稚園の年長さんは...
  - 図形を識別、説明できる
  - 複合された図形を分析、比較、そして作る事ができる
- 小学校の一年生は...
  - 図形とその特徴について理由付けすることができる

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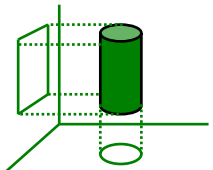
### 子ども教室でのより深く理解を促すのか

Plane Geometric Shapes		Solid Geometric Shapes	
<b>square</b> • 4 equal sides • 4 right (90°) angles • The sum of the inside angles equals 360°.	<b>circle</b> • closed curve with a set of points in one plane and the same distance from a center point • Circumference (C) is the perimeter of a circle.	<b>cube</b> • 6 equal square faces • 12 edges and 8 vertices • The angle between two adjacent faces is 90°.	<b>sphere</b> • no faces, sides, or vertices • All points are located at the same distance from the center.
<b>pentagon</b> • 5 sides and 5 angles • The sum of the inside angles equals 540°. • equilateral pentagon: sides & angles are equal	<b>triangle</b> • 3 sides and 3 angles • The sum of the inside angles equals 180°. • Types of triangles: equilateral, isosceles, right, scalene	<b>rectangular prism</b> • 6 rectangular faces, opposite faces are equal • 12 edges and 8 vertices • The angle between two adjacent faces is 90°.	<b>cylinder</b> • 2 circular faces that are congruent (same shape and size) and parallel (same distance from each other) • faces connected by a curved surface
<b>rectangle</b> • 4 sides opposite sides parallel & equal in length • 4 right (90°) angles • The sum of the inside angles equals 360°.	<b>rhombus</b> • 4 equal sides • opposite angles are equal • The sum of the inside angles equals 360°.	<b>pyramid</b> • 1 polygonal base • 3 or more triangular faces connect to make an apex • named according to shape of base	<b>regular tetrahedron</b> • triangular prism with 4 triangular faces, 6 edges, and 4 vertices • triangles are congruent (same shape and size) and equilateral (all sides the same length)
<b>trapezoid</b> • 4 sides • 2 parallel sides • The sum of the inside angles equals 360°.	<b>octagon</b> • 8 sides and 8 angles • 8 inside angles • The sum of the inside angles equals 1080°.	<b>cone</b> • A circular base with a curved surface connecting the base to the apex • Types of cones: right, oblique	<b>triangular prism</b> • 5 faces, 9 edges, and 6 vertices • 2 bases are triangular, congruent, and parallel
<b>hexagon</b> • 6 sides and 6 angles • Opposite sides of a regular hexagon are parallel. • The sum of the inside angles equals 720°.	<b>parallelogram</b> • 4 sides, opposite sides parallel and equal in length • The square, rhombus, and rectangle are parallelograms.		

### 小学校一年生は 図形をどのように理解しているか

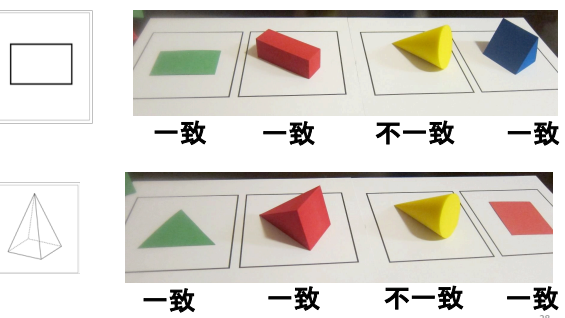
**参加者**  
一年生 36名 (女児20名)

**課題**  
図形の分解と合成



Hallowell, Okamoto, Romo, & La Joy (2015)

### 図形の分解と合成課題



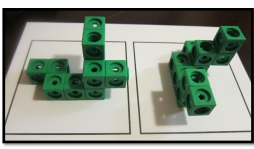
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一致   一致   不一致   一致

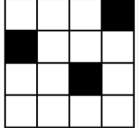
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### 子どもの図形の理解？

- メンタル回転課題  
Casey et al. (2008)



- 空間スパン課題  
Crammond's (1992)



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### 算数、数学の授業で 空間思考力を育む必要性

- 空間思考力は指導次第で伸びる
- 種々の授業介入で空間思考力の伸びが確認されている
  - コンピューターゲーム
  - 折り紙
  - パズル
  - 絵を描く
  - ブロック使用

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