Typical & Atypical Cognitive Development

Unit 0. Introduction into course topics and course structure

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COURSE STRUCTURE AND REQUIREMENTS

- Structure
  - 60 minutes lecture in English (introducing the topic); Paul Seitlinger
  - 30 minutes break
  - followed by a 60 minutes seminar in Estonian (deepening the introduced course content); Grete Arro and Kati Aus

- Requirements
    - Reflecting on previous unit (in written form, answering 3-5 questions)
    - Optional: Preparing for the next unit by reading a topic-related article
    - Taking part in the seminar
  - Taking online exam
    - Answering open-ended questions on presented course contents (within one week)

C O U R S E T O P I C S

Unit 0 (15th of February, T-412)

- Introduction: Why does Cognitive Science matter in the educational context?

Unit 1 (8th of March, T-412)

- Cognitive development from the nature-nurture perspective? What is the impact of genes versus environment?

Unit 2 (15th of March, T-412)

- How does the cognitive system develop? What are typical developmental stages? How do these stages relate to different cognitive components?

Unit 3 (22nd of March, T-412)

- What are potential reasons for individual differences in (typical and atypical) cognitive development?

Unit 4 (5th of April, T-412)

- How can we diagnose/measure and how can we train cognitive abilities?

Unit 5 (12th of April, T-439)

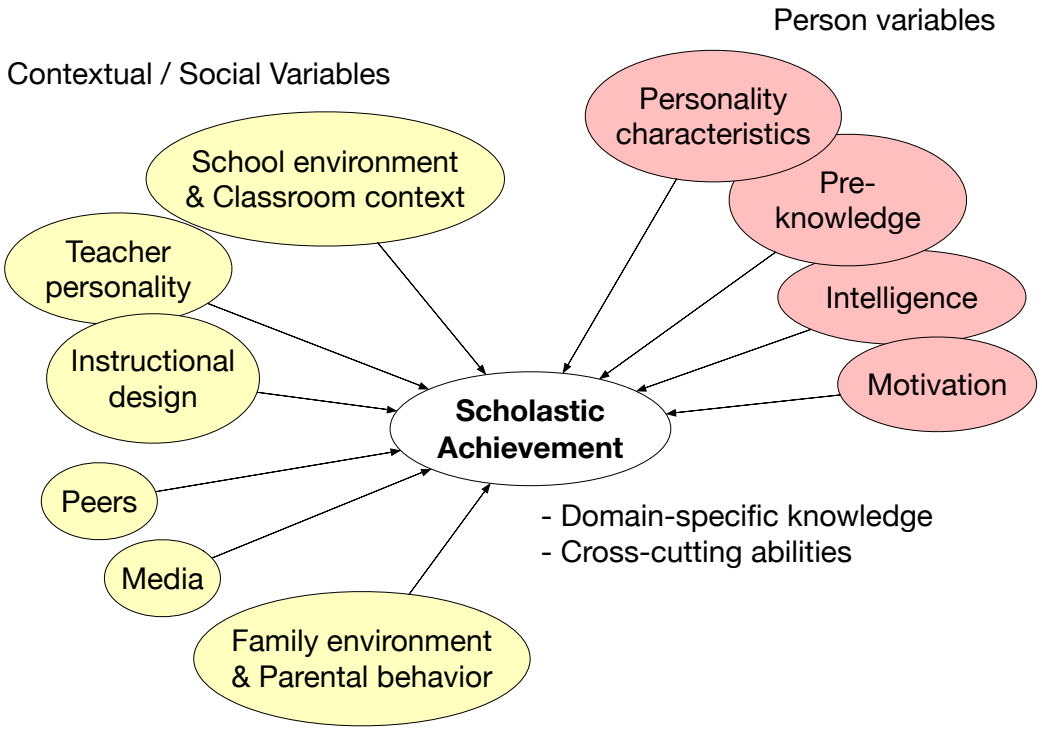
- Recap & Preparing for Exam

Exam (20th of April, Web-based)

WHY COGNITION MATTERS

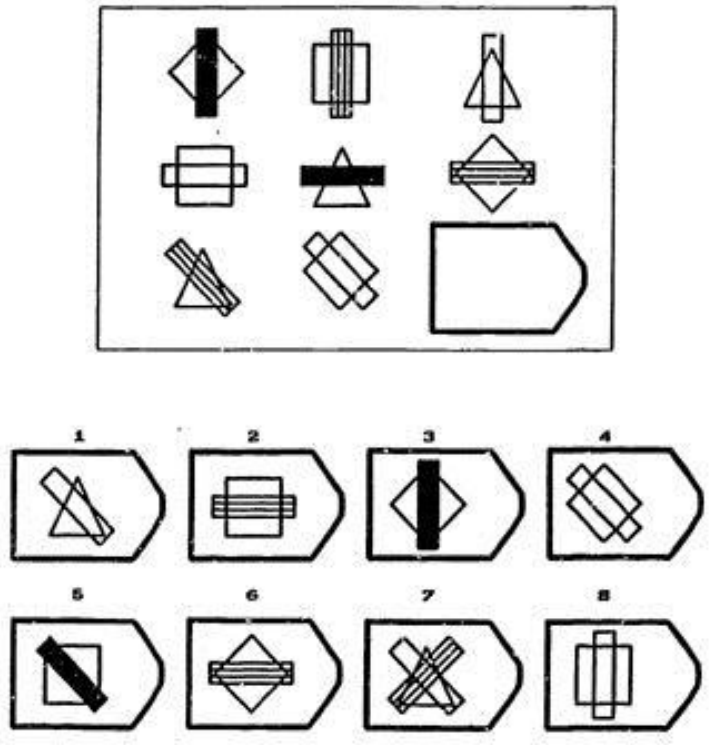
Determinants of scholastic achievement (based on Brühwiler & Helmke, 2018)

Which of these variables has the strongest impact?



WHY COGNITION MATTERS

- Intelligence is one of the strongest predictors of educational achievement (e.g., Hattie, 2009)
- What is intelligence?
  - A general mental capacity to draw conclusions, to plan, to solve problems, to reason in abstract categories, to acquire new knowledge
  - Typically, the performance in tests with mentally demanding tasks
  - Relatively stable personality trait



Example of the Raven matrices IQ test

WHY COGNITION MATTERS

- More intelligent/gifted students are better (faster and more effective) in
  - recognizing regularities and rules relevant for solving problems
  - acquiring and organizing knowledge
- *Learning scenarios of future school curricula become more challenging*
  - *E.g., Discovery Learning: Self-directed information search in addition to knowledge acquisition*

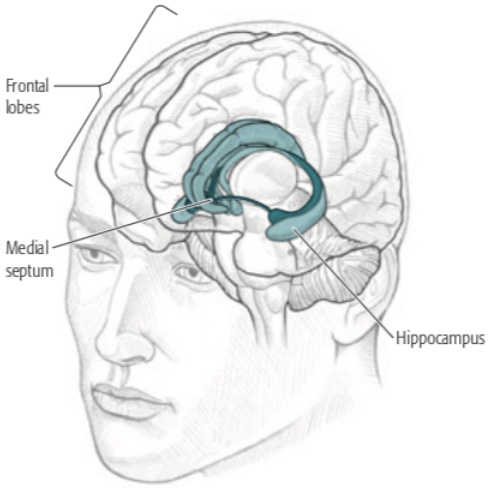
  →*Performance differences between more and less gifted students might become larger*

  →Urgent questions in education:
    - How to design future education in an inclusive way?
      - What are effective strategies to help less well-equipped children in school?

POTENTIAL APPROACH TOWARDS INCLUSIVE EDUCATION

- Looking at intelligence in a more nuanced way: what are the cognitive components that bring about intelligent behavior?

Basic functions (examples)	Emerging cognitive processes (examples)	Involved brain structures (examples)
Controlling attention	• Drawing conclusions • Imagination • Planning • Decision-making • Problem solving • …	Interplay of • Working Memory (at the front of the brain = Pre-Frontal lobe) • Long-Term Memory (e.g., Hippocampus, temporal lobe)
Retrieving from memory		
Mentally manipulating pieces of information		
Integrating new thoughts into memory		



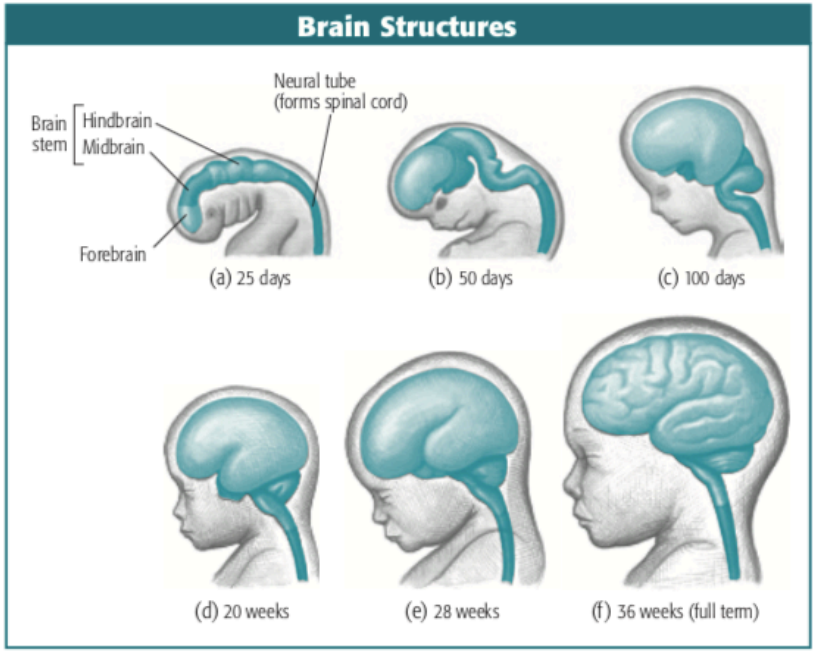
- Identifying regularities in how these components develop during childhood
- Deriving ways and strategies to support cognitive development

WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

Bio-psychological facts on our learnability (neural plasticity)

1. Humans have large brains relative to their body size

   → **Much of neural development postponed until after birth**

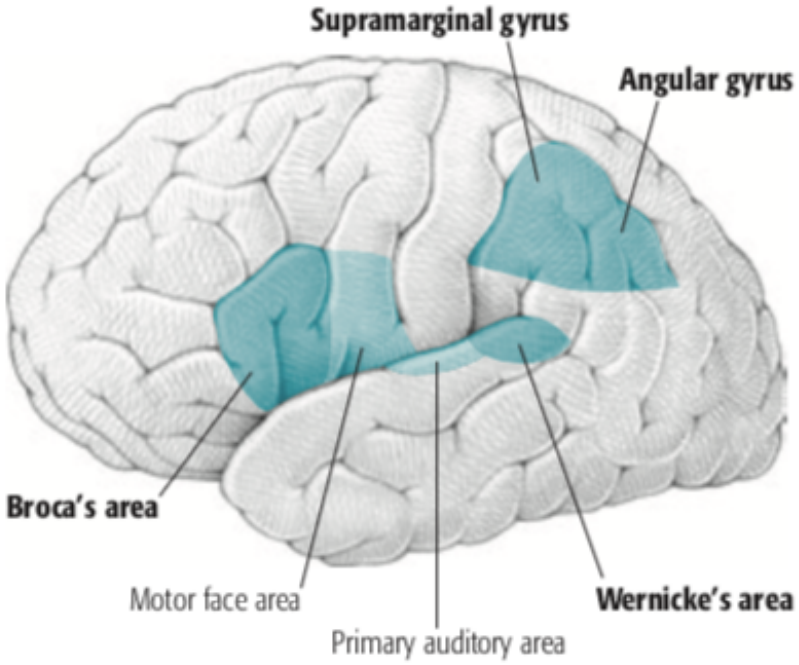


Picture taken from Anderson (2015)

- Though birth canal expanded to its limits, brain size can't be larger than 350 cm^3 at birth
- Doubles in 1st year of life: 700 cm^3
- Soon after, growth rate slows down but the volume again doubles before reaching puberty: 1.400 cm^3
- **Prolonged time of development**
  - about 15 years ~ 1/5 of the human life span
  - **needed to acquire complex cultural practices, such as language**

WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

Cognitive development (like learning your mother tongue) = Development of neural “communication structure”



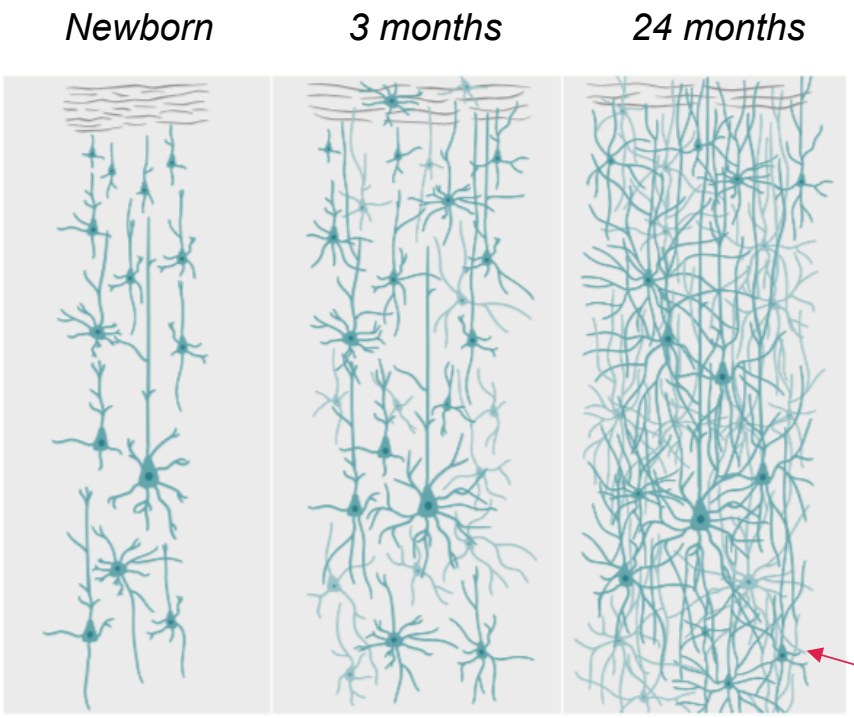
Picture taken from Anderson (2015)

- All **cognition** (e.g., understanding and producing words) **is distributed** across **specialized areas** that
  - **play specific roles**, such as
    - comprehension of words (Wernicke’s area)
    - production of words (Broca’s area)
  - **communicate** to exchange their processing products (e.g., meaning and sound of a word)

WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

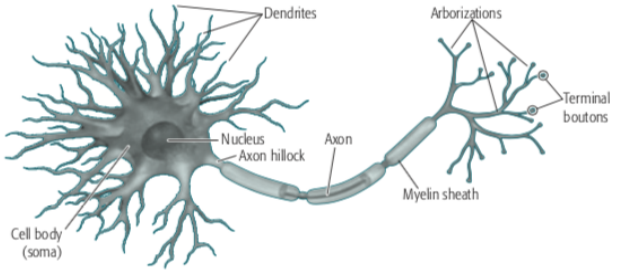
Cognitive development = Development of neural “communication structure”

*Brain development around **Broca**’s area*



Picture taken from Anderson (2015)

- Neural communication is based on
  - neurons (basic processing units)
  - connections between neurons = **Synapses**
- Learning to represent knowledge (e.g., word meaning) by building up new synaptic connections between neurons
  - **Synaptogenesis** peaks around the age of 2
  - Soon after, elimination of unnecessary structure = **Synaptic pruning** for **neural**



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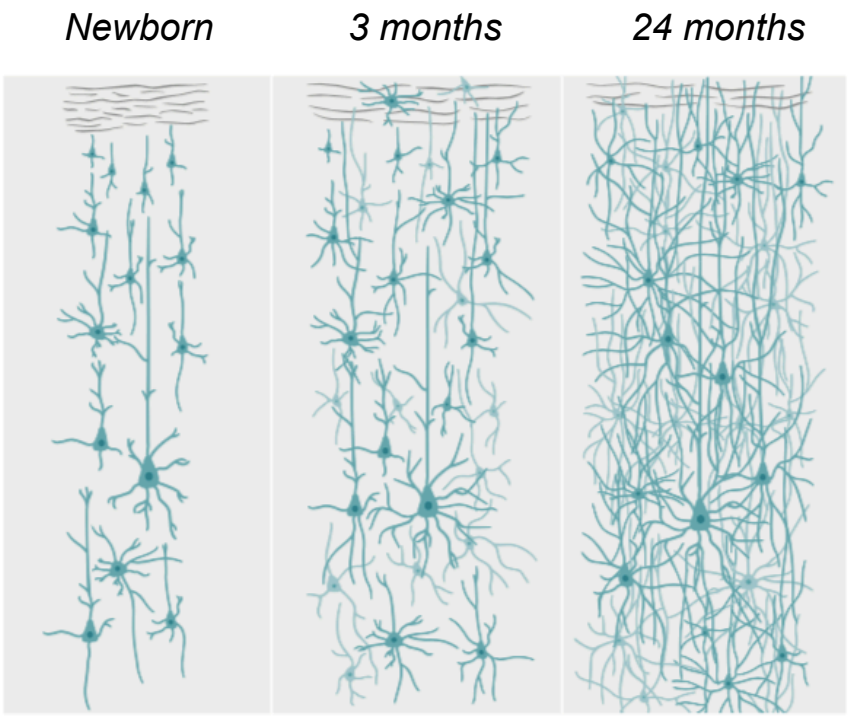

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- **Synaptic pruning**
  https://www.youtube.com/watch?v=rxPT78F_ZVE&feature=share
  - Between the ages of **2 and 16**
  - "**Use it or lose it**" principle
    - Constant stimulation → synapses become stronger and permanent
    - Little stimulation → elimination

→ Interplay of biology (**nature**) and learning experiences (**nurture**)

→ Implication for Education?

- Reflect on it in her first assignment (see last slide)

WHY DOES COGNITION MATTER FOR EDUCATION?

Summary and some first conclusions

- New learning scenarios place high cognitive demands on students

  → *A need for strategies to let less gifted students participate and benefit as well*

- Human cognition
  - is distributed across communicating and specialized brain areas
    - Neural communication based on synapses connecting simple processing units (neurons)
  - Synaptic pruning
    - helps to save energy and fine-tune the brain
- Learning and cognitive development takes place as an interplay between
  - the formation of important and the pruning of unimportant synapses
  - genetic factors and environmental learning experiences

  → *Specific knowledge about our cognitive system and how it develops to realize beneficial learning experiences in everyday school life*

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LITERATURE OF TODAY'S SESSION

- Anderson, J. (2015). Cognitive psychology and its implications (8th edition). New York, NY: Worth Publishers.
  - Parts of chapter 1 ("The Science of Cognition") and chapter 14 ("Individual Differences in Cognition")