In Tribute to Bob Siegler’s Mentorship

Children’s Relational Thinking:
An information-processing perspective and a microgenetic approach

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Key Themes or Domains of Bob’s Research in Children’s Thinking

- Scientific Reasoning & Understanding
- Rule Assessment
- Numerical Understanding
- Strategy Choices
- Microgenetic Approach
- Mathematical Cognition
- Children’s Learning
- Numerical Estimation
- Board Games
- Understanding of Fractions
Children’s Relational Thinking

Relational Thinking:
The capacity to manipulate in our minds abstract mental representations of relations among objects, attributes, and events.

Relational reasoning is central to human thinking and is evident in early childhood as a building block in many areas of higher-order cognition:

- analogical thinking
- spatial reasoning
- pictorial mapping
- symbolic functioning
- metaphorical thinking
- scientific reasoning
Role of Relational Reasoning in Children’s Thinking:

A study using the NICHD longitudinal data set demonstrates the central role of relational reasoning in children’s thinking and learning

Merritt, Chen, et al. (under review)

Structural equation modeling: A holistic approach to tracking the source of variability in high-school STEM achievements:

<table>
<thead>
<tr>
<th>1 Month</th>
<th>36 Months</th>
<th>54 Months</th>
<th>3rd and 4th Grade</th>
<th>9th Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal Education</td>
<td>-0.18**</td>
<td>0.36***</td>
<td>0.29**</td>
<td></td>
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<tr>
<td>Engagement</td>
<td></td>
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<tr>
<td>Enrichment</td>
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<td>Planning</td>
<td>0.34**</td>
<td></td>
<td></td>
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<tr>
<td>Relational Reasoning</td>
<td></td>
<td>0.31**</td>
<td></td>
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<tr>
<td>Executive Function</td>
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<td>STEM Achievement</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Calculation</td>
<td>-0.27**</td>
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<tr>
<td>Calculation</td>
<td></td>
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</tr>
</tbody>
</table>

** indicates statistical significance at the 0.01 level.
Structural equation modeling: A holistic approach to tracking the source of variability in high-school STEM achievements:

Cognitive Processes Involved in Children’s Relational Reasoning:

A componential analysis
an eye-tracking method
A microgenetic approach

Examining the cognitive processes involved in relational reasoning: 5- to 8-year-old children’s relational reasoning in solving matrix completion tasks:

Chen et al., (2016) *Developmental Psychology*
Examining trial by trial children’s relational problem solving and the processing strategies that underlie their relational thinking:

- Encoding relations
- Integrating rules
- Completing the model
- Generalizing strategies across tasks

Examples of the matrix completion tasks used in the present study
Five- & 6-year-olds’ and 7- & 8-year-olds’ matrix completion problem-solving performance over the four phases
Children's strategy use in encoding relations

Children's strategy use in integrating relations
Children's strategy use in toggling – completing the model

Five- & 6-year-olds’ matrix completion problem-solving performance over the four phases in the No Feedback and Feedback conditions
Children’s strategy use in encoding (Panel A), integrating (Panel B), and toggling (Panel C)
A stepwise regression analysis:

- **Age**
- **Encoding** (32%)
- **Integrating**
- **Toggling** (Additional 5%)

**Problem-Solving Performance**

**Additional 11%**

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**Cognitive Processes Involved in Children’s Relational Reasoning:**

Extending the componential analysis to 3- to 6-year-old children’s relational reasoning in solving *classic analogy tasks* (A:B::C:?)

Nishida, Chen et al. (in preparation)
Classic analogy tasks: Both abstract and concrete:
Preliminary analyses suggested that:

- Older children outperformed the younger group in solving the analogy tasks;
- Older children were more likely to use the encoding and toggling strategies in solving the problems;
- Encoding and Toggling measures were predictors of problem-solving performance;
- Executive Function was predictor of strategy use as well as problem-solving performance.
Relational Thinking: A comparison between children with autism spectrum disorder (ASD) and typically developing (TD) children

Extending the componential analysis to different populations using a different type of relational reasoning task: *pictorial mapping problems*

Li, Chen et al. (under review)

Children participated in four groups: 6- and 8-year-old ASD children and age-matched TD children. The older ASD group and the younger TD group were matched by IQ.

Differences in relational mapping between ASD and TD children were predicted by the *Weak Central Coherence theory*, which posits that individuals with autism tend to engage in local, detail-focused processing instead of engaging in global processing and extracting coherent representations.
Examples of the picture comparison task (A), object-mapping task (B), and the cross-mapping task (C).
Children with ASD tended to focus on lower-level commonalities, such as featural similarities, and to omit the higher-level relations in solving the relational mapping tasks;

Children with ASD were less likely to use the encoding and toggling strategies in solving the problems;

Both encoding and toggling measures were predictors of problem-solving performance;

Executive functions were predictors of strategy use as well as problem-solving performance;

Deficiencies evident in this study in ASD children's relational thinking support the Weak Central Coherence (WCC) theory.

Relational Thinking in Young and Older Adults: A study on analogical reasoning

Honomichl, Miller, & Chen (in preparation)
A classic analogy task: One transformation:

```
1  2  3  4

arrow  ←  ●  ?
```

A classic analogy task: Three transformations:

```
1  2  3  4

1  2  3  4

1  2  3  4
```

```
arrow  ●  ●  ?
```

```
up  ●  ●  ?
```

```
up  ●  ●  ?
```

```
up  ●  ●  ?
```

```
up  ●  ●  ?
```
Preliminary analyses suggested that:

- Younger adults outperformed the older group in solving the classic analogy tasks;

- Problem-solving performance decreased with problem complexity (i.e., increased number of transformations), especially for the older group;

- Older adults were less likely to engage in toggling when solving the problems;

- Processing strategies were predictors of problem-solving performance;

- Working memory acted as mediator of age-related changes in problem-solving strategies and performance.

**A Componential Model of Relational Thinking:**

- **Encoding**: Representing relations and integrating relevant rules
- **Mapping**: Completing the model by aligning relations between entities, spaces, and structures
- **Generalizing**: Transferring the processing strategies across isomorphic tasks
The Ability to encode, map, and generalize...

• Is a predictor of relational reasoning performance
• Increases with age during childhood
• Declines with age during late adulthood
• Mediates between EF and problem-solving performance
• Is deficient in ASD children
• Is promoted by experience, feedback & instruction

Thank You!