# Typical & Atypical Cognitive Development

## Unit 0. Introduction into course topics and course structure

15th February 2019

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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 (answering 1-2 questions)
    - Preparing for the next unit by reading a topic-related (short) article (answering 3-5 questions)
    - Taking part in the seminar
  - Taking online exam
    - Answering open-ended questions on presented course contents (to be returned within one week)
- **Course materials**
  https://seasense.github.io

# 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, lecture provided as video; seminar in T-412)**

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

**Unit 5 (12th of April, lecture provided as video; seminar in T-412)**

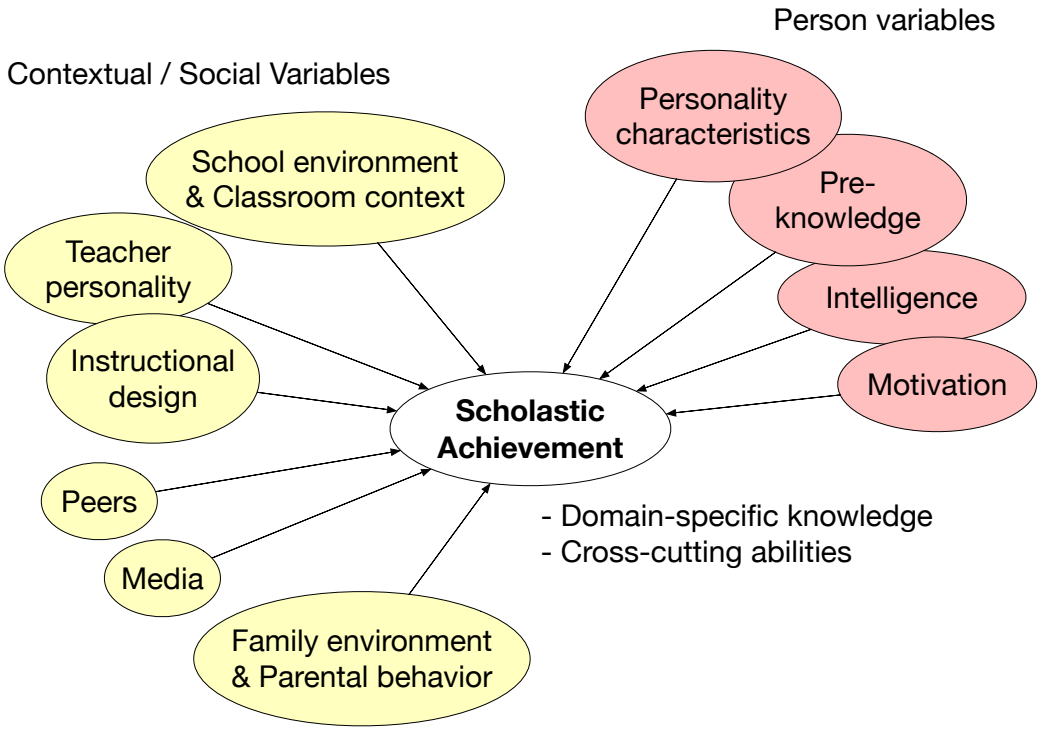
- How can we design Discovery Learning in an inclusive way?

**Exam (20th of April)**

# WHY COGNITION MATTERS

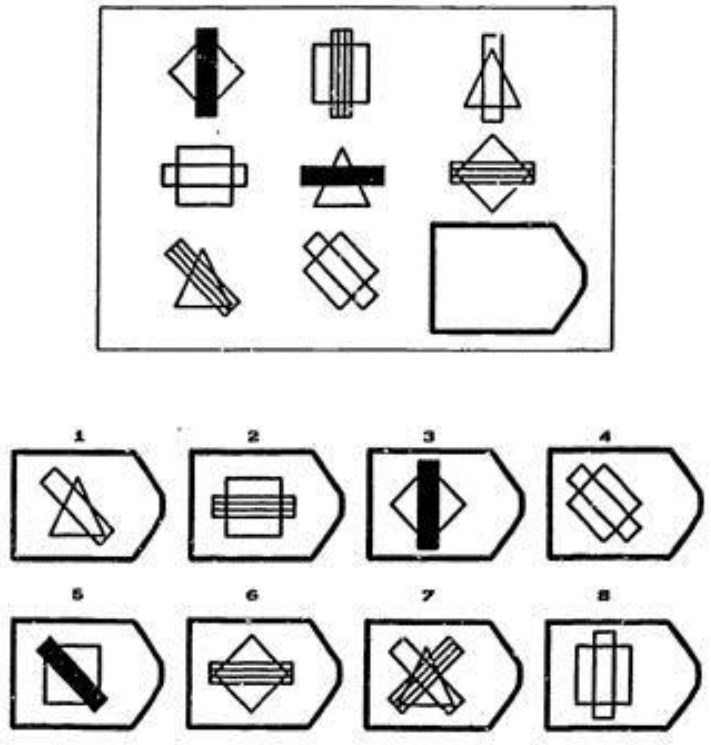
Determinants of scholastic achievement (based on Brühwiler & Helmke, 2018)

**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*

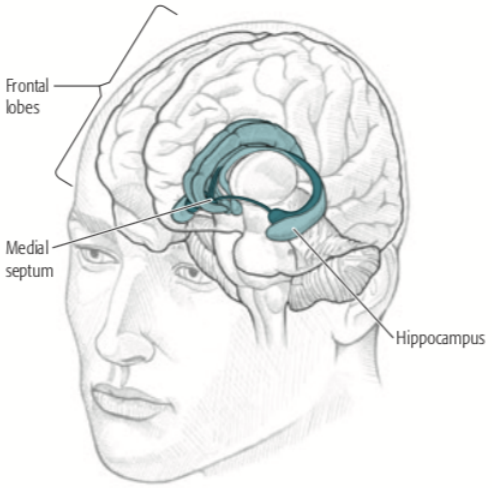
  →*Performance differences between more and less gifted students might become larger*

  →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<br>• Imagination<br>• Planning<br>• Decision-making<br>• Problem solving<br>• … | Interplay of<br>• Working Memory (at the front of the brain = Pre-Frontal lobe)<br>• Long-Term Memory (e.g., Hippocampus, temporal lobe) |
| Retrieving from memory | | |
| Mentally manipulating pieces of information | | |
| Integrating new thoughts into memory | | |



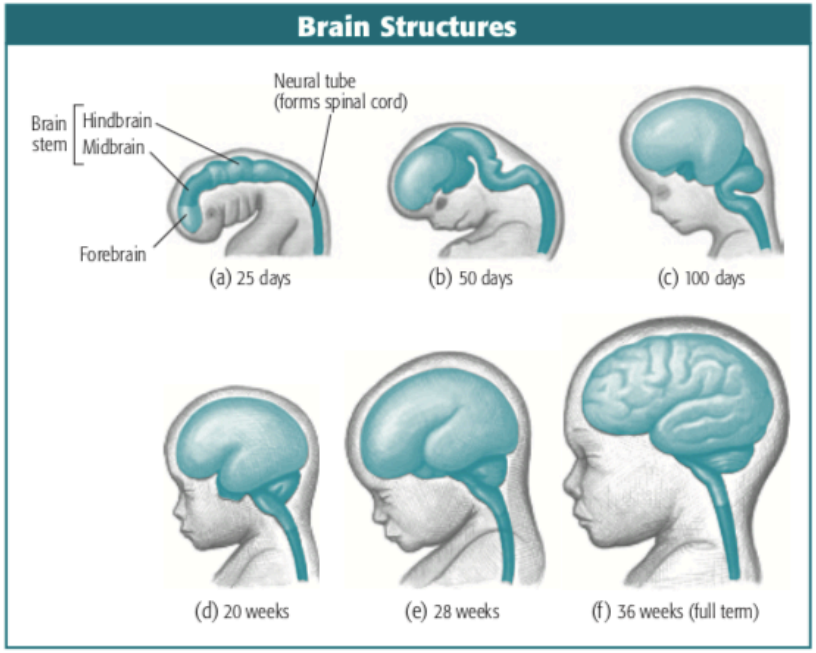

- Identifying regularities in how these components develop during childhood
- Deriving ways and strategies to support cognitive development

# WHY WE CAN INFLUENCE COGNITIVE DEVELOPMENT

Bio-psychological facts on our learnability (neural plasticity)

- Humans have large brains relative to their body size

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

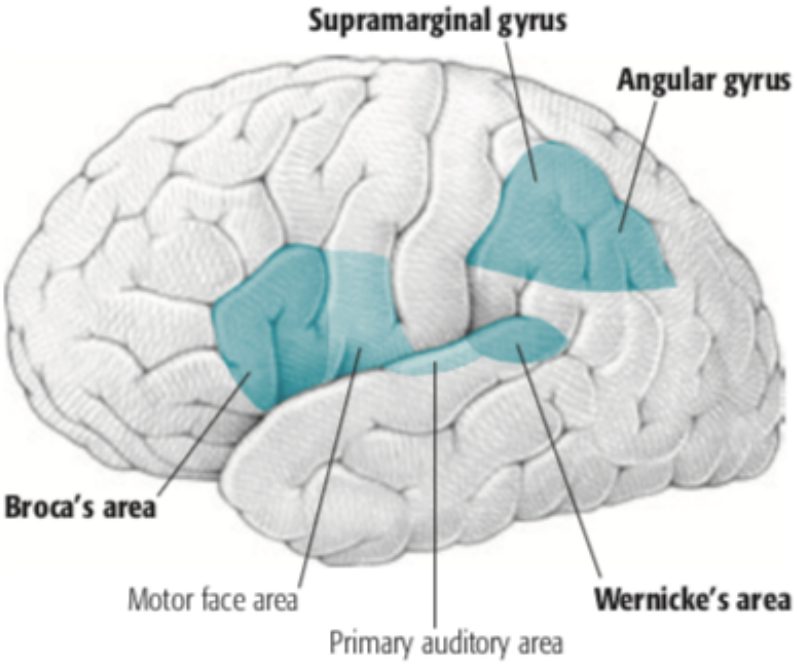



*Picture taken from Anderson (2015)*

- 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"



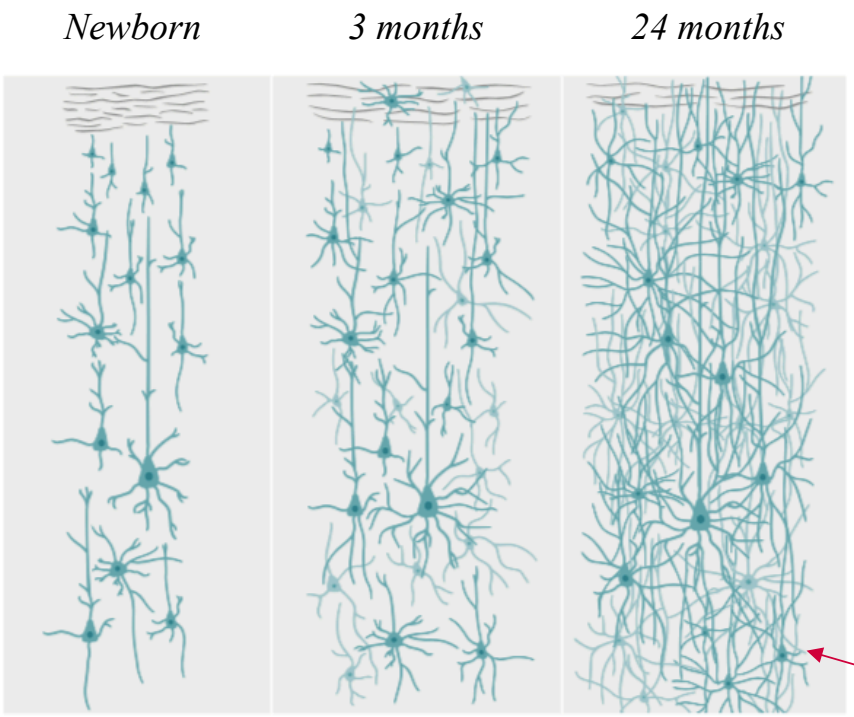

*Picture taken from Anderson (2015)*

- 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

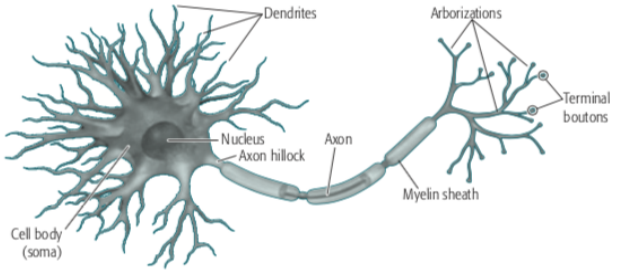
Cognitive development = Development of neural "communication structure"

*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 efficiency** (saving energy)



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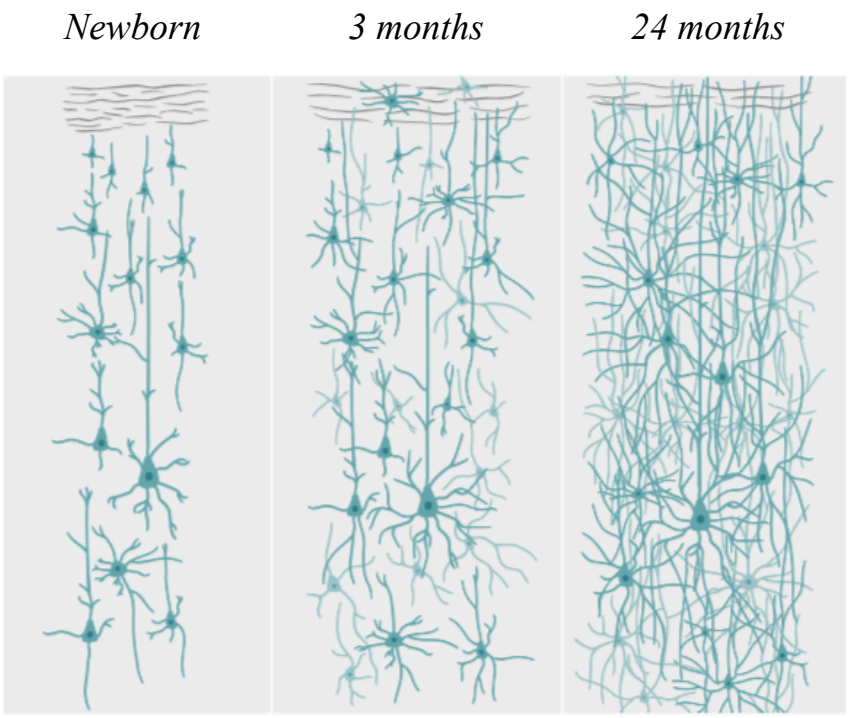


*Picture taken from Anderson (2015)*

- **Synaptic pruning** https://www.youtube.com/watch?v=rxPT78F_ZVE
- 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**)

→ Education: helping to separate the important from the less important experiences / neural stimulations

# 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*

# A S S I G N M E N T

- Assignment 1a
  - Go to https://seasense.github.io and select the link ‘Courses’
  - Go to ‘CogniDev’ and then,
    - click on ‘Slides” to recapitalize today’s course content
    - click on ‘Reflection’ to open a document providing further instructions
- Assignment 1b
  - Download and read the article for the next session (Unit 1)
  - click on ‘Questions’ to open a document providing further instructions

- Send your reflections and answers (in English) to me (paul.seitlinger@tlu.ee) by the 1st of March the latest.

# 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")
    - Can be retrieved from https://tamlyvanbang2k04.files.wordpress.com/2017/08/cognitive-psychology-and-its-implications-john-r-anderson.pdf