Development of Reasoning
Development of Reasoning

- Single-response reasoning
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
    - Inductive inference
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
Development of Reasoning

- **Single-response reasoning**
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - **Deductive (formal) reasoning:**
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - Deductive (formal) reasoning:
    - Categorical & transitive inference
Development of Reasoning

- **Single-response reasoning**
  - **Inductive reasoning:**
    - Inductive inference
    - Analogical inference
  - **Deductive (formal) reasoning:**
    - Categorical & transitive inference
    - Rule use
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - Deductive (formal) reasoning:
    - Categorical & transitive inference
    - Rule use
- Extended reasoning
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - Deductive (formal) reasoning:
    - Categorical & transitive inference
    - Rule use

- Extended reasoning
  - flexibility; planning in children
Inductive reasoning:
From specific to general
Inductive reasoning:
From specific to general

- Inductive inference:
Inductive reasoning: From specific to general

- Inductive inference:
  - Find patterns in limited evidence (example?)
Inductive reasoning: From specific to general

- Inductive inference:
  - Find patterns in limited evidence (example?)
    - Toddlers?? Chen et al: “pull the string”
Inductive reasoning:
From specific to general

Inductive inference:
- Find patterns in limited evidence (example?)
  - Toddlers?? Chen et al: “pull the string”
- Problem: how to select most relevant info?
Inductive reasoning:
From specific to general

Inductive inference:
- Find patterns in limited evidence (example?)
  - Toddlers?? Chen et al: “pull the string”
- Problem: how to select most relevant info?
  - Children’s balance scale “rules”: Going the distance
Inductive reasoning:
From specific to general

- Inductive inference:
  - Find patterns in limited evidence (example?)
    - Toddlers?? Chen et al: “pull the string”
  - Problem: how to select most relevant info?
    - Children’s balance scale “rules”: Going the distance
    - Other kinds of problems?
Sample problem...
Sample problem...

“A patient has an inoperable stomach tumor. There is a type of ray that, at great intensity, can destroy the tumor. At that intensity, however, the ray will also destroy any tissue it passes through. How can you save the patient?”
Sample problem...

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...
Sample problem...

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Does the story help? Why?
Anological Inference (Inductive)
Analogical Inference (Inductive)

- Effects on solving hard problems
Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
  - Effects of surface similarity (age matters!)
Anological Inference (Inductive)

- Effects on solving hard problems
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  - Hints & discussion (Brown & Kane study...)

Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
  - Effects of surface similarity (age matters!)
  - Hints & discussion (Brown & Kane study...)
  - Role of content knowledge:
Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
  - Effects of surface similarity (age matters!)
  - Hints & discussion (Brown & Kane study...)
  - Role of content knowledge:

  PLANET: SOLAR SYSTEM::ELECTRON:???
Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
  - Effects of surface similarity (age matters!)
  - Hints & discussion (Brown & Kane study...)
  - Role of content knowledge:
    - PLANET: SOLAR SYSTEM::ELECTRON:???
    - RUNAWAY STROLLER: EISENSTEIN::SINKING PIANO: ???
Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
  - Effects of surface similarity (age matters!)
  - Hints & discussion (Brown & Kane study...)
  - Role of content knowledge:

  PLANET: SOLAR SYSTEM::ELECTRON:???
  RUNAWAY STROLLER: EISENSTEIN::SINKING PIANO: ???
Anological Inference (Inductive)

- Effects on solving hard problems
- Children use analogy to solve problems:
  - Effects of surface similarity (age matters!)
  - Hints & discussion (Brown & Kane study...)
  - Role of content knowledge:
    - PLANET: SOLAR SYSTEM::ELECTRON:???
    - RUNAWAY STROLLER: EISENSTEIN::SINKING PIANO: CAMPION
Brown & Kane (1988): Effects of hints and discussion
Brown & Kane (1988): Effects of hints and discussion

- 100
- 75
- 50
- 25
- 0

3-year-olds  4-year-olds  5-year-olds

- hints/disc.
- no hint
- control
Brown & Kane (1988): Effects of hints and discussion

- 3-year-olds
- 4-year-olds
- 5-year-olds

Hints/disc.
No hint
Control
Brown & Kane (1988): Effects of hints and discussion

![Bar chart showing effects of hints and discussion for 3-year-olds, 4-year-olds, and 5-year-olds. The chart compares 'hints/disc.', 'no hint', and 'control' conditions.]
Brown & Kane (1988): Effects of hints and discussion

![Bar chart showing the effects of hints and discussion on performance of 3-year-olds, 4-year-olds, and 5-year-olds. The chart compares the performance of groups with hints/discussion, no hint, and control conditions.]
Deductive Reasoning: From general to specific
Deductive Reasoning: From general to specific

Example: Laura (3 yrs., to mom, re: open soda can): “Whose is this? It’s not yours ‘cause it doesn’t have lipstick.”
Deductive Reasoning: From general to specific
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?
Categorical (class-relation) inferences...
Categorical (class-relation) inferences...

“Are there more bunnies or more animals?”
Categorical (class-relation) inferences...

“Are there more bunnies or more animals?

- Kids under 7-8 years often say “bunnies”!
Categorical (class-relation) inferences...

“Are there more bunnies or more animals?

- Kids under 7-8 years often say “bunnies”!
  - Why?
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?

- Categorical syllogisms:
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?

- Categorical syllogisms:
  1. All artists are beekeepers
Deductive Reasoning: From general to specific

- **Categorical & transitive inferences:**
  - can children ever do these?

- **Categorical syllogisms:**
  1. All artists are beekeepers
     All beekeepers are clowns
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?

- Categorical syllogisms:
  1. All artists are beekeepers
     All beekeepers are clowns
     All artists are clowns
Single-model

All artists are beekeepers
All beekeepers are clowns
All artists are clowns
Deductive Reasoning: From general to specific

- **Categorical & transitive inferences:**
  - can children ever do these?

- **Categorical syllogisms:**
  1. All artists are beekeepers
     All beekeepers are clowns
     All artists are clowns
Deductive Reasoning: From general to specific

- **Categorical & transitive inferences:**
  - can children ever do these?

- **Categorical syllogisms:**
  1. All artists are beekeepers
     All beekeepers are clowns
     All artists are clowns
Categorical & transitive inferences:
- can children ever do these?

Categorical syllogisms:

1. All artists are beekeepers
   All beekeepers are clowns
   All artists are clowns

2. Some artists are beekeepers
Deductive Reasoning: From general to specific

- **Categorical & transitive inferences:**
  - can children ever do these?

- **Categorical syllogisms:**
  1. *All artists are beekeepers*
     *All beekeepers are clowns*
     *All artists are clowns*
  2. *Some artists are beekeepers*
     *No beekeeper is a clown*
Deductive Reasoning: From general to specific

- **Categorical & transitive inferences:**
  - can children ever do these?

- **Categorical syllogisms:**
  1. **All artists are beekeepers**
     - All beekeepers are clowns
     - All artists are clowns
  2. **Some artists are beekeepers**
     - No beekeeper is a clown
     - Some artists are not clowns
Multiple-model

Some artists are beekeepers
No beekeeper is a clown
1. Some artists are beekeepers
   No beekeeper is a clown
Multiple-model

1. Artists
   - Beekeepers
   - Clowns

2. Beekeepers
   - Artists
   - Clowns

Some artists are beekeepers
No beekeeper is a clown
Multiple-model

1. Beekeepers
   Artists
   Clowns

2. Beekeepers
   Artists
   Clowns

3. Beekeepers
   Artists
   Clowns

Some artists are beekeepers
No beekeeper is a clown
Multiple-model

1. Beekeepers
   - Artists
   - Clowns

2. Beekeepers
   - Artists
   - Clowns

3. Beekeepers
   - Artists
   - Clowns

Some artists are beekeepers
No beekeeper is a clown
Some artists are not clowns
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?

- Categorical syllogisms:
  - All artists are beekeepers
  - All beekeepers are clowns
  - All artists are clowns
  - Some artists are beekeepers
  - No beekeeper is a clown
  - Some artists are not clowns
Deductive Reasoning: From general to specific

- **Categorical & transitive inferences:**
  - can children ever do these?

- **Categorical syllogisms:**
  - All artists are beekeepers
  - All beekeepers are clowns
  - All artists are clowns
  - Some artists are beekeepers
  - No beekeeper is a clown
  - Some artists are not clowns

- 11-12-yr-olds: 51% vs. 0% correct
Deductive Reasoning: From general to specific

- Categorical & transitive inferences:
  - can children ever do these?

- Categorical syllogisms:
  - All artists are beekeepers
  - All beekeepers are clowns
  - All artists are clowns
  - Some artists are beekeepers
  - No beekeeper is a clown
  - Some artists are not clowns

- 11-12-yr-olds: 51% vs. 0% correct
  - Difference: Number of “mental models”
Can young children do deductive reasoning?
Can young children do deductive reasoning?

- yes, but depends on:
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
  - social/linguistic context (Donaldson)
Can young children do deductive reasoning?

- yes, but depends on:
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  - social/linguistic context (Donaldson)

- Adults also are subject to...
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
  - social/linguistic context (Donaldson)

- Adults also are subject to...
  - biases (bridge collapse) & social context (Brueer later)
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
  - social/linguistic context (Donaldson)

- Adults also are subject to...
  - biases (bridge collapse) & social context (Bruer later)
  - familiarity effect (Hawkins, Pea et al [Bjorklund]):
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
  - social/linguistic context (Donaldson)

- Adults also are subject to...
  - biases (bridge collapse) & social context (Bruer later)
  - familiarity effect (Hawkins, Pea et al [Bjorklund]):
    All garbage is precious
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
  - social/linguistic context (Donaldson)

- Adults also are subject to...
  - biases (bridge collapse) & social context (Bruer later)
  - familiarity effect (Hawkins, Pea et al [Bjorklund]):
    - All garbage is precious
    - Anything precious is delicious
Can young children do deductive reasoning?

- yes, but depends on:
  - knowledge
  - social/linguistic context (Donaldson)

- Adults also are subject to...
  - biases (bridge collapse) & social context (Bruer later)
  - familiarity effect (Hawkins, Pea et al [Bjorklund]):
    - All garbage is precious
    - Anything precious is delicious
    - Is all garbage delicious?
Development of Reasoning

- Single-response reasoning
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - Deductive (formal) reasoning:
    - Categorical & transitive inference
    - Rule use
Development of Reasoning

- **Single-response reasoning**
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - Deductive (formal) reasoning:
    - Categorical & transitive inference
    - Rule use

- **Extended reasoning**
Development of Reasoning

- **Single-response reasoning**
  - Inductive reasoning:
    - Inductive inference
    - Analogical inference
  - **Deductive (formal) reasoning:**
    - Categorical & transitive inference
    - Rule use

- **Extended reasoning**
  - flexibility; planning in children
Extended reasoning:
1. Switching inferences or rules
Extended reasoning:
1. Switching inferences or rules
   - Flexible cognition
Extended reasoning:
1. Switching inferences or rules

- Flexible cognition
  - Critical in math, science, AND reading
Extended reasoning:
1. Switching inferences or rules

- Flexible cognition
  - Critical in math, science, AND reading
    - Knowing when an algorithm or principle permits different operations; finding ways to re-describe a function or equation
Extended reasoning:
1. Switching inferences or rules

- Flexible cognition
  - Critical in math, science, AND reading
    - Knowing when an algorithm or principle permits different operations; finding ways to re-describe a function or equation
    - Using different problem-solving procedures; testing different hypotheses
Extended reasoning:
1. Switching inferences or rules

- **Flexible cognition**
  - Critical in math, science, AND reading
    - Knowing when an algorithm or principle permits different operations; finding ways to re-describe a function or equation
    - Using different problem-solving procedures; testing different hypotheses
    - Making multiple inferences about a text
Extended reasoning:
1. Switching inferences or rules

- Flexible cognition
  - Critical in math, science, AND reading
    - Knowing when an algorithm or principle permits different operations; finding ways to re-describe a function or equation
    - Using different problem-solving procedures; testing different hypotheses
    - Making multiple inferences about a text
  - Development:
Extended reasoning:
1. Switching inferences or rules

- **Flexible cognition**
  - Critical in math, science, AND reading
    - Knowing when an algorithm or principle permits different operations; finding ways to re-describe a function or equation
    - Using different problem-solving procedures; testing different hypotheses
    - Making multiple inferences about a text
  - Development:
    - *example: flexibly classifying an object...*
Flexible Rule-Based Classification
Flexible Rule-Based Classification
Flexible Rule-Based Classification

- Dimensional Change Card Sorting (Zelazo et al):
Flexible Rule-Based Classification

- Dimensional Change Card Sorting (Zelazo et al):
  - how does performance change with age?
Flexible Rule-Based Classification

- Dimensional Change Card Sorting (Zelazo et al):
  - how does performance change with age?
  - perseverative errors? resistance to interference?
So are 4-year-olds flexible?
So are 4-year-olds flexible?

- Task-switching paradigm (Holt, Deák, Ceponiene, Cepeda):
So are 4-year-olds flexible?

- Task-switching paradigm (Holt, Deák, Ceponiene, Cepeda):
  - 4-, 6-, and 19-year-olds
Task “switch costs” decline with age
- Task “switch costs” decline with age
Planning
Planning

- Children’s don’t plan very far ahead
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal

- Grocery shopping (Rogoff):
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal
- Grocery shopping (Rogoff):
  - Example of scaffolding
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal
- Grocery shopping (Rogoff):
  - Example of scaffolding
- What works? Building a pyramid (Wood)
Figure 4.3 Photographs showing stages in the construction of the pyramid
Planning

- **Children’s don’t plan very far ahead**
  - Focus on obvious sub-goals at expense of main goal

- **Grocery shopping (Rogoff):**
  - Example of scaffolding

- **What works? Building a pyramid (Wood)**
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal

- Grocery shopping (Rogoff):
  - Example of scaffolding

- What works? Building a pyramid (Wood)
  - Parents use many scaffolding strategies!
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal

- Grocery shopping (Rogoff):
  - Example of scaffolding

- What works? Building a pyramid (Wood)
  - Parents use many scaffolding strategies!
  - Most effective: “contingent scaffolding”
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal
- Grocery shopping (Rogoff):
  - Example of scaffolding
- What works? Building a pyramid (Wood)
  - Parents use many scaffolding strategies!
  - Most effective: “contingent scaffolding”
    - IF struggling THEN give more help
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal

- Grocery shopping (Rogoff):
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- What works? Building a pyramid (Wood)
  - Parents use many scaffolding strategies!
  - Most effective: “contingent scaffolding”
    - IF struggling THEN give more help
    - If succeeding THEN fade help OR challenge
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal

- Grocery shopping (Rogoff):
  - Example of scaffolding

- What works? Building a pyramid (Wood)
  - Parents use many scaffolding strategies!
  - Most effective: “contingent scaffolding”
    - IF struggling THEN give more help
    - If succeeding THEN fade help OR challenge
  - Seems obvious, but not all parents do it
Planning

- Children’s don’t plan very far ahead
  - Focus on obvious sub-goals at expense of main goal

- Grocery shopping (Rogoff):
  - Example of scaffolding

- What works? Building a pyramid (Wood)
  - Parents use many scaffolding strategies!
  - Most effective: “contingent scaffolding”
    - IF struggling THEN give more help
    - If succeeding THEN fade help OR challenge
  - Seems obvious, but not all parents do it
  - (and HARD to do when multi-tasking!)