Typical & Atypical Cognitive Development

Unit 0. Introduction into course topics and course structure

15th February 2019

Paul Seitlinger, Kati Aus, Grete Arro

School of Educational Sciences
Tallinn University

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-412)

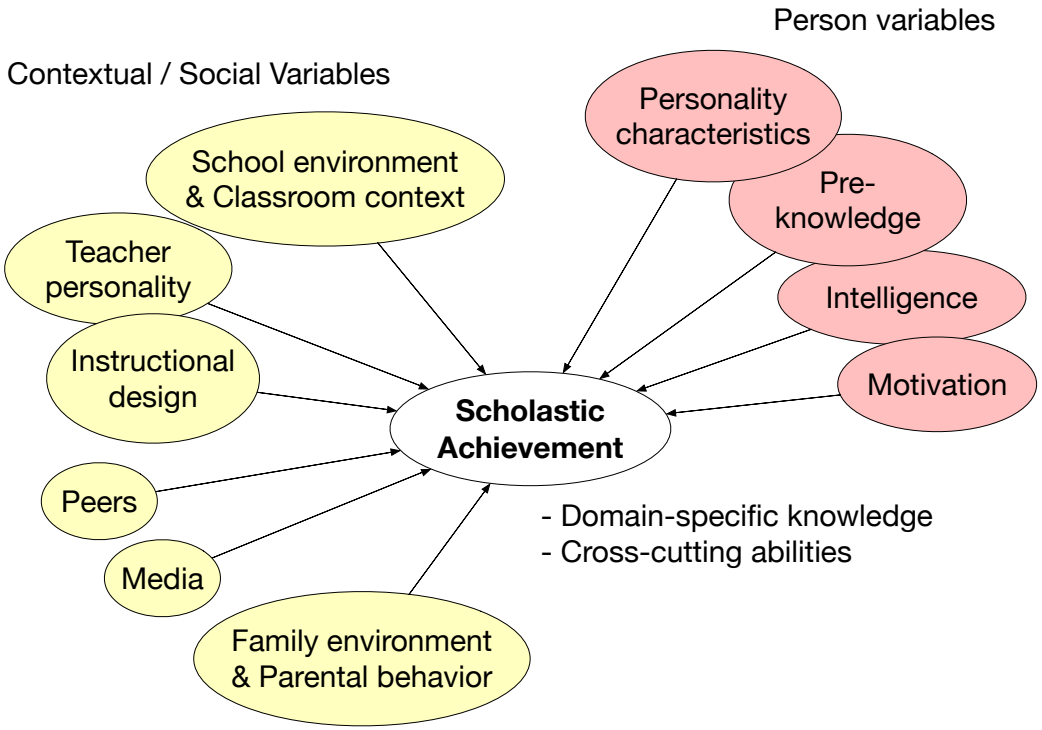
- Recap & Preparing for Exam

Exam (20th of April, Web-based)

WHY COGNITION MATTERS

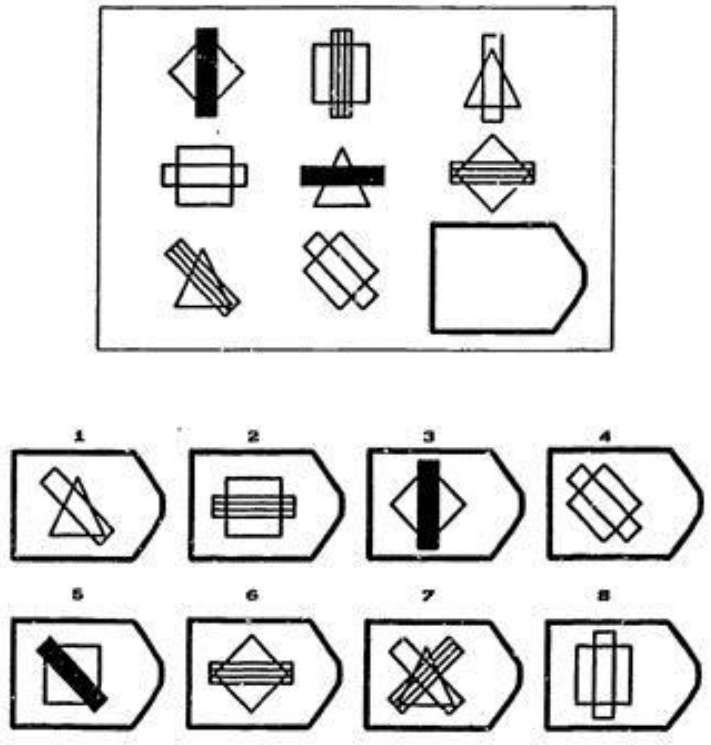
Determinants of scholastic achievement (based on Brühwiler & Helmke, 2018)

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*

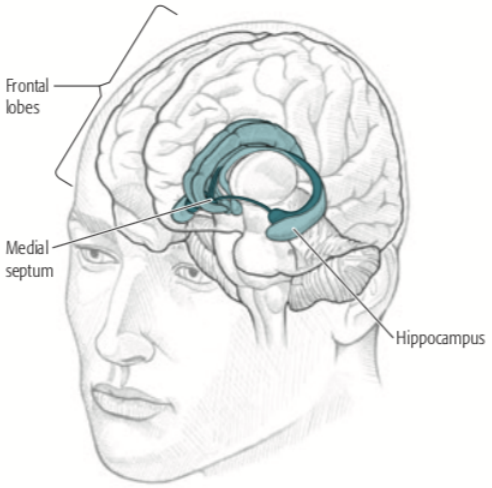
  →*Performance differences between more and less gifted students might become larger*

  →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		



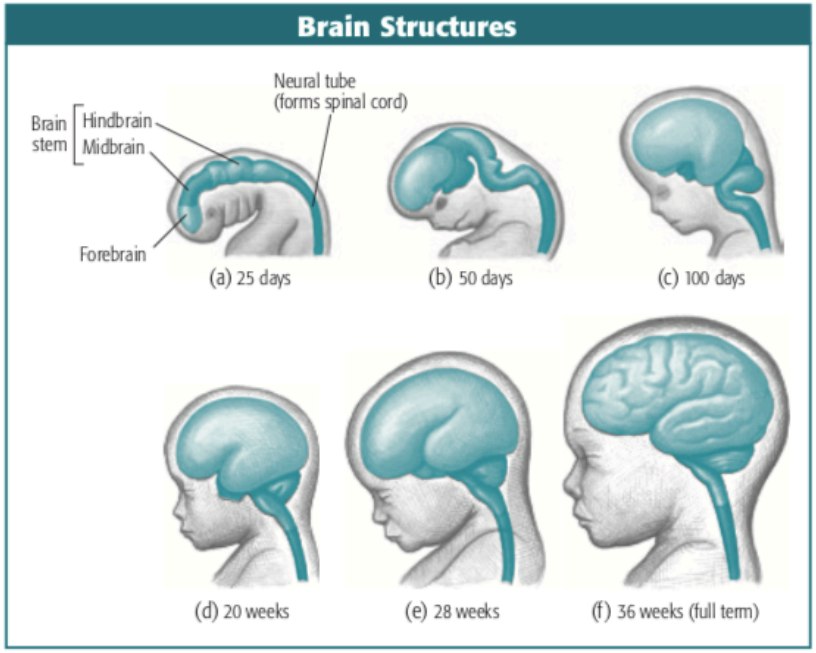
- Identifying regularities in how these components develop during childhood
- Deriving ways and strategies to support cognitive development

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**

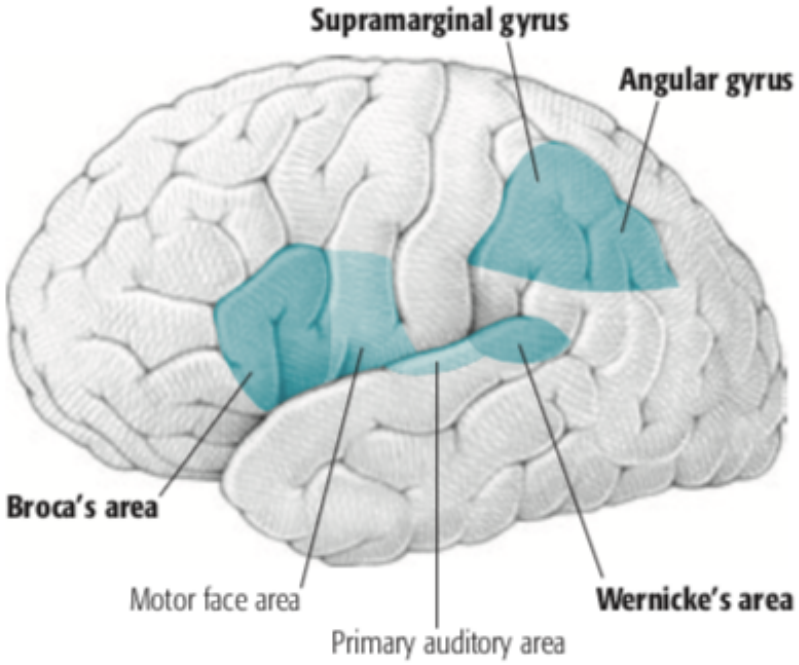


Picture taken from Anderson (2015)

- 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”



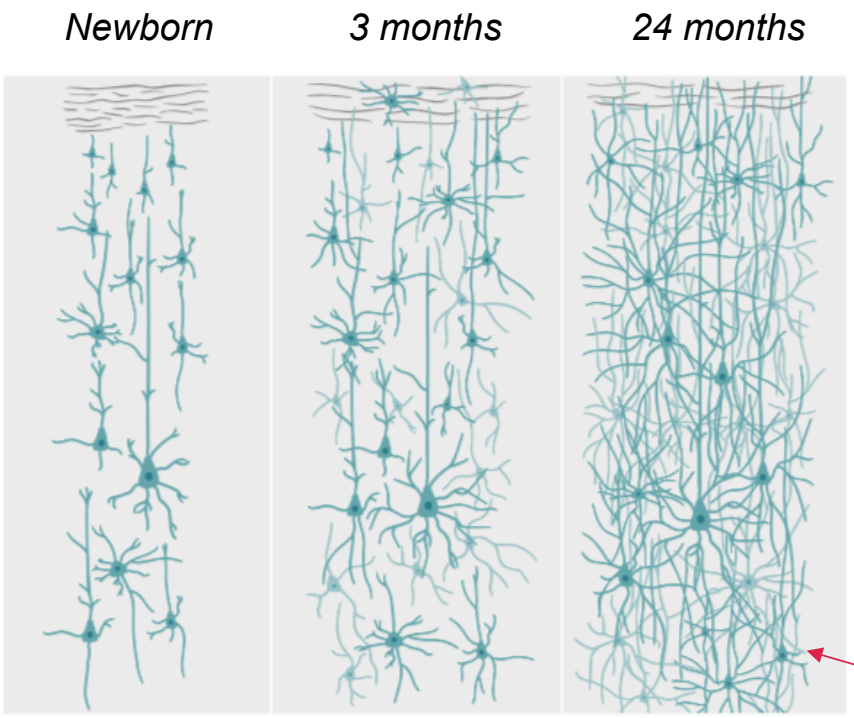
Picture taken from Anderson (2015)

- 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

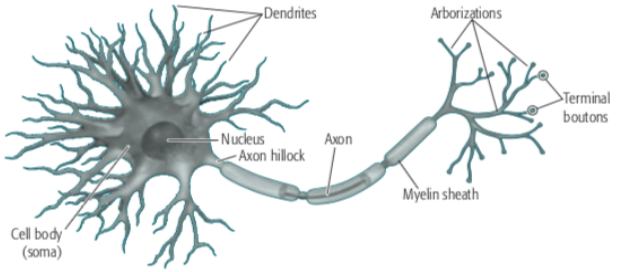
Cognitive development = Development of neural “communication structure”

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



Picture taken from Anderson (2015)

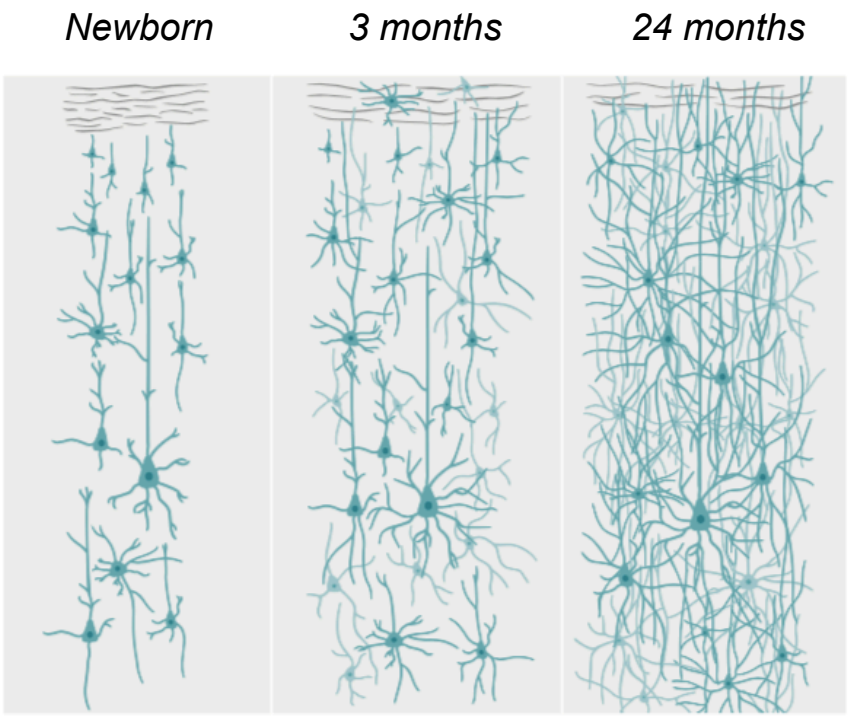
- Neural communication is based on
  - neurons (basic processing units)
  - connections between neurons = **Synapses**
- Learning to represent knowledge (e.g., word meaning) by building up new synaptic connections between neurons
  - **Synaptogenesis** peaks around the age of 2
  - Soon after, elimination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



WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

Cognitive development = Development of neural "communication structure"

*Brain development around **Broca**'s area*



Picture taken from Anderson (2015)

- **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*

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-412)

- How can we design Discovery Learning in an inclusive way?

Exam (20th of April, Web-based)

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")