



**National Mathematics Panel**  
Overview for Interim Report

Learning Processes Group  
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New Orleans, LA

# Contributing Members

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# Overview

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- Goals
- How do we know?
- Learning and cognition
- What children bring to school
- Whole number arithmetic
- Learning disabled and gifted children

# Goals

- Principles of learning and cognition
- Mathematical knowledge children bring to school
- Math learning in key content areas:
  - Whole Number Arithmetic
  - Fractions
  - Estimation
  - Geometry
  - Algebra
- Individual and group difference
- Brain science and math learning

# How Do We Know?

- Theory testing with multiple approaches
- Procedures
  - Observation
  - Verbal report
  - Reaction time and error patterns
  - Priming and implicit measures
  - Experimental studies (dual task, practice, ...)
  - Computer simulations of learning and cognition
  - Brain imaging and related technologies
- Conclusions based on convergent results across procedures

# Principles of Learning and Cognition

- Cognition = functional capabilities of the brain
- Learning = improvements in these capabilities as a result of maturation and experience
- Much is known:
  - Working Memory – attention driven ability to mentally represent and transform information
    - Language, Visuospatial, Episodic
  - Long-term memory – storage of information for later use
    - Declarative (verbatim recall of facts),  
Procedural (e.g., algorithms), Conceptual

# Principles of Learning and Cognition

- Learning requires working memory/attentional focus
- Different experiences for different forms of knowledge
  - Verbatim/fact learning – extensive practice distributed over time
  - Gist/Concept learning – may occur with insight, demonstration, exploration, instruction
- Practice leads to automatic retrieval of declarative information or execution of procedures
- Conceptual knowledge promotes transfer to new situations

# Choking Under Pressure

- Situations that focus on one's competency, such as high stakes testing
- Choking occurs because competency-related thoughts intrude into working memory
  - Results in functional reduction of working memory; attention shifts back and forth from competency thoughts to test items
- Remedy = automaticity of test-related content



# What Children Bring to School

- Children have an inborn sense of quantity
  - Infants discriminate sets of small quantities and are sensitive to small additions/subtractions to these sets
  - Toddlers have a basic sense of ordinal relations
  - Preschool children can count, add, subtract, and make simple measurements
- Early sense of quantity is necessary but not sufficient for school-based learning
  - Large differences in the more formal knowledge children bring to kindergarten (e.g., knowing Arabic numerals); children who start behind, stay behind
- There are promising interventions to reduce differences

# Whole Number Arithmetic

- Fast and efficient retrieval of facts: Declarative Memory
  - Cognitive and learning mechanisms are understood
  - Most children in the U.S. do not achieve this
  - Interfere with problem solving in which facts are embedded
- Learning algorithms: Procedural Memory
  - Mechanisms are understood for add, subtract, multiply
    - Poor understanding of related concepts (e.g., base-10, trading)
    - Errors of inference (e.g., commutativity and subtraction)
  - Little research on long division

# Whole Number Arithmetic

- Core concepts: *Commutativity, Associativity, Distributive, Identity, Inverse Relations, Base-10*
  - Most research is on commutativity and addition; some on Base-10
  - Less research on distributive, identity
  - U.S. children and many adults do not understand many of these concepts

# Individuals and Group Differences

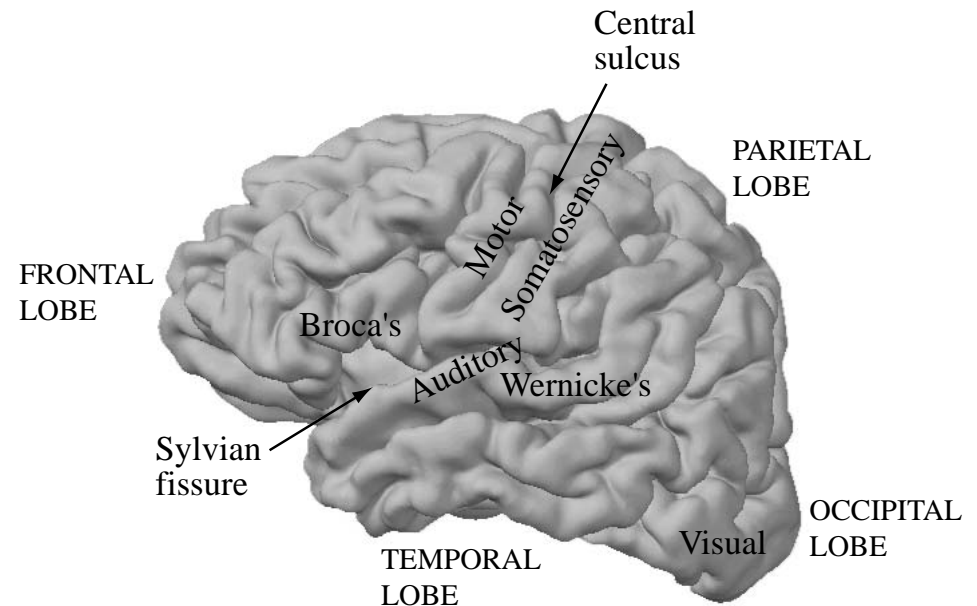
- Race and ethnicity
- Gender
- Learning Disabilities
  - 5% to 10% before graduating high school
  - Arithmetic
    - Delayed acquisition of procedures
    - Poor memory for facts
  - Mechanisms
    - Aspects of working memory & long-term memory
    - Poor conceptual knowledge – procedural delay

# Individuals and Group Differences

- Gifted children
  - Faster learning – less practice and exposure
  - Mechanisms
    - Enhanced executive functions/attentional control
    - Mathematically gifted: Enhanced visuospatial memory, memory for numbers

# Brain Science and Math Learning

- Initial Learning
  - Prefrontal/Working Memory - effort
  - Intraparietal sulcus – number sense
- Skill Development
  - Reduction prefrontal
  - Sometimes reduction in intraparietal
  - Increased engagement of angular gyrus



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## Next Steps

- Reviews of Fractions, Estimation, and core areas of Geometry and Algebra
- Review of Differences and Similarities across Race, Ethnicity, and Gender for key areas
- Draw Explicit Links with Other Task Groups