Learning & Brain Development

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Nutrition | Brain | Cognition

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Outline

1. Learning & Cognition
2. Brain development: Building brain connections
3. Myelination: Making connections fast & efficient

Learning is about acquiring abilities & knowledge

Changes in performance, behavior or knowledge

- It is a developmental process *(see graph)* with …
- Adaptations by using information from past experiences, refining them and making predictions of the future

It depends on mental processes of thinking & understanding (= cognition);

- It Perception, including visual perception
- Language
- Memory
- Executive Functions
- Attention
- Motor

ASQ, Ages and Stages Questionnaires;
DMC, Developmental Milestones Checklist;
KDI, Kilifi Developmental Inventory;
MDAT, Malawi Developmental Assessment Tool;
PRIDI, Regional Project on Child Development Indicators;
SBECDS, Saving Brains Early Childhood Development Scale.

https://www.tankonyvtar.hu/hu/tartalom/tamop412A/2011-0023_Learning_in_digital/0204.scorml;
Tetzlaff et al. 2012; Lancaster et al. BMJ Glob Health 2018; Maccow 2011 (Pearson)

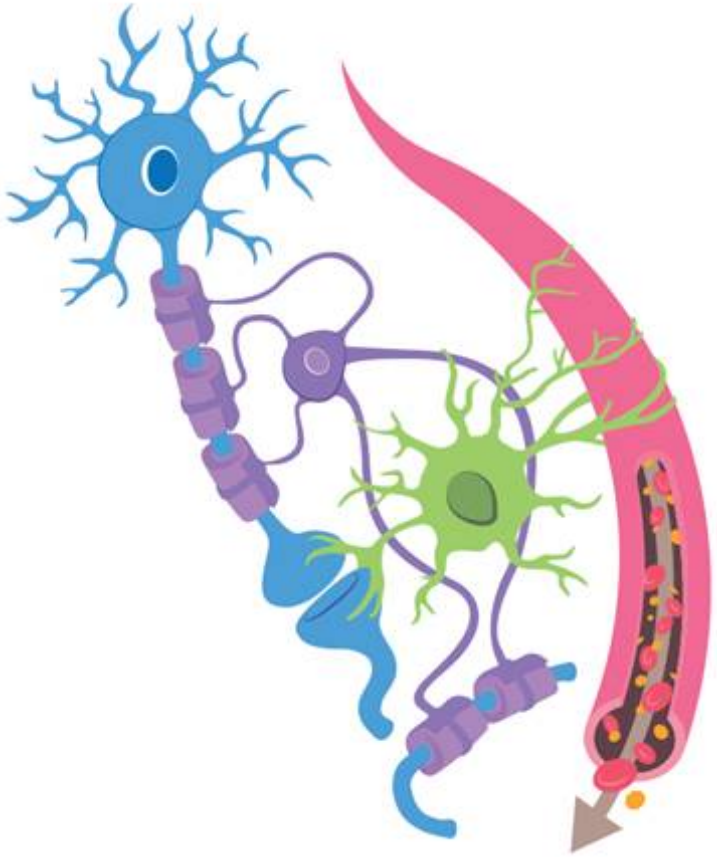
Learning is influenced by brain development & maturity

Children learn in different ways & learning differences may be related to, e.g.;

- Genetics,
- Temperament;
- Environment, including nutrition
- Age, and
- Level of development and brain maturity, including vision & visual processing

https://www.apa.org/education/k12/brain-function; https://www.vlca.com/visionlearning.php: Siu & Murphy 2018

Brain development: the brain is more than neurons



80 - 100 billions neurons[1]

- Neuron: information transmission and processing

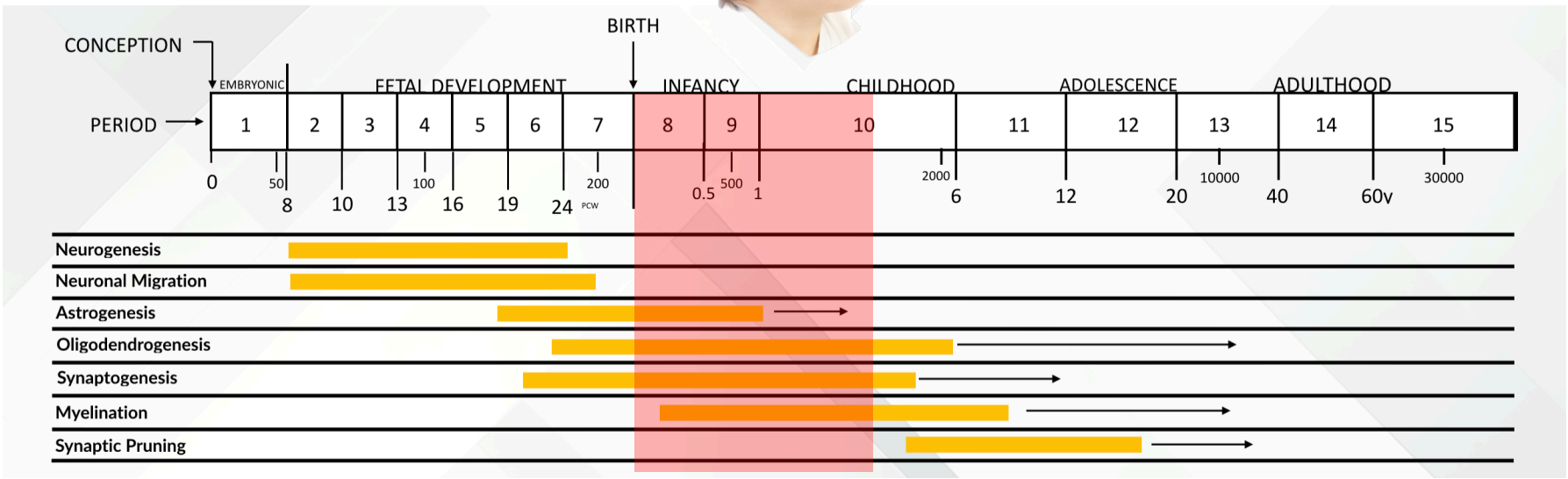
100 billions non-neuronal cells

- Astrocyte: supports BBB, brain energy, damage repair
- Oligodendrocyte: myelination
- Endothelial cell/Pericyte: blood vessels linings, tissue growth
- Microglia (*not shown*): primary immune cells of the brain

1. *Wong A, et al. Front Neuroengineering 2013;6:1–22*

After birth, the brain growth in size & in complexity

Neurons get connected for fast & efficient information processing

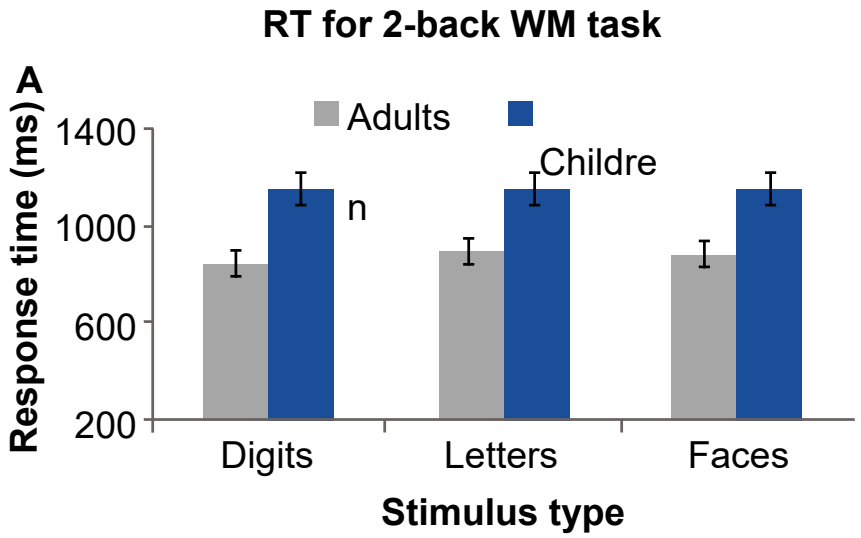


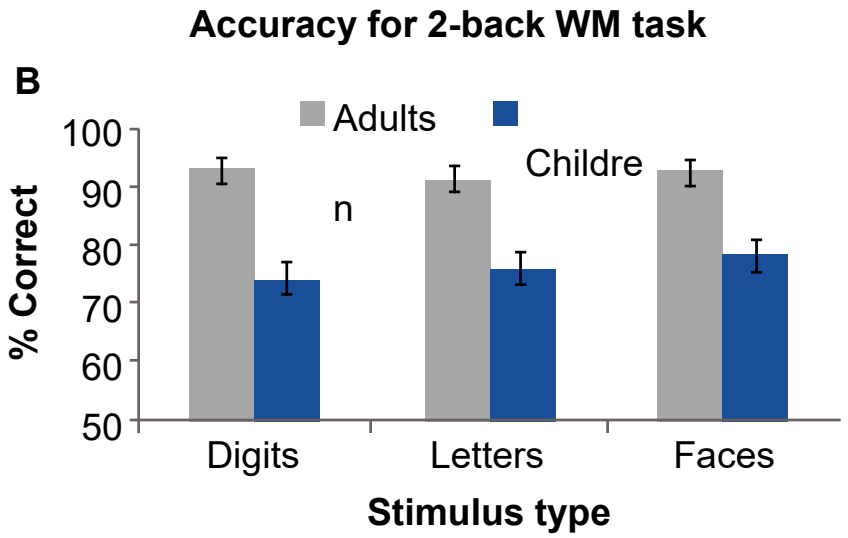
After birth, the brain growth in size & in complexity

Neurons get connected for fast & efficient information processing

Information processing is still slower and less accurate in children than in adults[1]

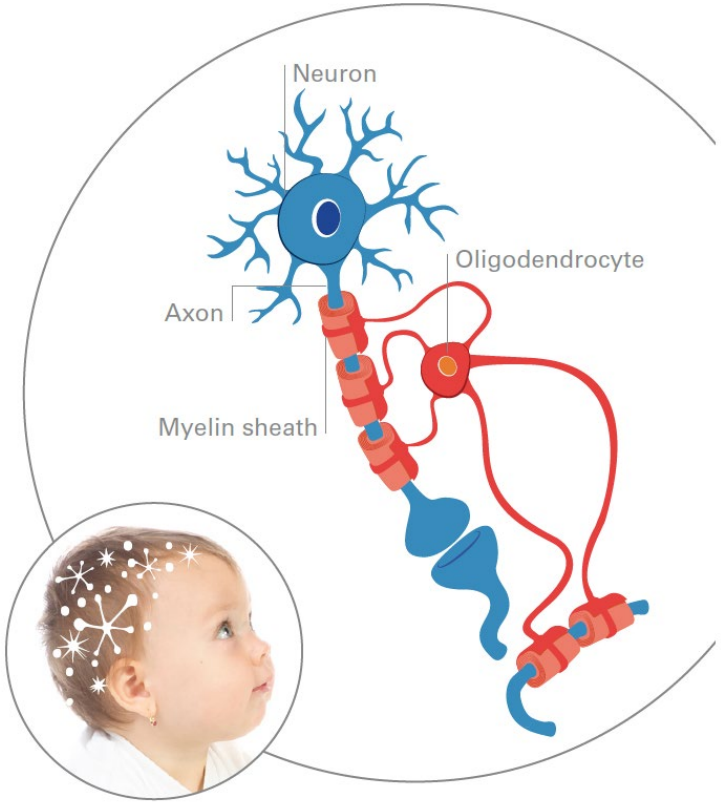
8-yr-olds (N=15) vs adults (N=15)





Behavioral results: Adults were significantly faster (A) and made significantly fewer errors (B) than children; Error bars reflect standard errors.

Myelination facilitates information processing



Myelination is a hallmark of neurodevelopment

Wrapping of nerve fibers (axons) with a lipid-rich sheath

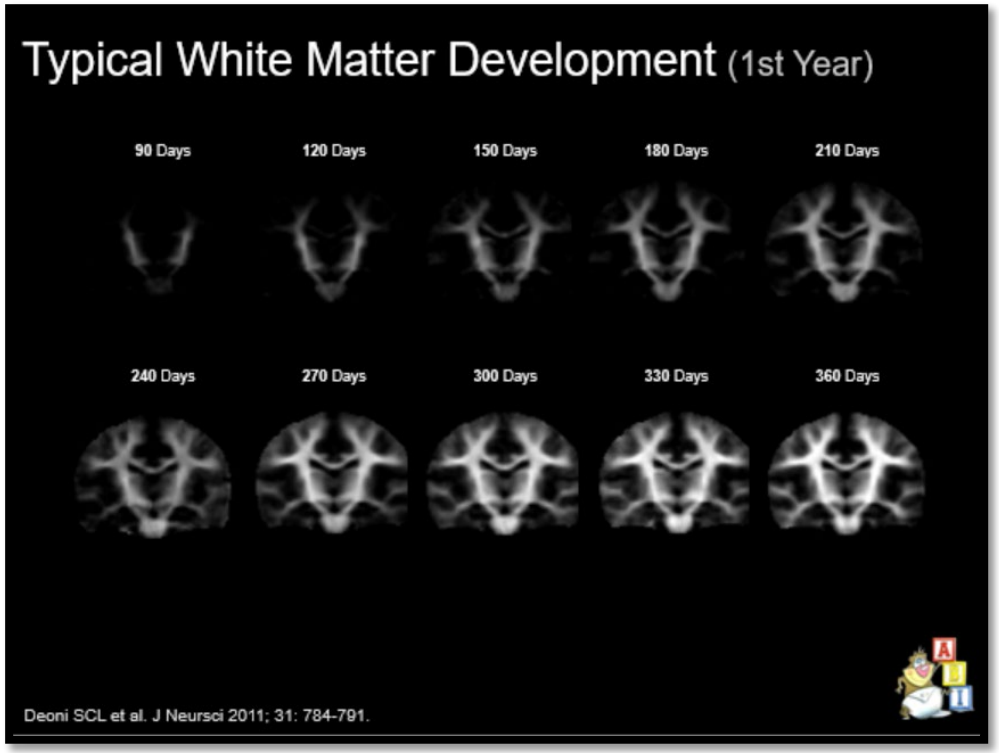
Ensures fast, efficient & synchronized communication between cells and networks

- Velocity of unmeylinated axon[1]: 5m/sec
- Velocity of meylinated axon[1]: 100 m/sec

Matures alongside cognitive and behavioral development

1. Koeppen & Stanton 2008

Myelination starts in utero and follows a specific developmental pattern into adolescence



Human clinical studies show a link between myelination and cognitive abilities:

- General cognitive ability[1]
- Language[2] & reading[3]
- Working memory[4]
- Processing speed[5]
- Sensory reactivity[6]

→ Important skills for learning

1. Schmithorst et al., 2005; Deoni et al., 2014; 2. Büchel et al., 2004; Catani et al., 2007; O'Muircheartaigh et al., 2013;
3. Nagy et al., 2004; Beaulieu et al., 2005; 4. Nagy et al., 2004; Short et al., 2013; 5. Turken et al., 2008; Bartzokis et al., 2010; Lu et al., 2013; 6Weinstein et al., 2014

Key Messages

- Child learning is influenced by brain development & maturation
- Important postnatal brain development processes are linked to establishing brain connections and networks
- One of those processes is myelination, the coating of axons with lipid-rich myelin sheaths
- Myelination facilitates signal transduction between cells and thus supports fast, efficient and synchronized brain communication
- This is important for cognitive performance and learning

THANK YOU