Theories of Cognitive Development

Psychology of Childhood
Cognitive Development

- Age-related changes in children’s knowledge and thinking
  - learning and memory
  - causal knowledge
  - language
  - concepts
  - mental abilities related to academic skills
Theories of Cognitive Development

- Why do we bother with theories of cognitive development
  - Organize understanding of many individual cognitive changes
  - Raise crucial questions about human nature
  - Motivate new research
Influential Theories of Cognitive Development

- Piaget’s theory
- Sociocultural theories
- Core-knowledge theories
- Information-processing theories
Beginning about 1920, Piaget developed the first ‘cognitive’ theory
- infant cognition
- language development
- conceptual development
- mathematical and scientific reasoning
- moral development
Piaget’s Most Revolutionary Idea

Child as scientist

1. construct their own knowledge from experimenting on the world.
2. learn many things on their own without the intervention of older children or adults.
3. are intrinsically motivated to learn and do not need rewards from adults to motivate learning
Piaget’s Principles: What changes?

- There are distinct stages of cognitive development, with the following properties.
  - Qualitative change: Children of different ages (and at different stages) think in different ways.
  - Broad applicability: The type of thinking at each stage pervades topic and content areas.
  - Brief transitions: Transitions to higher stages of thinking are not necessarily continuous.
  - Invariant sequence: The sequences of stages are stable for all people through all time. Stages are not skipped.
piaget’s principles:
what does not change?

- three processes work together from birth to account for continuities:
  - assimilation: people translate incoming information into a form they can understand.
  - accommodation: people adapt current knowledge structures in response to new experience.
  - equilibration: people balance assimilation and accommodation to create stable understanding.
Piaget’s Principles: How do nature/nurture interact?

- **Nature and nurture interact to produce cognitive development.**
  - **Adaptation:** Children respond to the demands of the environment in ways that meet their own goals.
  - **Organization:** Children integrate particular observations into a body of coherent knowledge.
Overview of Piaget’s Stages

1. **Sensorimotor stage (birth to 2 years)**
   - Knowledge tied to sensory and motor abilities
   - *Fails tests of the object concept*

2. **Preoperational stage (2 to 7 years)**
   - Objects and events are represented by mental symbols
   - *Fails tests of conservation*

3. **Concrete operational stage (7 to 12 years)**
   - Children can reason logically about concrete objects and events.
   - *Fails to engage in systematic hypothesis testing*

4. **Formal operational stage (12 years and up)**
   - Children can reason abstractly and hypothetically.
Piaget’s Sensorimotor Stage

- **Substage 1 (birth to 1 month): Reflexive Activity**
  - Building knowledge through reflexes (grasping, sucking).
  - No attempt to locate objects that have disappeared.

- **Substage 2 (1 to 4 months): Primary Circular Reactions**
  - Reflexes are organized into larger, integrated behaviors (grasping a rattle and bringing it to the mouth to suck).
  - Still no attempt to locate objects that have disappeared.
Piaget’s Sensorimotor Stage

- **Substage 3 (4 to 8 months): Secondary Circular Reactions**
  - Repetition of actions on the environment that bring out pleasing or interesting results (banging a rattle).
  - Search for objects that have dropped from view or are partially hidden

- **Substage 4 (8 to 12 months): Coordination of Secondary Reactions**
  - Mentally representing objects when objects can no longer be seen, thus achieving “object permanence.”
  - Search for completely hidden objects but makes “A-not-B error.”
A not B error
Piaget’s Sensorimotor Stage

- **Substage 5 (12 to 18 months): Tertiary Circular Reactions**
  - Actively and avidly exploring the possible uses to which objects can be put
  - Ability to follow visible displacements of an object
- **Substage 6 (18 to 24 months): Symbolic Thought**
  - Able to form enduring mental representations, as demonstrated by “deferred imitation,” the repetition of others’ behaviors minutes, hours, or days after it has occurred.
  - Ability to follow invisible displacements
Invisible Displacement
Piaget’s Preoperational Stage

- **Development of symbolic representations**, that is, the use of one object to stand for another.
  - For instance, a stick becomes a horse; an eyepatch and kerchief make a pirate.
- **Characteristic Errors**
  - **Egocentrism**: Looking at the world only from one’s own point of view.
  - **Centration**: Focusing on a single, perceptual feature to the exclusion of other features.
Egocentrism in Spatial Reasoning
Egocentrism in Language

My dad is a policeman...

I have a real big dog...

He caught a robber once...

He licks my face all the time...
Seriation cases of seriation, thinking about classes, and conservation. Piaget suggested. Consider, for example, the difficult to explain if the children truly lacked certain cognitive structures. But in many cases, young children typically still make errors. But in many cases, their performance also vastly improves in ways that would be difficult for Piaget's results.

Patterns of behavior lend support to the alternative explanations for Piaget's results. Supports transitive reasoning.

Set continuously. Piaget thought that children younger than about 7 years of age (for example, to understand that if Adam is taller than Bill, and Bill is taller than Chris, then Adam also must be taller than Chris). Piaget claimed that preoperational children's cognitive structures do not allow them to use transitive reasoning.

Failures at these tasks have often been cited as clear evidence that children younger than roughly 7 years of age (see Figure 9.10). Their performance also vastly improves in ways that would be difficult for Piaget's results.

In Piaget's seriation task, the child is asked to arrange a set of rods in order from shortest to longest. Doing so correctly requires careful attention to the way each rod's length relates to the others. If you can remember all those relationships, you will quickly know that if rod A is longer than rod B, and rod B is longer than rod C, then rod A is also longer than rod C.

You must also remember to look at both ends of the rods and along the tops if the bottoms are also changing relative to the other. For example, younger children may have trouble remembering how the length of each rod relates to the others. If so, perhaps solving the memory problem would make transitive reasoning easy for them.

In the studies designed to test the alternative explanations, Bryant & Trabasso extensively trained young children to compare pairs of colored rods to determine which was longer. The children learned the length relationships for pairs of rods by associating the lengths with the color of the rods and memorized inequality relationships (E>D, D>C, C>B, B>A) so that they were able to correctly report size inequalities when just looking at the rods inserted in the box. They were then asked about several new pairs of rods.

In Bryant and Trabasso's study, researchers trained children by pulling pairs of colored rods out of a holder and showing the children the size relationships. This finding suggests that young children had failed at the task because of the tasks' memory demands, not because they were incapable of transitive reasoning.

In the study to figure out whether young children might be failing at seriation tasks because of problems with memory or other elements that children younger than around 7 fail because they are incapable of transitive reasoning or because of other elements that they lack the ability to use transitive reasoning to understand the inequalities. This finding suggests that young children had failed at Piagetian tasks.

If the younger child truly lacks the ability to use transitive reasoning, then it should be possible to show clear differences between younger and older children on any task that requires transitive reasoning. But consider for a moment how Piaget's classic studies demonstrate that children fail at this task. They often line up the rods as ordered a few rods at a time but are unable to arrange the whole set continuously. Piaget thought that children younger than about 7 years of age (for example, to understand that if Adam is taller than Bill, and Bill is taller than Chris, then Adam also must be taller than Chris). Piaget claimed that preoperational children's cognitive structures do not allow them to use transitive reasoning.

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Centration in Class inclusion

Are there more daffodils or more flowers?

There are more daffodils.

In Piaget's view, the limitations on preoperational children's understanding of these kinds of relationships keep them from realizing how hierarchically arranged categories relate to each other (Inhelder & Piaget, 1958, 1964). The limitations in reasoning account for children's striking failures to understand classification. In one of Piaget's tasks, a preschooler was shown a bouquet of flowers consisting of nine daffodils and three daisies and then was asked whether there were more daffodils or more flowers. The children, whom Piaget considered preoperational, may not have realized that the daffodils were a subset of the category of all flowers (see Figure 9.12). Many preschoolers responded that there were more daffodils—which was logically impossible. Piaget argued that preoperational children lacked the appropriate mental operators to infer transitivity somehow does away with their need to use real transitive reasoning to determine the novel length relationships.

For example, recognizing that if rod D is longer than rod B, and rod B is longer than rod A, then rod D must also be longer than rod A. The memory training had striking effects on the children's performance. Once the younger children had demonstrated reliable memories for the length relationships they were taught, they could easily make judgments about the new rod pairs. They then were presented with pairs of rods that were a true test of transitive reasoning (Halford, 1993). Such accounts would have to show that reducing the children's memory load by training them to remember some inequalities, presumably by using transitive reasoning (for instance, recognizing that if rod D is longer than rod B, and rod B is longer than rod A, then rod D must also be longer than rod A). The right experimental task, such as training children to remember some inequalities, presumably by using transitive reasoning (for instance, recognizing that if rod D is longer than rod B, and rod B is longer than rod A, then rod D must also be longer than rod A).
Piaget’s Concrete Operations Stage

• Stage in which logical thinking begins.
• Exemplified by the conservation concept.
  • Children understand the conservation concept when they understand that changing the appearance or arrangement of objects does not change their key properties.
# Conservation Concepts

<table>
<thead>
<tr>
<th>CONSERVATION OF LIQUID QUANTITY</th>
<th>PHASE 1</th>
<th>PHASE 2</th>
<th>PHASE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Do they have the same amount of orange drink or a different amount?&quot;</td>
<td><img src="image" alt="Phase 1" /></td>
<td><img src="image" alt="Phase 2" /></td>
<td><img src="image" alt="Phase 3" /></td>
</tr>
<tr>
<td>&quot;Now watch what I do&quot; (pouring contents of one glass).</td>
<td>&quot;Now, do they have the same amount of orange drink or a different amount?&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Liquid Quantity Problem
**Conservation Concepts**

<table>
<thead>
<tr>
<th>Conservation of Solid Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Do they have the same amount of clay or a different amount?”</td>
</tr>
<tr>
<td>“Now watch what I do” (stretching one piece of clay).</td>
</tr>
<tr>
<td>“Now, do they have the same amount of clay or a different amount?”</td>
</tr>
</tbody>
</table>
Conservation of Number

| CONSERVATION OF NUMBER | "Is there the same number or a different number?" | "Now watch what I do" (spreading one row). | "Now, is there the same number or a different number?" |
Numeric Quantity Problem
Piaget’s Formal Operations Stage

- Ability to think abstractly and reason hypothetically.
- Ability to engage in scientific thinking.
What influences how long it will take for the pendulum to complete an arc?
Criticisms of Piaget’s Theory

- **Sociocultural approach:**
  - Children’s thinking is affected by social interactions

- **Core Knowledge approach:**
  - Infants and young children have and use a lot of innate mental machinery for complex abstract thought

- **Information processing approach:**
  - Children’s thinking is a computational process
  - Children’s thinking is not as consistent as the stages suggest.
Empirical Evaluation

- Piaget very greatly underestimated children’s abilities
  - Preoperational child is a myth (Gelman, 1978)
    - Class inclusions are represented by preschoolers (Markman, 1990)
    - Conservation errors are almost universally conversational errors (Mehler & Bever, 1968; McGarrigle & Donaldson, 1974)
Class inclusion

Piaget’s question:
More blue circles or more circles all together?

Markman’s question:
More baby circles or more circles in the family?
Fig. 1. The length of the rows in (a) was 7 inches (18 cm) for M & M's and 8 inches (20 cm) for clay pellets; in (b) 7 and 3 inches (18 and 8 cm) for M & M's and 8 and 5 inches (20 and 13 cm) for clay pellets. There was a 1\frac{1}{2}-inch (3-cm) space between each of the four clay pellets and a 2-inch (5-cm) space between each of the four M & M's. The clay pellets were \( \frac{1}{2} \) inch (1.3 cm) in diameter. The M & M candies were all of the same color.

Fig. 2. The proportion by age of responses choosing the row with more members in the situation shown in Fig. 1b. Numbers inside bars indicate total number of subjects of that age.
McGarrigle & Donaldson (1974)

“Oh look! It’s naughty teddy! He’s going to spoil the game!”
Empirical Evaluation

- **Between-concept changes not stage-like**
  - Successful conservation of liquid, solid, and numeric quantity do not rise (or fall) together as if they were part of a general pattern of thinking (Siegler, 1981)
  - Characteristic errors on one type of conservation (e.g., liquid) do not reliably predict types of errors on other types of conservation (e.g., number)
Empirical Evaluation

- **Within-concept changes not stage-like**
  - Even within a particular conservation task (e.g., numeric quantity), children’s errors do not follow a set sequence
    - regressions are common
    - “stages” are skipped
    - frequency of correct responses often emerge gradually
Empirical Evaluation

- Children are terrible experimenters; they do not learn to control variables systematically on their own (Klahr, 2004)

Fig. 1. The ramps used during the exploration and assessment phases. On each of the two ramps, children could vary the steepness, surface, and length of the ramp, as well as the type of ball. The confounded experiment depicted here contrasts (a) a golf ball on a steep, smooth, short ramp with (b) a rubber ball on a shallow, rough, long ramp.
Empirical Evaluation

Children are very seldom interested in attaining detailed causal understanding (though they do believe it exists)
Empirical Evaluation

- **No progress in understanding basic mechanisms of change**
  - “For 40 years now we have had assimilation and accommodation, the mysterious and shadowy forces of equilibration, the Batman and Robin of the developmental processes. What are they? How do they do their thing? Why is it after all this time, we know more about them than when they first sprang on the scene? What we need is a way to get beyond vague verbal statements of the nature of the developmental processes” (Klahr, 1982)
Sociocultural Approach

- Russian psychologist Lev Vygotsky portrayed children as social beings intertwined with other people who were eager to help them learn and gain skills.
Sociocultural Approach

- **Child as apprentice**
  - Some of children’s abilities are culturally-dependent
  - Some cognitive change originates in social interaction
  - Children are both learners and teachers.
"If Juan and Jose drink a lot of beer, the mayor of the town gets angry. Juan and Jose are drinking a lot of beer now. Do you think the mayor is angry with them? Kpelle woman: "No - so many men drink beer, why should the mayor get angry?"
Some Important Social Interactions

- **Sharing our thoughts**
  - **Joint attention:** Infants and social partners focus on common referent.
  - **Social referencing:** Children look to social partners for guidance about how to respond to unfamiliar events.

- **Social scaffolding:**
  - More competent people provide temporary frameworks that lead children to higher-order thinking.

- **Zone of proximal development:**
  - The range between what children can do unsupported and what they can do with optimal social support.
Empirical Evaluation

- Social support is often a necessary but insufficient condition for cognitive development (Siegler & Liebert, 1983)
- Effect of language on thought is still hotly debated
- ZPD almost impossible to falsify
Empirical Evaluation

- Peers can be terrible teachers because their confidence outweighs their competence (Levin & Druyan, 1993)
If Juan and Jose drink a lot of beer, the mayor of the town gets angry. Juan and Jose are drinking a lot of beer now. Do you think the mayor is angry with them?

If the horse is well fed, it cannot work very well. Today, Rama’s horse was well fed. Can it work very well today?

Dash & Das, 1987
Core-Knowledge Approach

• **Child as Primate Scientist**
  - Children have innate cognitive capabilities that are the product of human evolutionary processes.
  - Focus on human universals (e.g., language, social cognition, biological categorization, using numbers)
  - Children are much more advanced in their thinking than Piaget suggested.
Core-Knowledge Theories

- **Children’s domain-specific theories:**
  - Children actively organize their understanding into informal causal theories
    - psychology
    - biology
    - physics
Information-Processing Approach

- Child as Computer
  - Concerned with the development of domain-general processes
    - learning,
    - memory,
    - problem-solving skills.
  - Provides detailed description of the steps involved in thinking (like a computer program)
Conversation with a Child

Scene: Daughter and father in the yard. A playmate rides in on a bike.

Child: Daddy, would you unlock the basement door?
Father: Why?
C: Cause I want to ride my bike.
F: Your bike is in the garage.
C: But my socks are in the dryer!
Information Processing Analysis

- **Top goal:** I want to ride my bike.
  - constraint: I need to shoes to ride comfortably.
  - fact: I'm barefoot.
    - Subgoal 1: Get my sneakers
    - Fact: The sneakers are in the yard.
    - Fact: Sneakers are uncomfortable on bare feet.
      - Subgoal 2. Get my socks.
      - Fact: The sock drawer was empty this morning.
      - Inference: The socks are probably in the dryer.
        - Subgoal 3: Get them from the dryer.
        - Fact: The dryer is in the basement.
          - Subgoal 4: Go to the basement.
            - Fact: It's quicker to go through the yard entrance.
            - Fact: The yard entrance is always locked.
              - Subgoal 5: Unlock the door to the basement.
              - Fact: Daddies have keys to everything.
                - Subgoal 6: Ask daddy to unlock the door.
Information Processing Approach

- **Three major principles:**
  - Thinking is information processing.
  - Change is produced by a process of continuous self-modification.
  - The steps of change can be precisely specified by identifying mechanisms of change.
Information-Processing Approach: What changes?

- **Speed of memory processes change with practice**
  - Associating events with one another.
  - Recognizing objects as familiar.
  - Generalizing from one instance to another.
  - Encoding (representing features of objects and events in memory).
Increase in Processing Speed

(a) Visual Search
(b) Mental Rotation
(c) Mental Addition
(d) Tapping
Information-Processing Approach: What changes?

- Rules and strategies
  - Rules are like lines of code in a computer program; children add and subtract rules over development.
Information-Processing Approach: What changes?

- **Balance Scale Problem** (Siegler, 1976)
  - *Rule 1*: If the weight is same on both sides, side with more weight goes down.
  - *Rule 2*: If one side has more weight, predict it will go down. If weights on two sides are equal (Problem A), choose side with greater distance.
  - *Rule 3*: If both weight and distance are equal, predict balance. If one side has more weight or distance, and two side are equal on other dimension, predict that side with greater value on unequal dimension will go down. If one side has more weight and other more distance, guess (Problem B).
### Anatomy of Piagetian problems

<table>
<thead>
<tr>
<th>Task</th>
<th>A. Dominant dimension</th>
<th>B. Subordinate dimension</th>
<th>C. Relation between A &amp; B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance scale</td>
<td>Weight</td>
<td>Distance from fulcrum</td>
<td>$C = A \times B$</td>
</tr>
<tr>
<td>Conservation of liquid</td>
<td>Height of liquid</td>
<td>cross-sectional area of liquid</td>
<td>$C = A \times B$</td>
</tr>
<tr>
<td>Conservation of number</td>
<td>Length of row</td>
<td>Density of objects in row</td>
<td>$C = A \times B$</td>
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</table>
Information-Processing Approach: What changes?

- **Rules and strategies**
  - **Strategies** are flexible approaches to solving problems; strategies compete with another over development.
  - E.g., How would a computer solve the problem 7 + 6?
Overlapping-Waves Model of Information Processing

The diagram illustrates the percent use of different strategies across various age groups. Strategies include:

- **Strategy 1**: Peaking at younger ages and decreasing as age increases.
- **Strategy 2**: Increasing from younger to older ages.
- **Strategy 3**: Peaking at a certain age and then decreasing.
- **Strategy 4**: Increasing from younger to older ages, peaking later than Strategy 2.
- **Strategy 5**: Increasing from younger to older ages, peaking much later than the others.

The x-axis represents age, ranging from younger to older, while the y-axis represents percent use, ranging from less to more.
Microgenetic
Moral Reasoning

Stage 1: Blind Obedience
Stage 2: Fear of Punishment
Stage 3: Maintaining Relationships
Stage 4: Laws/Duties
Stage 5: Universal principles
Bottom Line

- Post-Piagetian theories deal with different aspects of development
  - sometimes conflict between approaches, sometimes greater conflict within an approach
- Most researchers view different approaches as complementary
- No Grand Unified Theory (yet)