Lean in Medical Education: Reaching for Quality Management Tools to Teach Human Anatomy Effectively in a Multicultural and Multilingual Learning Space

Neurobiological aspects of protracted post-adolescent emotional and cognitive development

Zdravko Petanjek

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Department of Anatomy and Clinical Anatomy
Institute of Anatomy „Drago Perović”

International Symposium on Teaching in Medical Education:
How to Teach Human Anatomy Effectively
Zagreb, September 27-28, 2024, University of Zagreb School of Medicine.
Organized by Department of Anatomy and Clinical Anatomy &
Centre for Improvement of Teaching Competencies

Department of Anatomy and Clinical Anatomy
Institute of Anatomy „Drago Perović"

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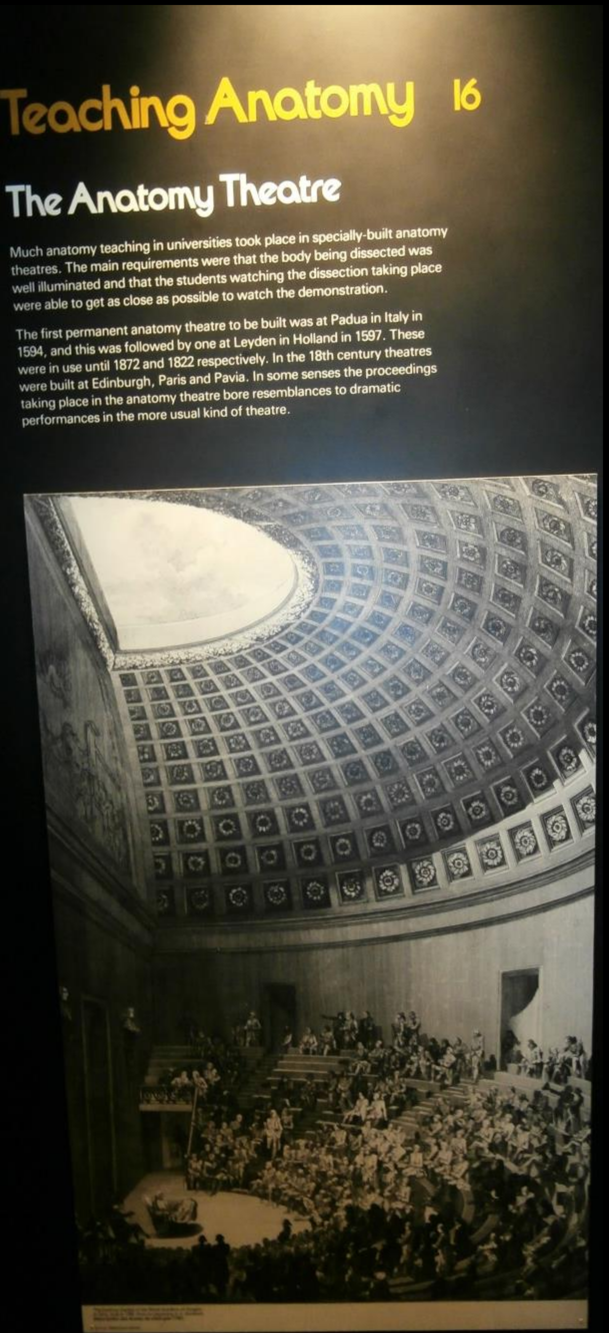
SVEUČILIŠTE U ZAGREBU MEDICINSKI FAKULTET

UNIVERSITAS STUDIORUM ZAGRABIENSIS MDCLXIX

1917–2017
100 godina Medicinskog fakulteta Sveučilišta u Zagrebu

Department of Anatomy and Clinical Anatomy
Institute of Anatomy „Drago Perović"

Traditions in Anatomy



The Anatomy Lesson of Dr. Nicolaes Tulp, January 31, 1632, *Rembrandt Harmenszoon van Rijn*

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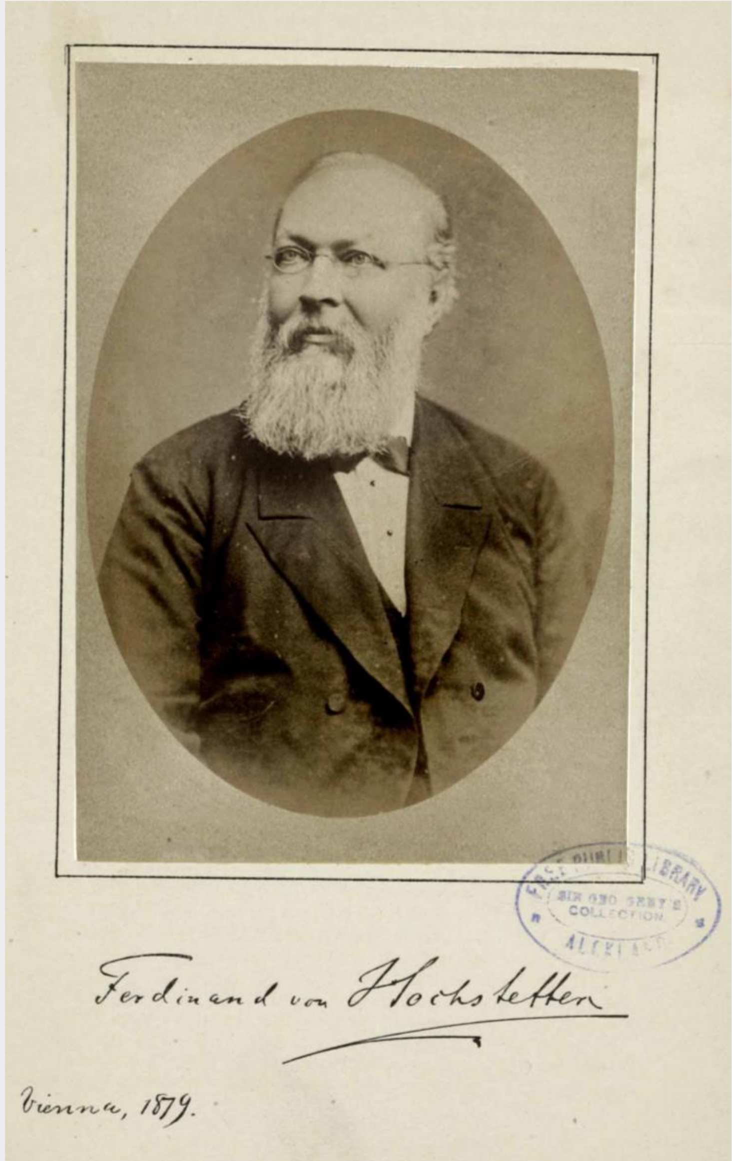

dr. Drago Perović

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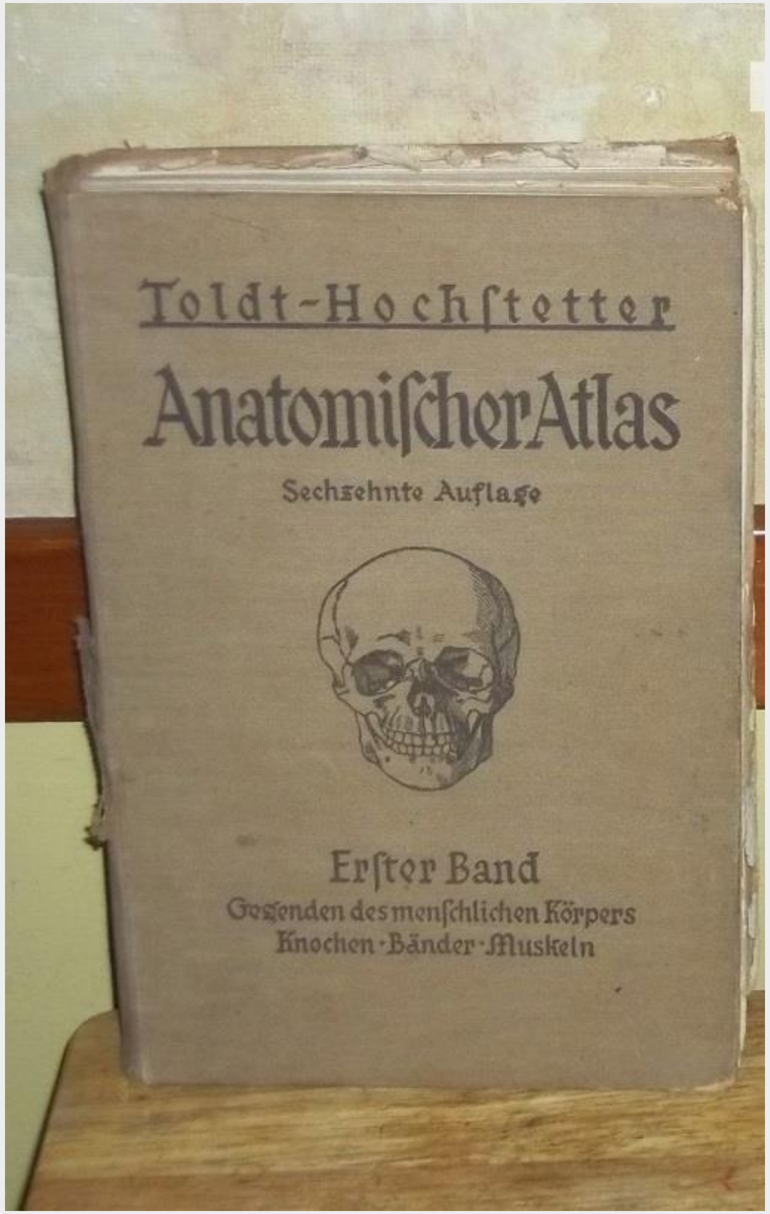

1. **PEOPLE**
2. **CLINICALLY ORIENTED**
3. **RESEARCH EXCELENCE**

Anatomischer Atlas : topographische und systematische Anatomie des Menschen in zwei Bänden / 1 Skelettsystem, Kopf- und Halseingeweide.

Author:	Carl Toldt; Ferdinand Hochstetter; Jelena Krmpotić-Nemanić
Publisher:	München [u.a.] : Urban & Schwarzenberg, 1979.
Edition/Format:	Book : German : 27. Aufl. / überarb. und hrsg. von Jelena Krmpotić-Nemanić View all editions and formats

dr. Jelena Krmpotić Nemanić

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⇒ “Anatomy,” derived from the Greek, *anatome* - **to cut or cut repeatedly** - dissection has been an integral part of anatomy teaching through the history.

⇒ The **traditional human anatomy teaching** - in person lectures, cadaveric dissection laboratory and anatomy textbook.

⇒ Traditional lectures (teaching) are mostly <u>based on knowledge transmission from lecturer to students</u> - **IS THIS STATMENT REALY TRUE?**

- **Nowadays**, curricula shift towards forms <u>of teaching based on knowledge construction by the students</u>.

⇒ Evidence-based and **student-centered strategies have shown to improve student engagement and interaction**: team-based learning, case-based learning, and flipped classroom – **WHAT IS THE COST BENEFIT**?

“Teaching oriented” –
Role of teacher is to teach.
Student’s “follow” teachers.

“Learning oriented” –
Role of teacher is to coach.
Teachers “direct and follow” student’s.

Who are our students?

- Highly motivated to learn as much as possible
- Independently thinks deeply about the topic
- Actively participates in class
- Shows initiative

- The motivation is to finish the studies, in principle with a minimum of effort
- He thinks about what will be on the exam
- Mostly passive in class
- No initiative

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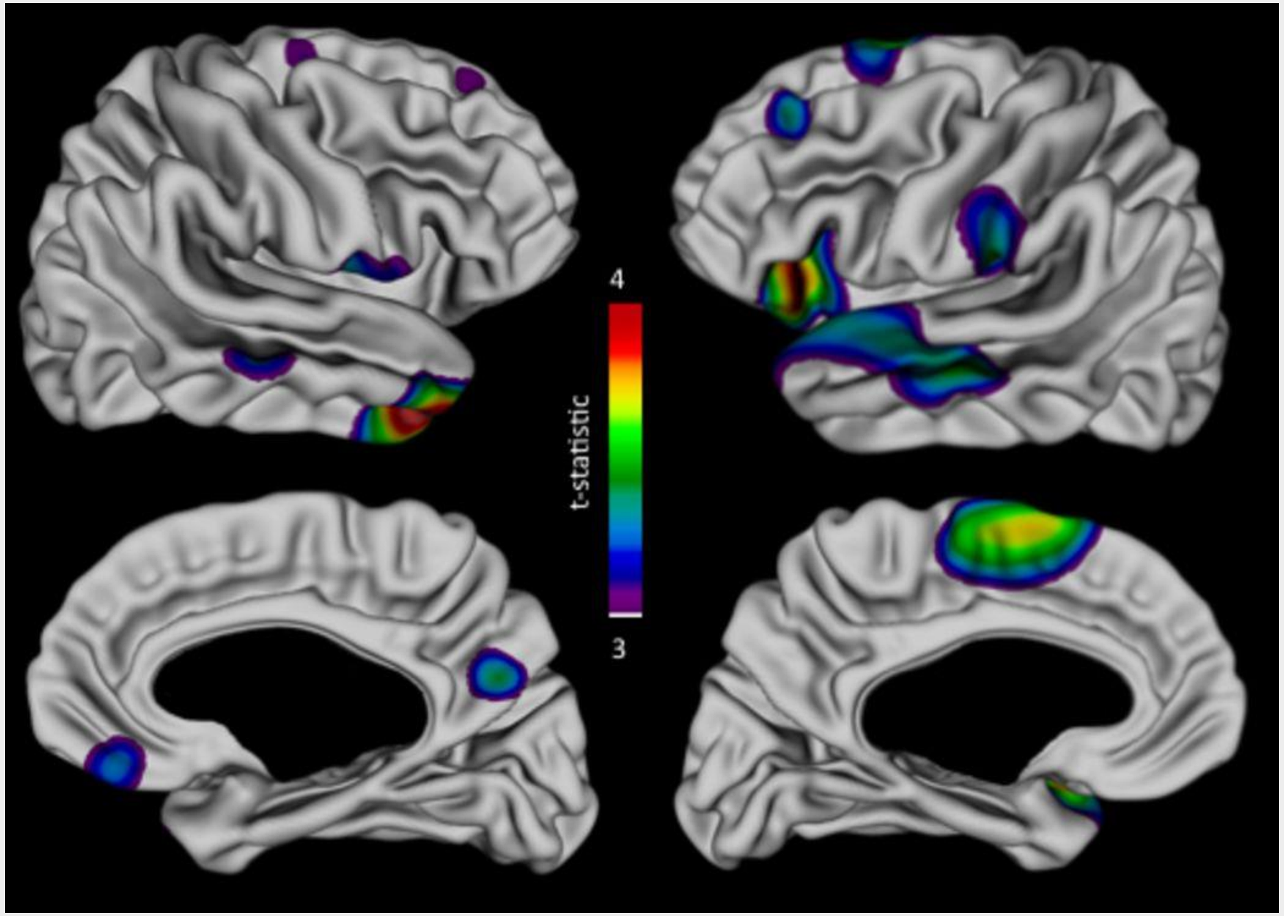
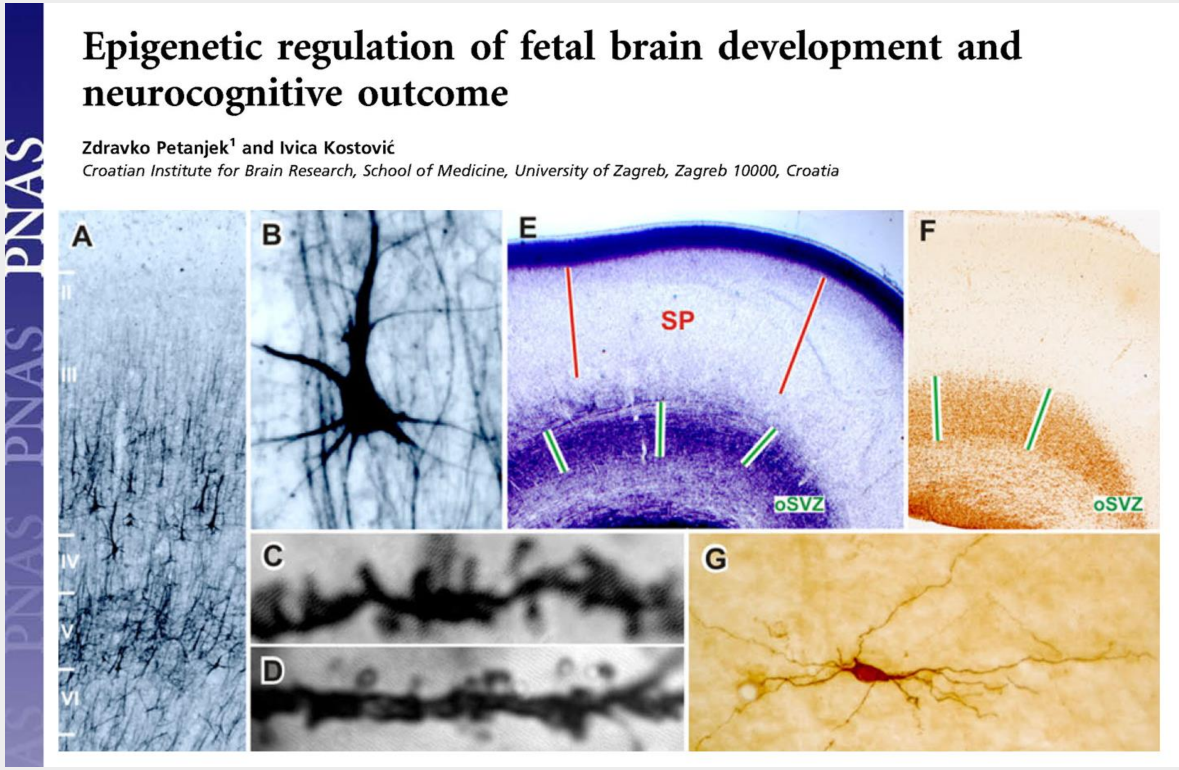
Is the brain structure "better" than 50 years ago?

Human brain growth in the 19th and 20th century. (Kretschmann et al., 1979. J Neurolo Sci. 40:169-188.)
https://pubmed.ncbi.nlm.nih.gov/372500/

Evidence for a secular increase in human brain weight during the past century. (Miller and Corsellis, 1977. Ann Hum Biol 4:253-257.) https://pubmed.ncbi.nlm.nih.gov/900889/




PNAS

Epigenetic regulation of fetal brain development and neurocognitive outcome

Zdravko Petanjek[1] and Ivica Kostović
Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Zagreb 10000, Croatia

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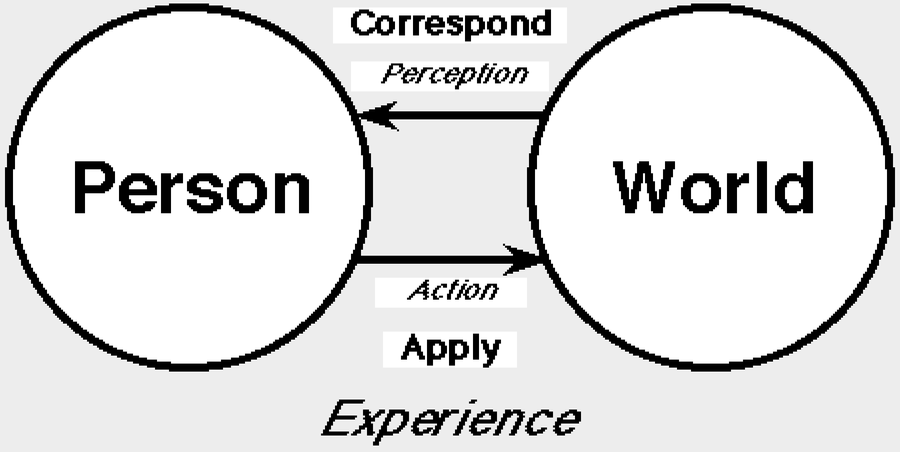

A fundamental characteristic of brain development is that environmental experiences are as important as genetic program.

Comparative morphological, neuroimaging and psychological measurements performed in the past century provided evidence that today's population (at least in average when compared to earlier generations) is showing important changes in the structural organization of human neocortical network and consequently in the level of cognitive performance.

There is huge societal impact of such findings.

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Socio-cultural evolution

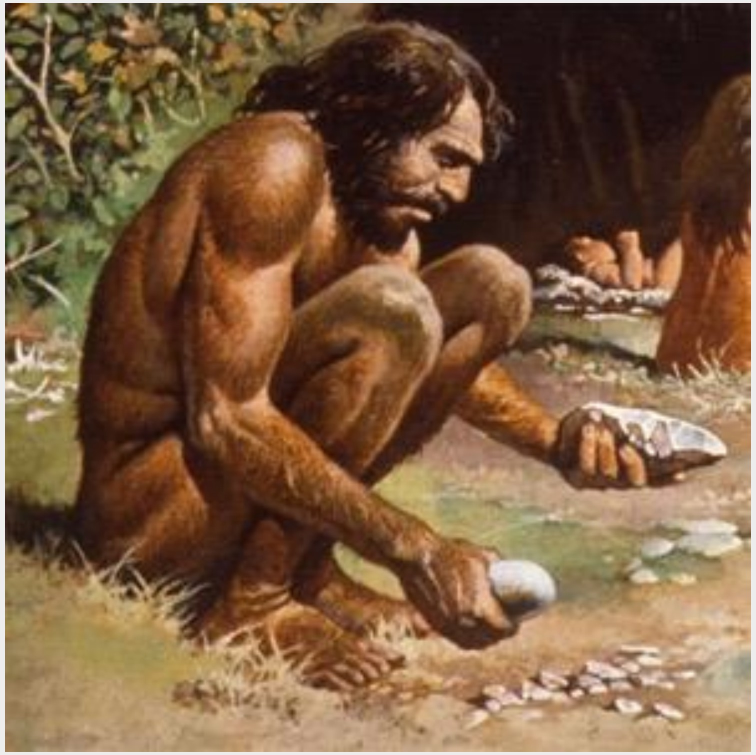
Remarkable advances in technologies that enable the extraordinary distribution and use of information have dramatically changed our way of life.

How are human beings adapting to such dramatic changes?

The pace and pervasiveness of these changes raise the question:

IS THE LIFE MORE STRESSFUL?

IS IT MORE DIFFICULT TO BECOME INDEPENDENT TODAY?



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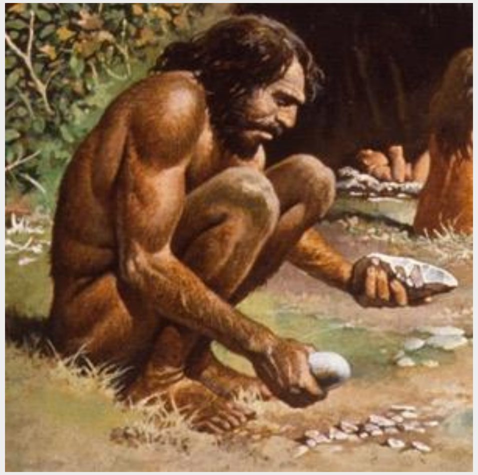
The way children and adolescents of today learn, play, and interact has changed more in the past 15 years than in the previous 570 since Gutenberg's popularization of the printing press.

The pace of "penetration" (i.e., the amount of time it takes for a new technology to be used by 50 million people) is unprecedented.

For radio, technological penetration took **38 years**; for telephone, **20 years**; for television (TV), **13 years**; for the World Wide Web, **4 years**; for Facebook, 3.6 years; for Twitter, 3 years; for iPads, **2 years**; and for Google plus, **88 days**.

Socio-cultural evolution



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THE HUMAN BRAIN IS A SOCIAL BRAIN

PERSONAL, SOCIAL AND WORKING ENVIRONMENT BECOMES EXTREMELY COMPLEX

During development life experiences change the STRUCTURE of the nervous system

Neuronal circuits are formed by genetic programs during embryonic development and modified through interactions with the internal and external environment.

DIFFERENCES IN
GENES AND ENVIRONMENT
MAKE EACH PERSONS
BRAIN UNIQUE.

Review Trends in Neurosciences Vol.31 No.12

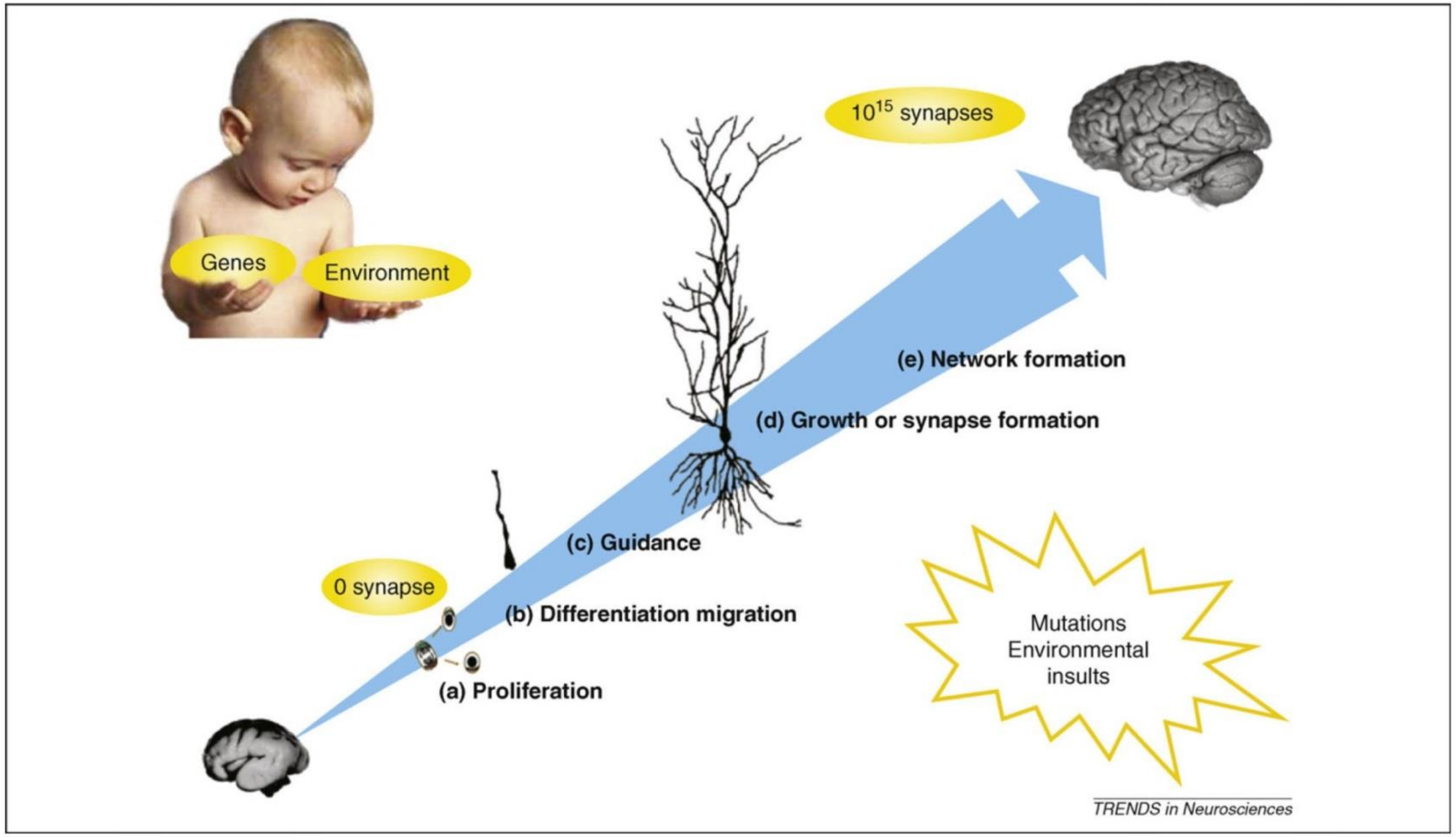
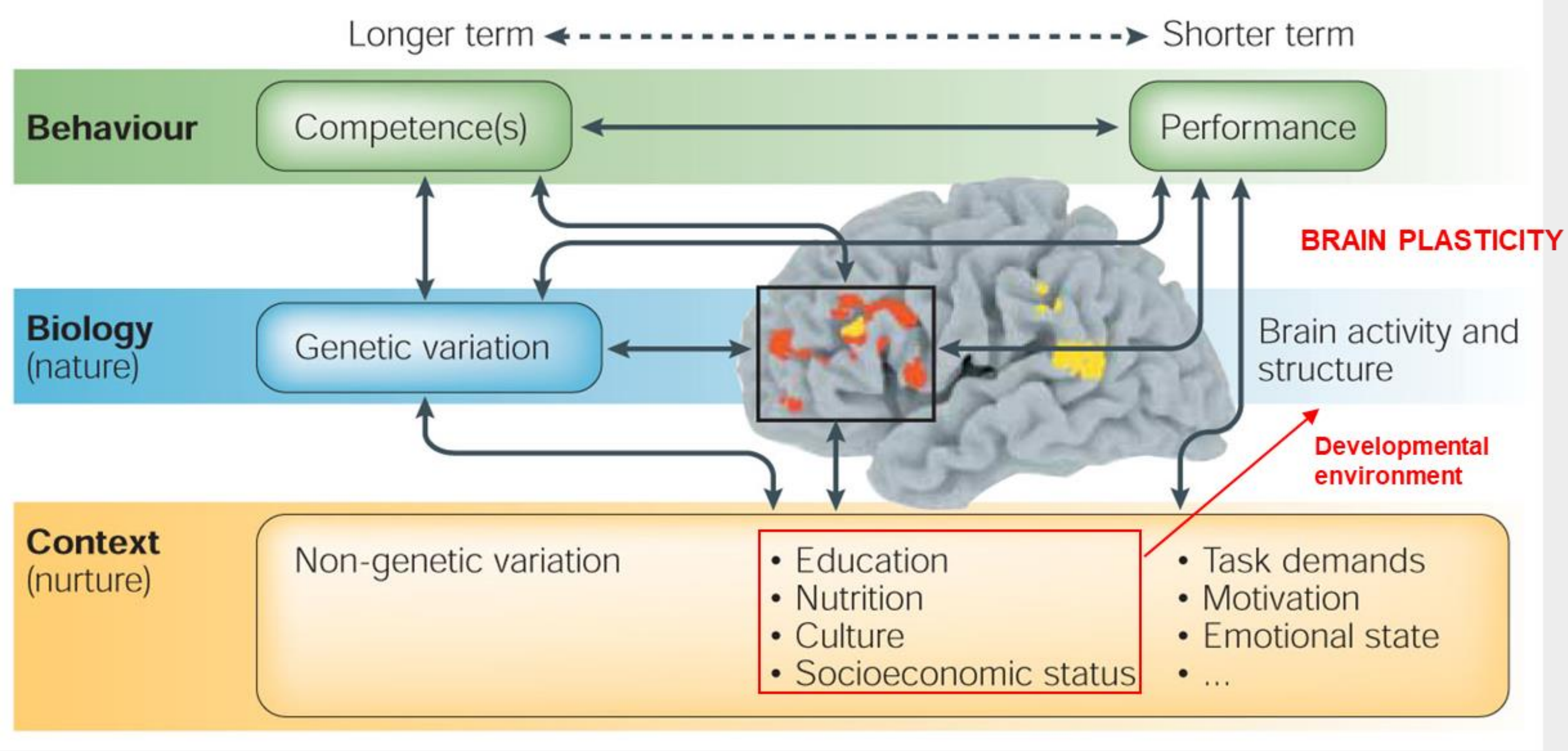


Figure 1. Schematic illustration to depict the impact of the environment and genetic mutations on all developmental stages. **(a)** Proliferation, **(b)** differentiation and migration, **(c)** guidance, **(d)** growth or synapse formation and **(e)** network elaboration are modulated by genetic and environmental factors. Alterations of these steps due to mutations and/or environmental factors can lead to developmental-stage-dependent malformations that will be associated with inappropriate proliferation, migration, guidance, differentiation, growth or synapse formation.

During development life experiences change the STRUCTURE of the nervous system



Volume 14, Number 4, 2008 THE NEUROSCIENTIST

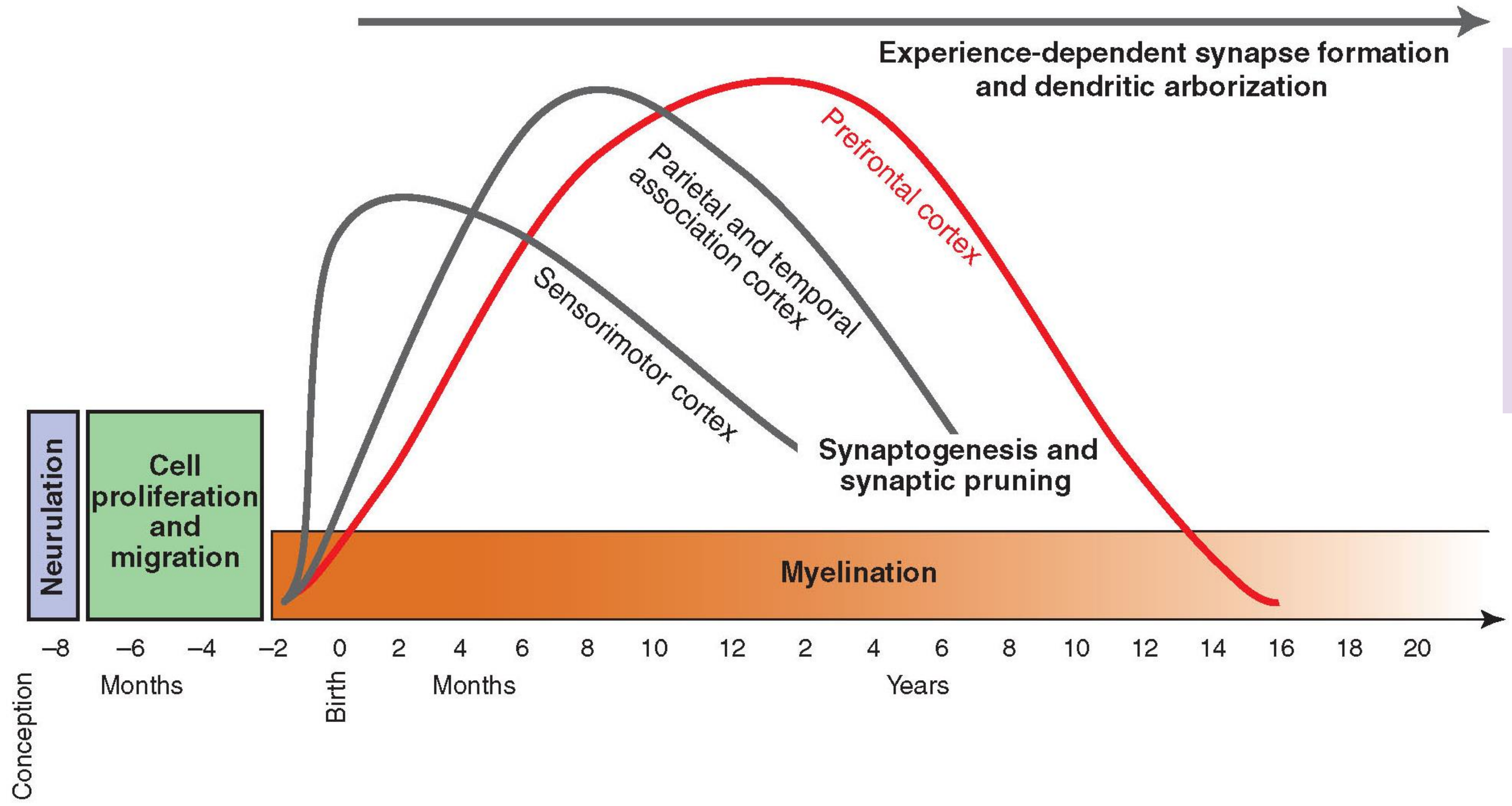
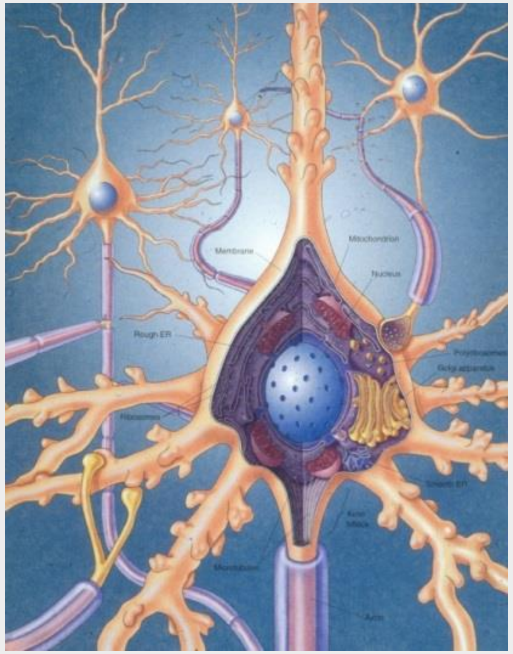


Fig. 1. Time course of human brain development. The development of the nervous system occurs through the interaction of several processes, some of which, including proliferation and migration of cells and the formation of the neural tube (neurulation), mostly occur before birth, although others continue into adulthood. The postnatal development includes regional changes in synaptic density, with the prefrontal cortex (PFC) being one of the latest, and protracted development of myelination. Reproduced from Casey and others (2005b) with permission.

Synaptic overproduction:
Fine tuning and synaptic pruning
Peak size is occurring at different ages in different regions



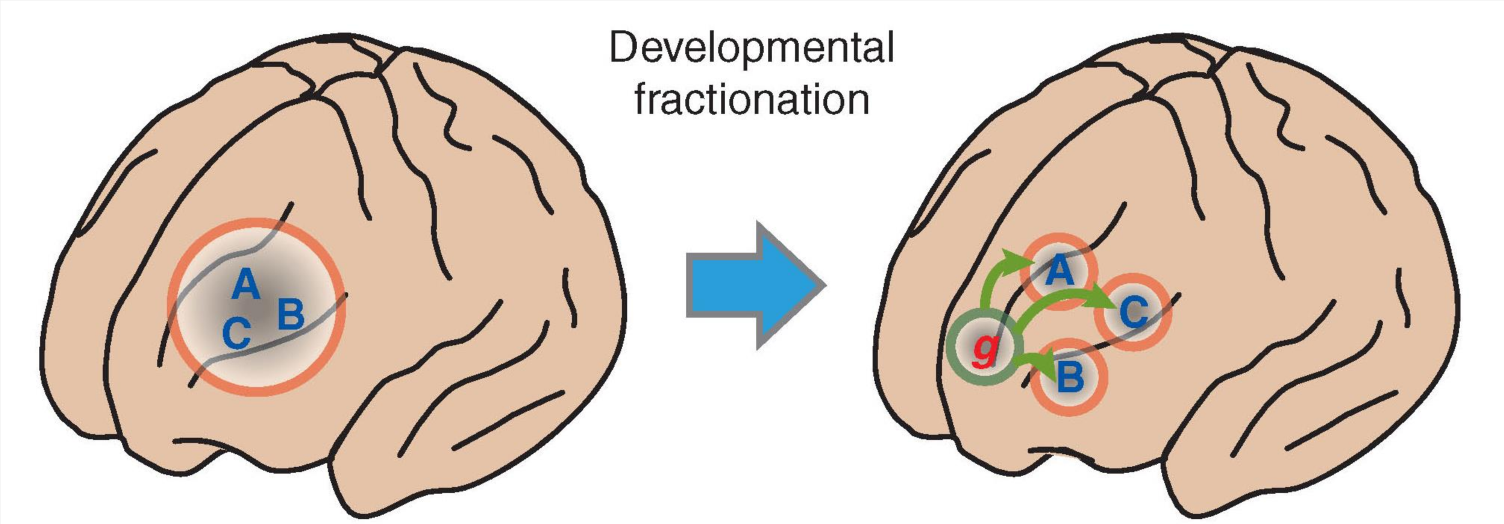
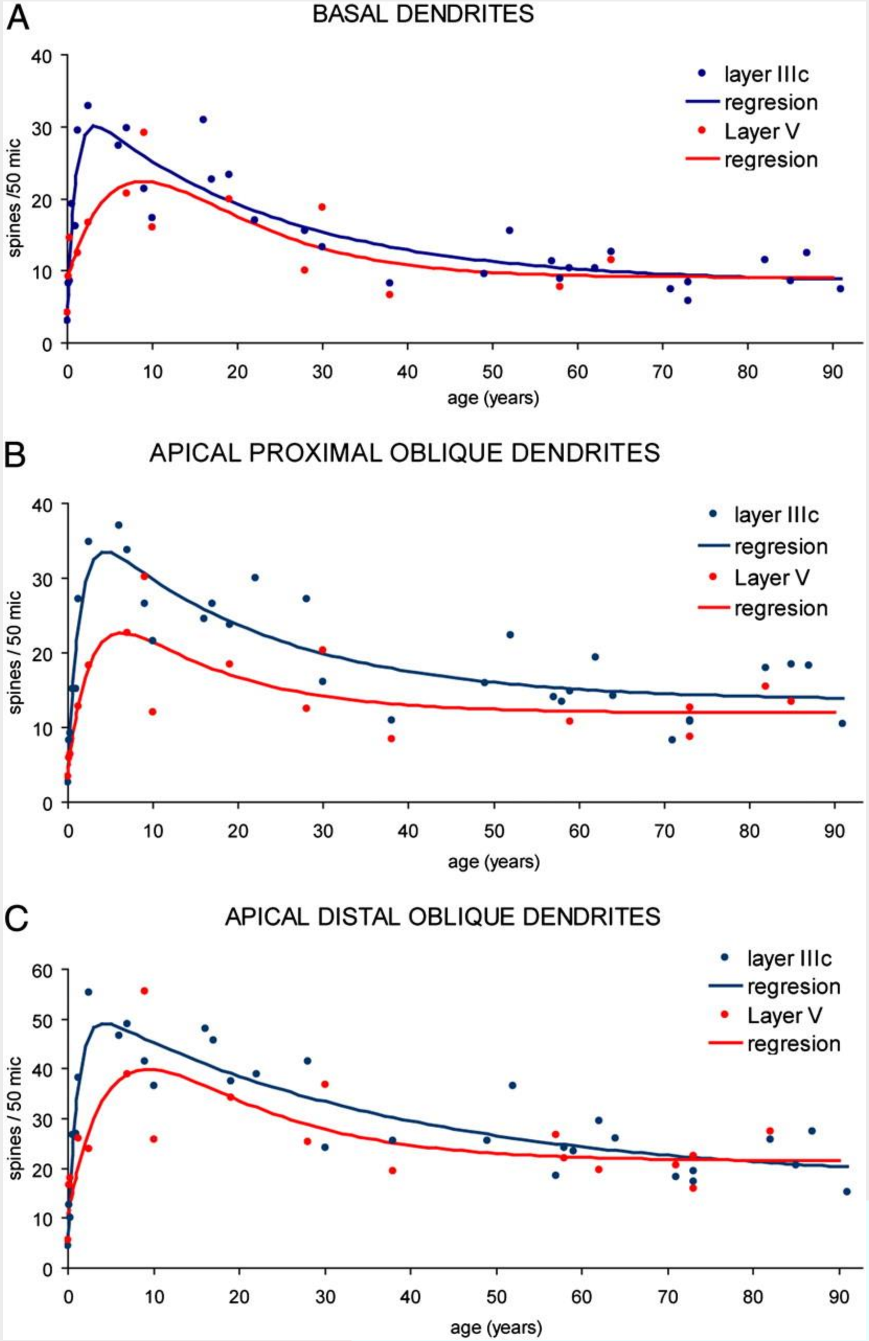


Fig. 6. Hypothetical diagram for functional neural development of the prefrontal cortex. In the immature brain (*left*), individual cognitive functions (A, B, and C) are processed in a common neural system, whereas the matured brain (*right*) has separable neural substrates for each function, and these fractionated systems are orchestrated by a general intelligence, *g*. It is notable that the independent networks are not necessarily topographically separable: they might be intermingled in the same area.

THE NEUROSCIENTIST Prefrontal Development in Young Children

Synaptic pruning is allowing GREATER "CONNECTIVITY" AND INTEGRATION OF NEURAL CIRCUITRY from disparate parts of the brain. This INCREASED COORDINATION OF BRAIN ACTIVITY IS A HALLMARK OF MATURATION, and is accompanied by an age-related increase in the correlation of activities in different parts of the brain on a wide variety of cognitive tasks.



PNAS | August 9, 2011 | vol. 108 | no. 32 | 13281–13286

Extraordinary neoteny of synaptic spines in the human prefrontal cortex

Zdravko Petanjek[a], Miloš Judaš[a], Goran Šimić[a], Mladen Roko Rašin[a,b,c], Harry B. M. Uylings[d], Pasko Rakic[b,c,1], and Ivica Kostović[a]

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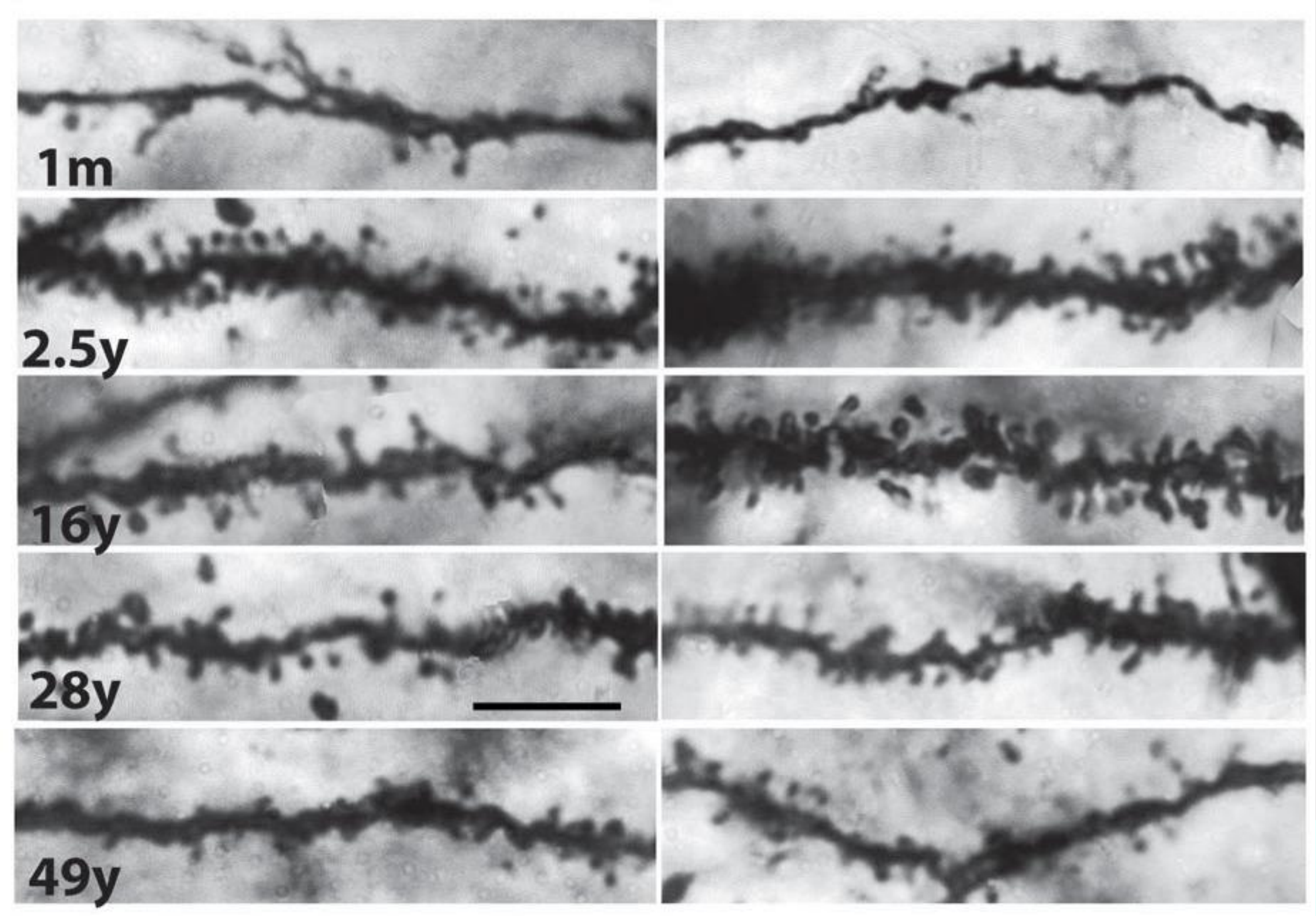
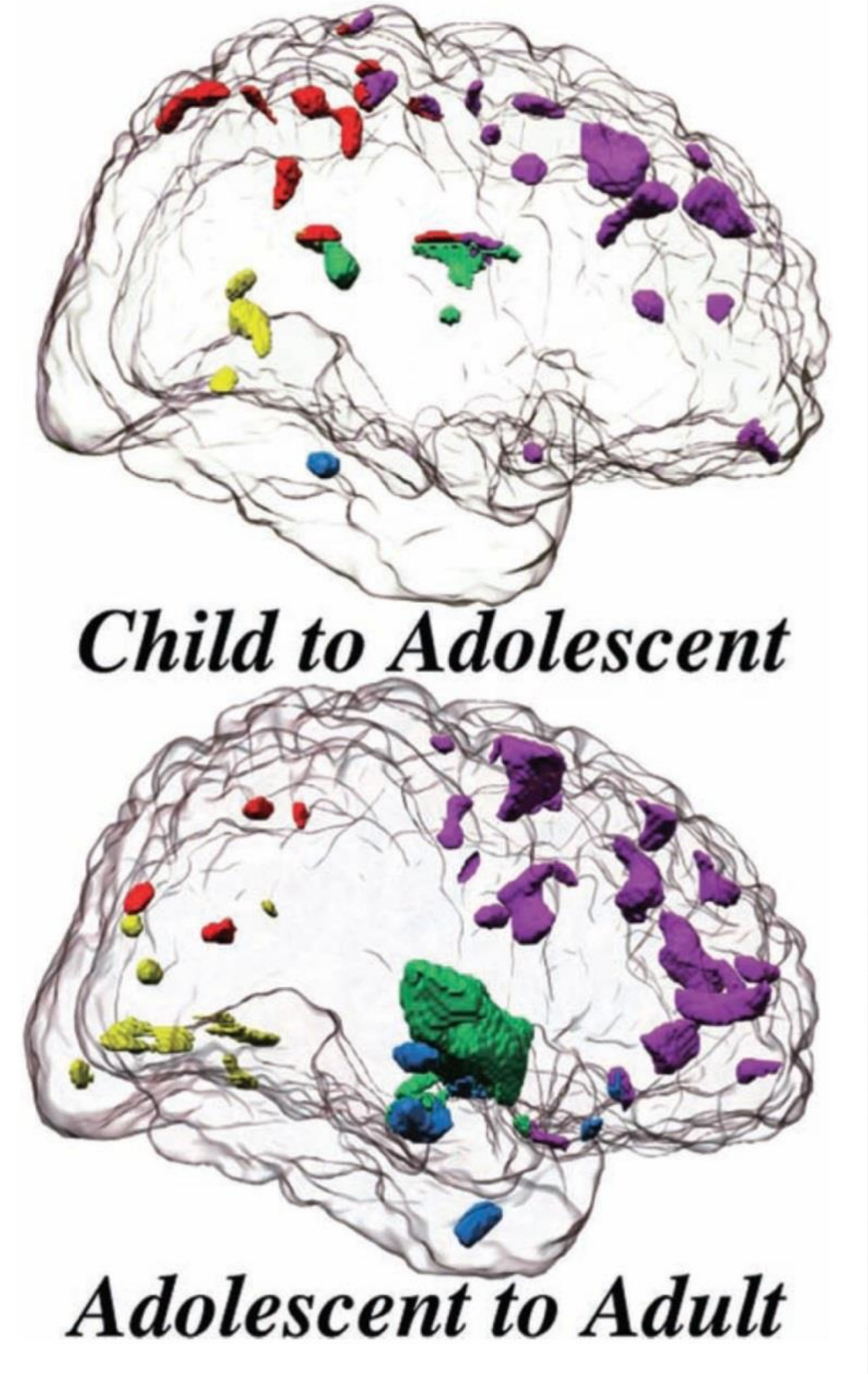
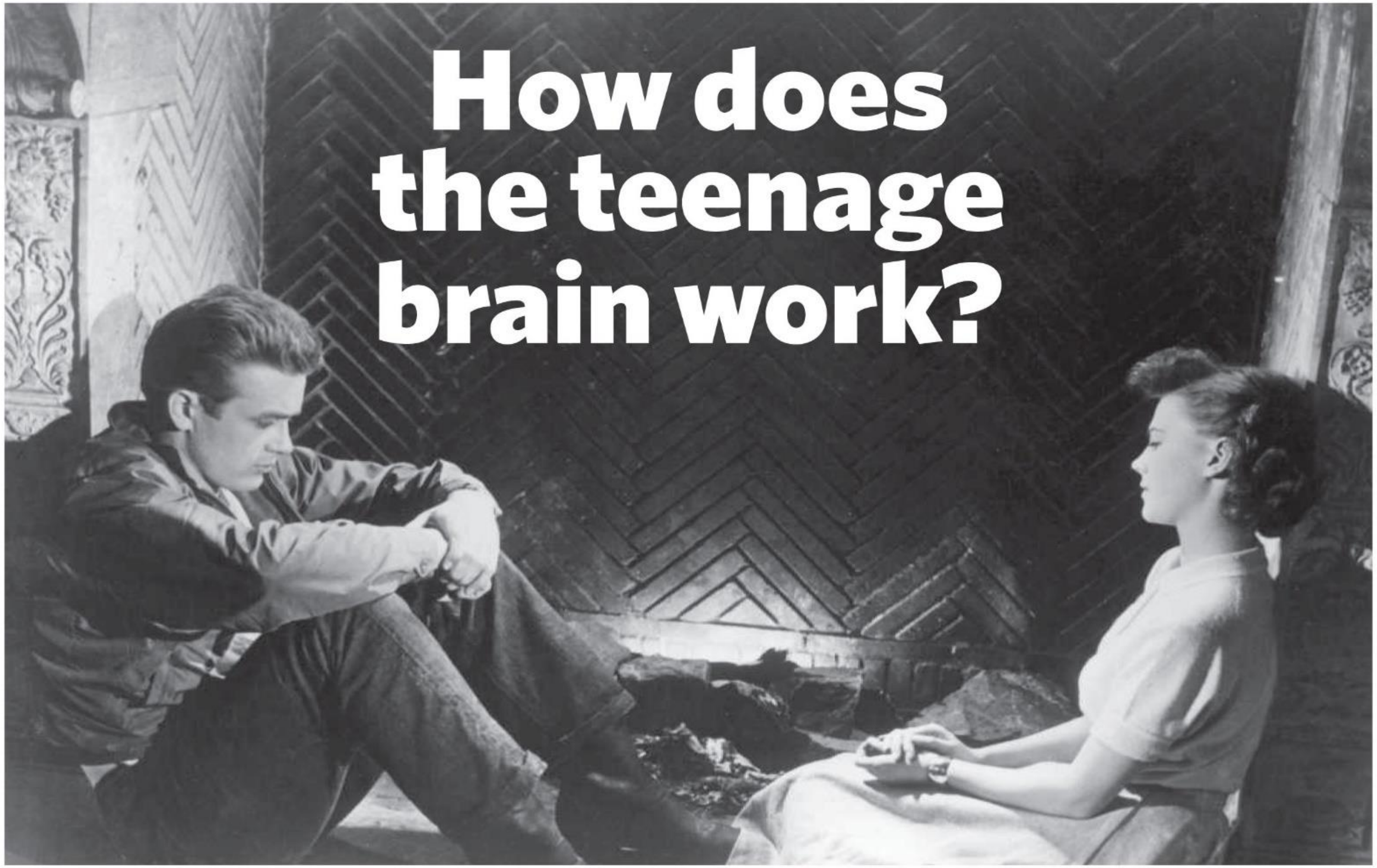


PNAS



NATURE|Vol 442|24 August 2006 NEWS FEATURE



Changes in the structure of children's brains may account for some of the risky business of adolescence, **Kendall Powell** finds.

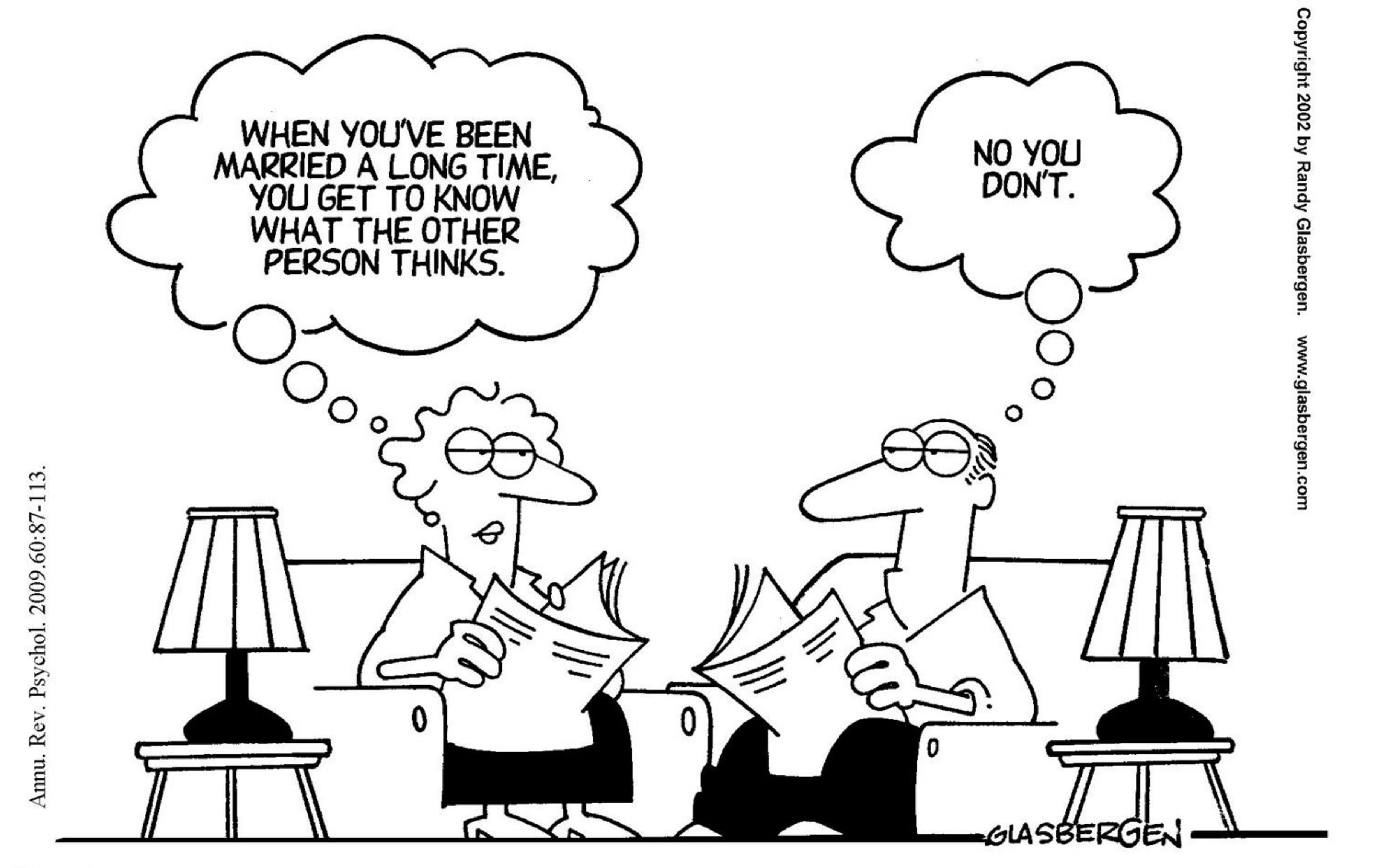
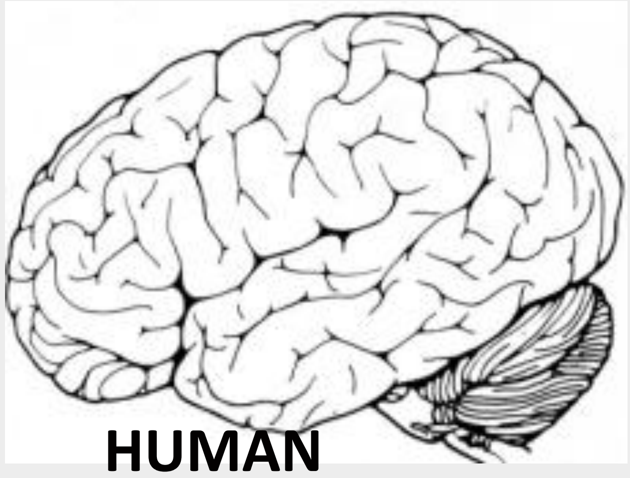
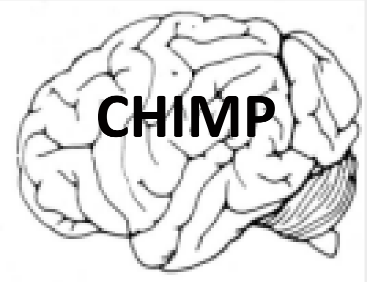


Figure 1

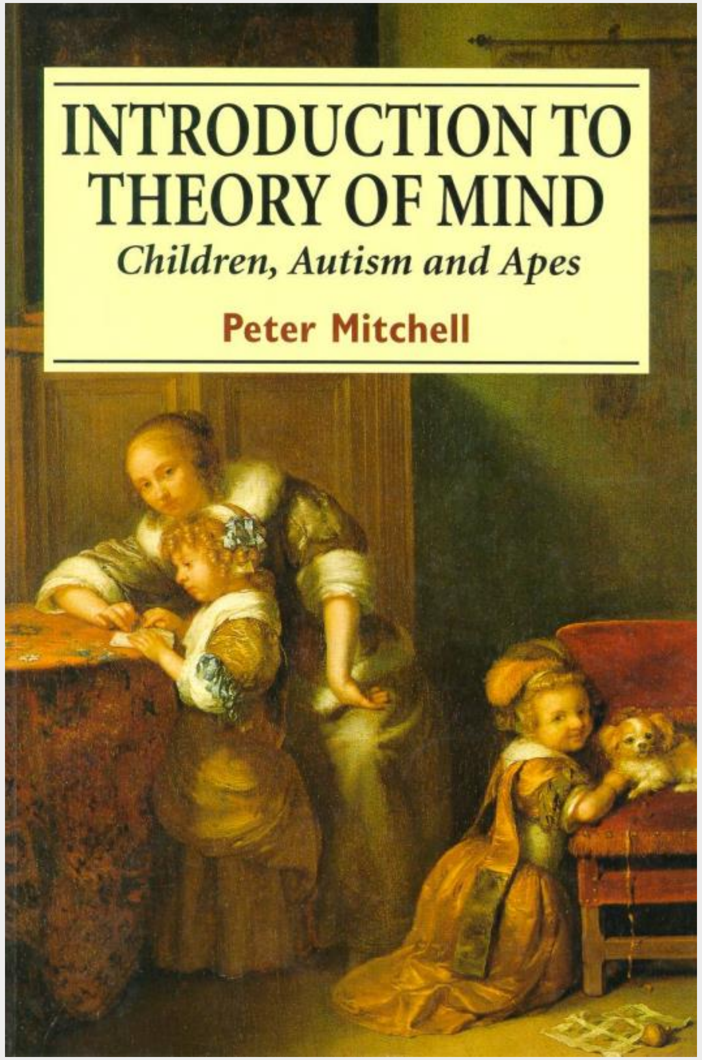
Mind reading and relationship intelligence. Cartoon © Randy Glasbergen. Reprinted with permission from **www.glasbergen.com**.





THE HUMAN BRAIN IS A SOCIAL BRAIN

Our ability to gauge the moods and intentions of others, to detect the truth or falsehood of their communications, to discern friend from foe, and to form alliances is among its most complex and important tasks. These skills are of premier importance to fulfill our biological imperatives of staying alive (through the protection of the group) and reproducing.



Theory of mind: evolutionary history of a cognitive specialization

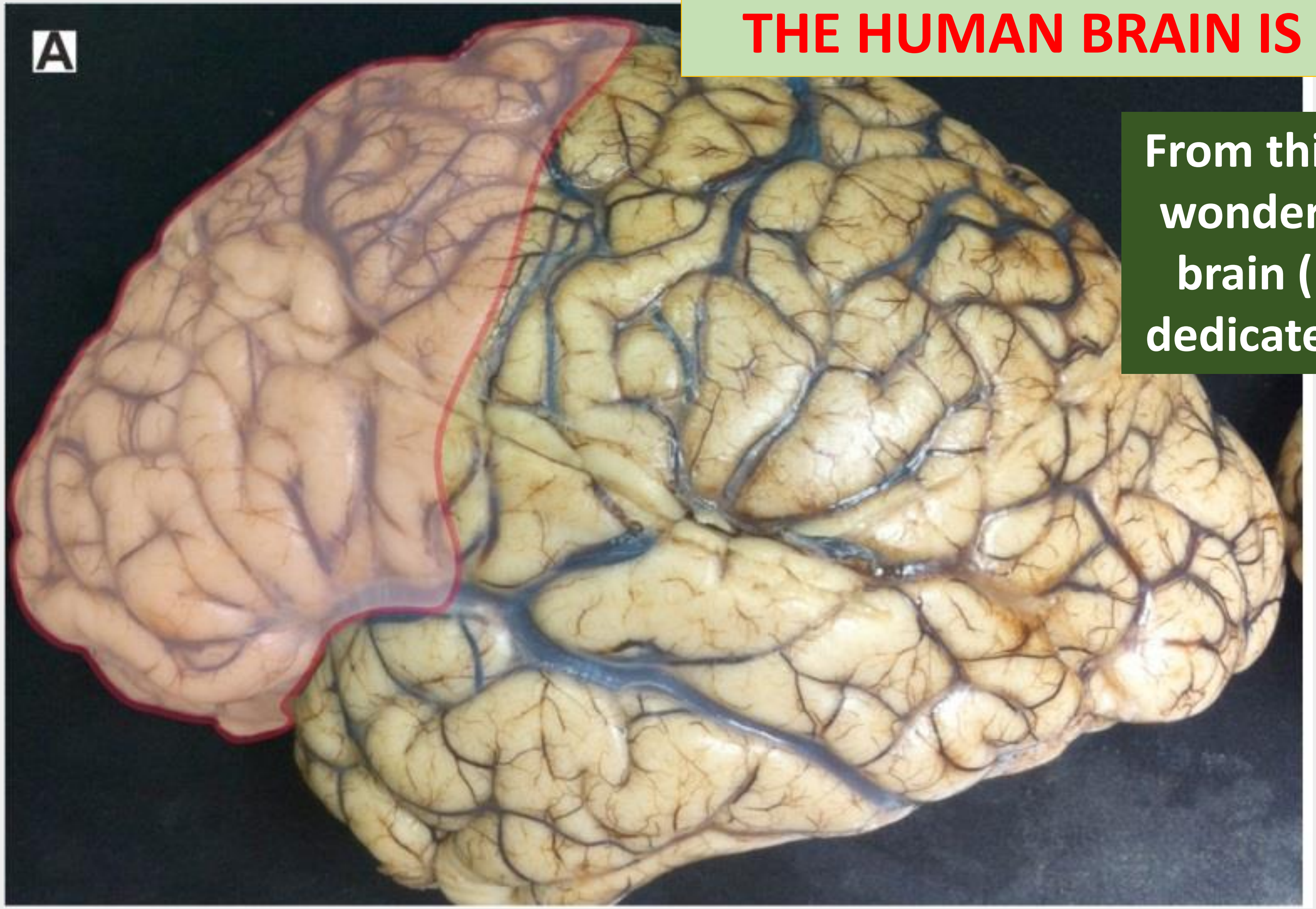
Daniel J. Povinelli and Todd M. Preuss

Traditional analyses of the evolution of intelligence have emphasized commonality and continuity among species. However, recent research suggests that humans might have specialized in a particular kind of intelligence that is related to understanding mental states such as desires, intentions and beliefs. Data indicate that the ability to reflect on one's own mental states, as well as those of others, might be the result of evolutionary changes in the prefrontal cortex. Behavioral studies in children and chimpanzees reveal both similarities and striking differences in the developmental pathways that lead to theory-of-mind capacities. Humans and great apes share many ancient patterns of social behavior, but it is too early to be certain if they interpret them in the same manner. Humans might have evolved a cognitive specialization in theory of mind, forever altering their view of the social universe.

Trends Neurosci. (1995) 18, 418–424

https://books.google.hr/books?id=6KN6GuoHPF4C&pg=PA216&lpg=PA216&dq=rising+chimp+and+infant+together&source=bl&ots=Kq_Yj5i_Ag&sig=GX85KrgGvCtLUb9-6hSAESa-utU&hl=hr&sa=X&ved=0ahUKEwiPx7CKg63WAhWHhRoKHScUAYkQ6AEIWzAL#v=onepage&q=rising%20chimp%20and%20infant%20together&f=false

THE HUMAN BRAIN IS A SOCIAL BRAIN



From this perspective, it is no wonder that so much of our brain (prefrontal region) is dedicated to social cognition.

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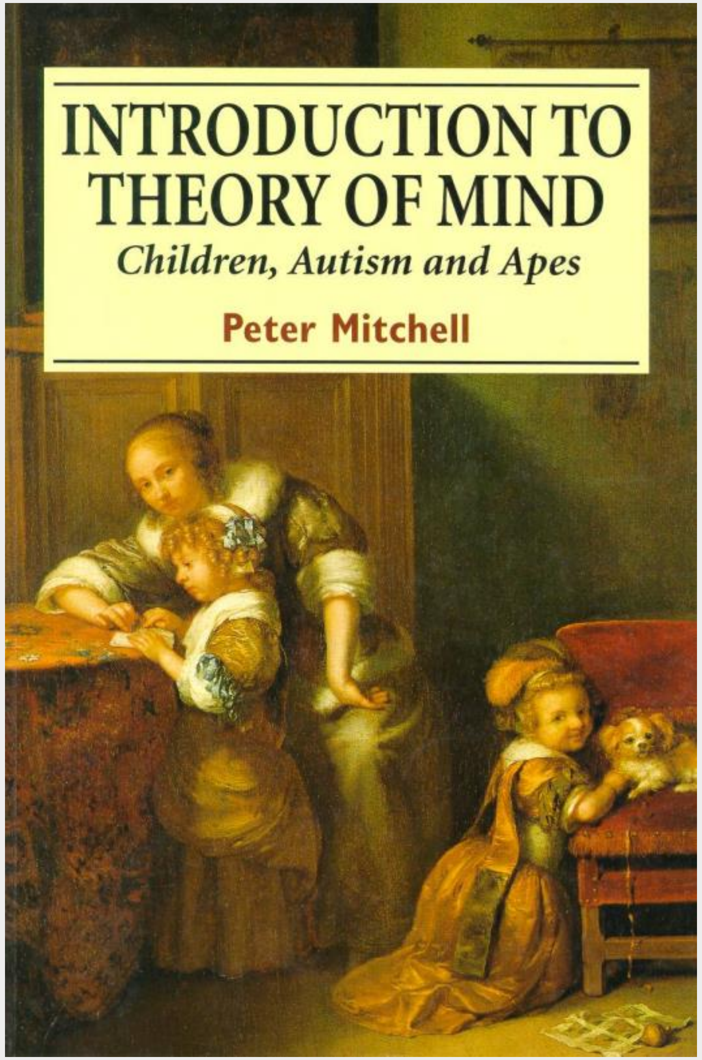
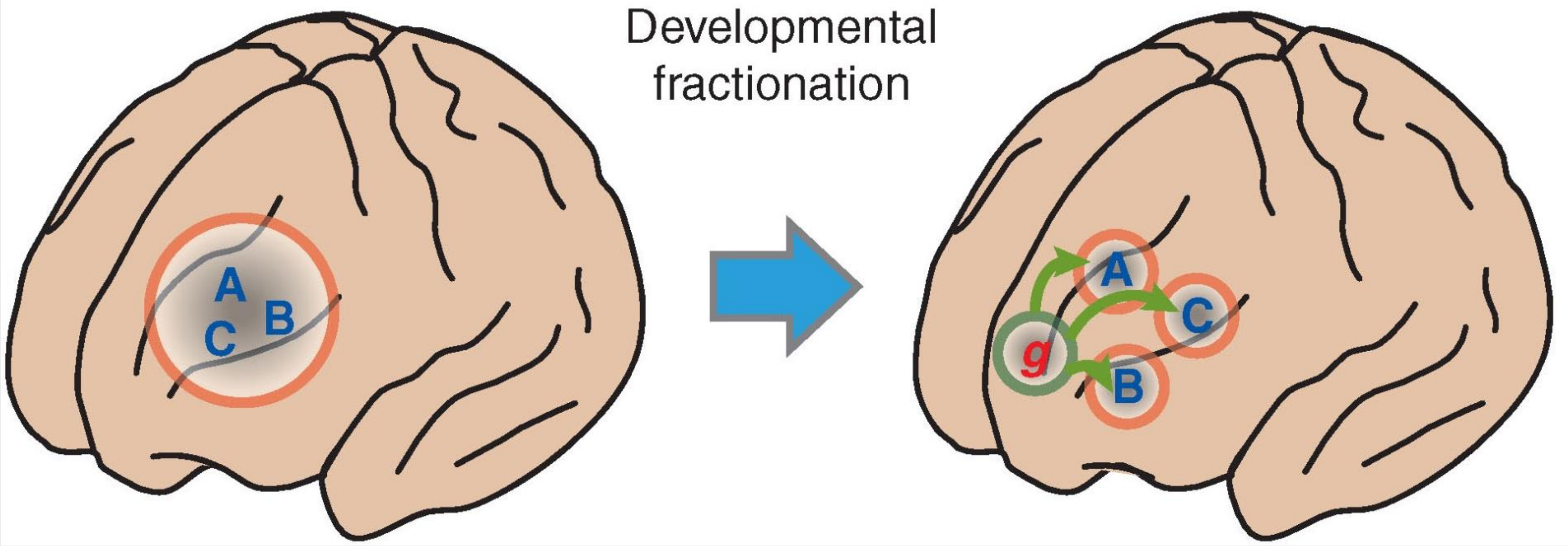
THE HUMAN BRAIN IS A SOCIAL BRAIN



Our ability to <u>gauge the moods and intentions of others</u>, to detect the truth or falsehood of their communications, to discern friend from foe, and to form alliances is among its most complex and important tasks. These skills are of premier importance to fulfill our biological imperatives of staying alive (through the protection of the group) and reproducing.

apear 18-24 postnatal months
Intensive maturation in period 18-25 years



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High order associative areas – PFC – The prefrontal cortex

Areas such as the prefrontal cortex are key component of neural circuitry involved in:

JUDGMENT,
IMPULSE CONTROL,
LONG-RANGE PLANNING.

They are particularly late
to reach adult morphometry,
continuing to undergo dynamic changes
well into the 20s.

Prog Brain Res 179

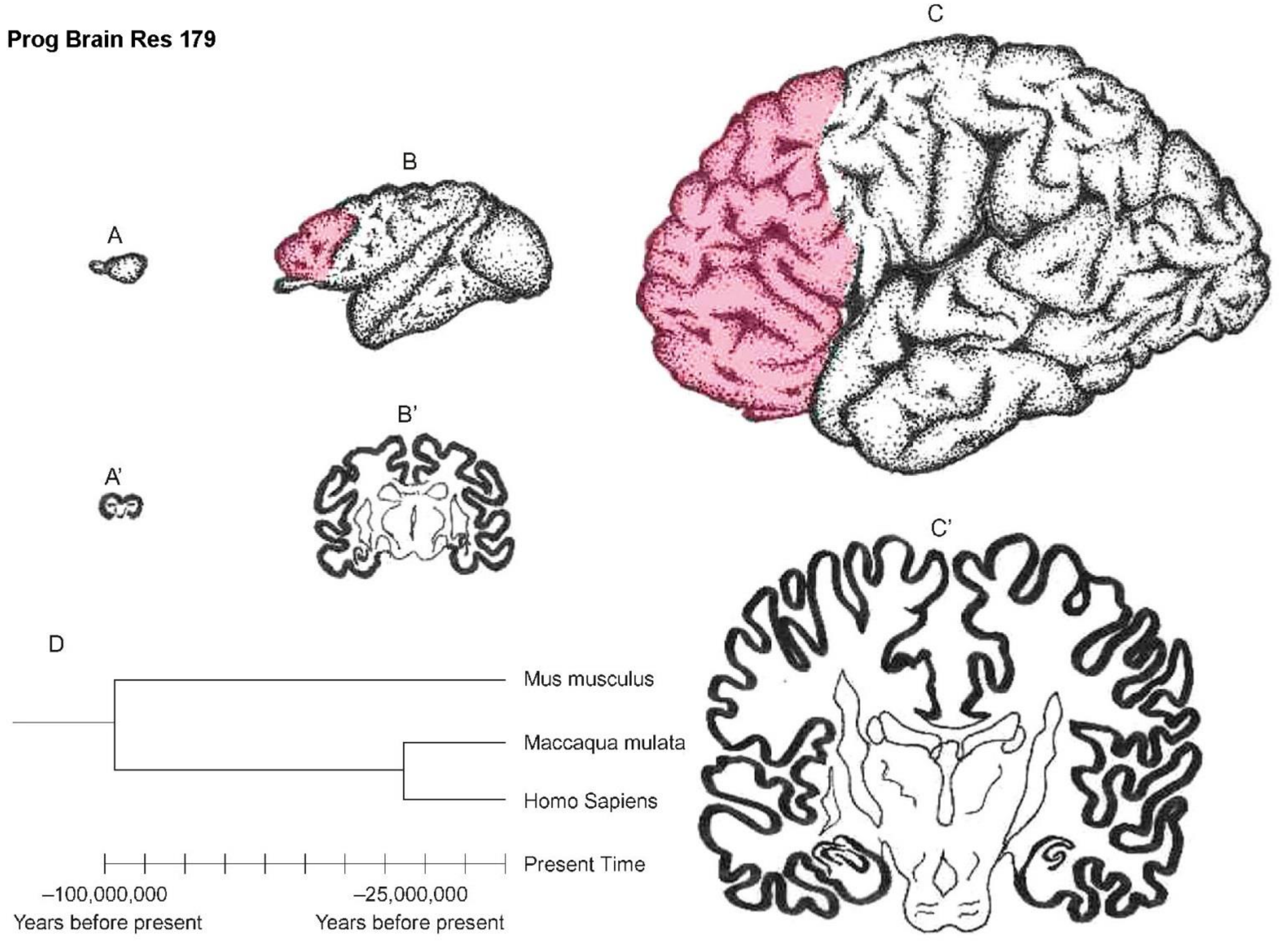


Fig. 1. Cerebral hemispheres of the mouse (A), macaque monkey (B), and human (C) drawn by Pasko Rakic at approximately the same scale to convey the overall difference in size and elaboration. The pink overlay indicates the area of the PFC that has no counterpart in

High order associative areas – PFC – The prefrontal cortex

The function of the human prefrontal cortex is to process highest brain functions, including mathematical and analytical skills, including affective modulation of emotional cues, self-conceptualization, mentalization, cognitive flexibility, working memory and language.

What does the prefrontal cortex do?

Attention: The ability to focus on one thing, while ignoring distractions.

Complex planning: Anytime you set a goal that requires some degree of planning, the prefrontal region is at work. Planning out tasks during the day, developing a business plan, etc.

Decision making: Prefrontal cortex helps us think logically and make more calculated assessments of situations, weighs the risks and tells whether a certain behavior or choice is a good idea vs. a bad one.

Impulse control: The ability to maintain self-discipline and avoid impulsive behaviors.

Logical thinking: Justifying behaviors based off of emotions rather than logic is common amongst young people. When the prefrontal cortex fully develops, logical thinking simultaneously improves. This means you become better at rationalizing and making smarter decisions. It also means the ability to write and solve math problems will improve.

High order associative areas – PFC – The prefrontal cortex

The function of the human prefrontal cortex is to process highest brain functions, including mathematical and analytical skills, including affective modulation of emotional cues, self-conceptualization, mentalization, cognitive flexibility, working memory and language.

What does the prefrontal cortex do?

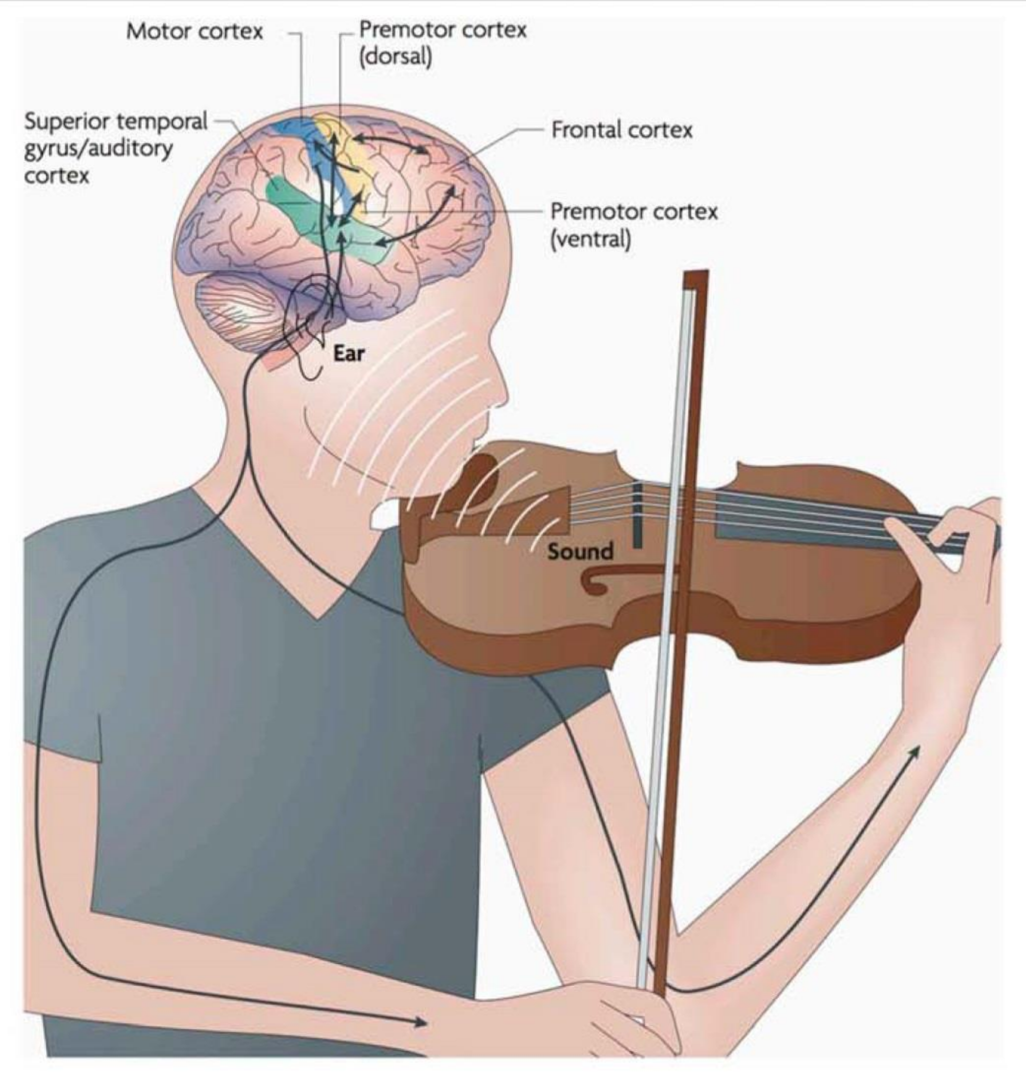
Organized thinking: During adolescence a barrage of thoughts are typically influenced by hormones causing concentration difficulties. The organization of your thoughts is a result of maturation of the prefrontal cortex.

Personality development: Without proper stimulation, adolescent may struggle with identity issues and developing a favorable personality.

Risk management: The ability to assess risky situations and determine whether they will result in long-term benefit is a byproduct of the prefrontal cortex. The ability to turn down immediate gratification for long-term rewards is a result of this proper prefrontal cortex functioning and to be poor at assessing risk is related with its immaturity or underdevelopment.

Short-term memory: Cognitive function and memorization capacity will improve with maturation of the prefrontal cortex

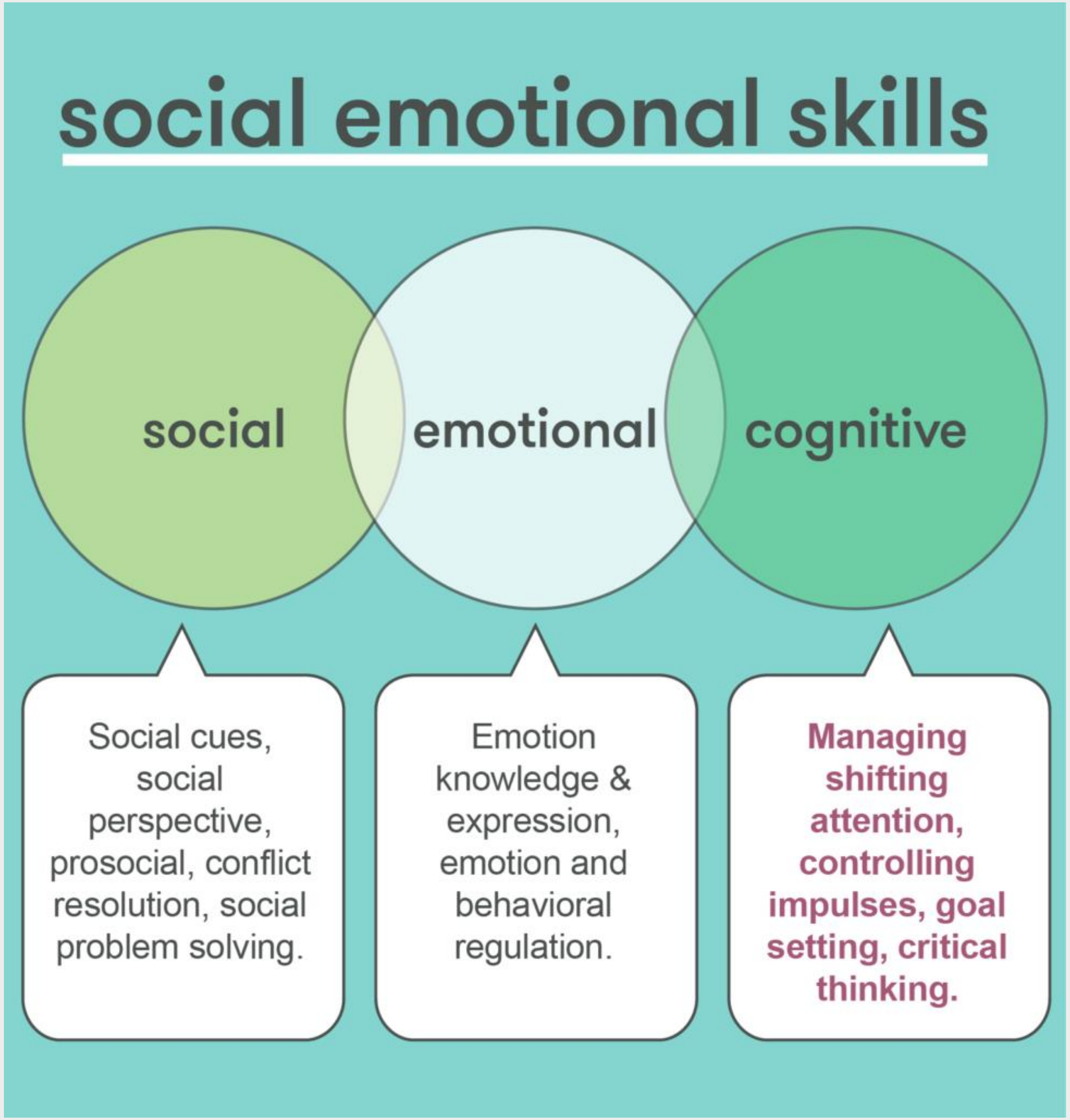
PROLONGED PLASTICITY AND LATE MATURATION OF THE PREFRONTAL CORTEX

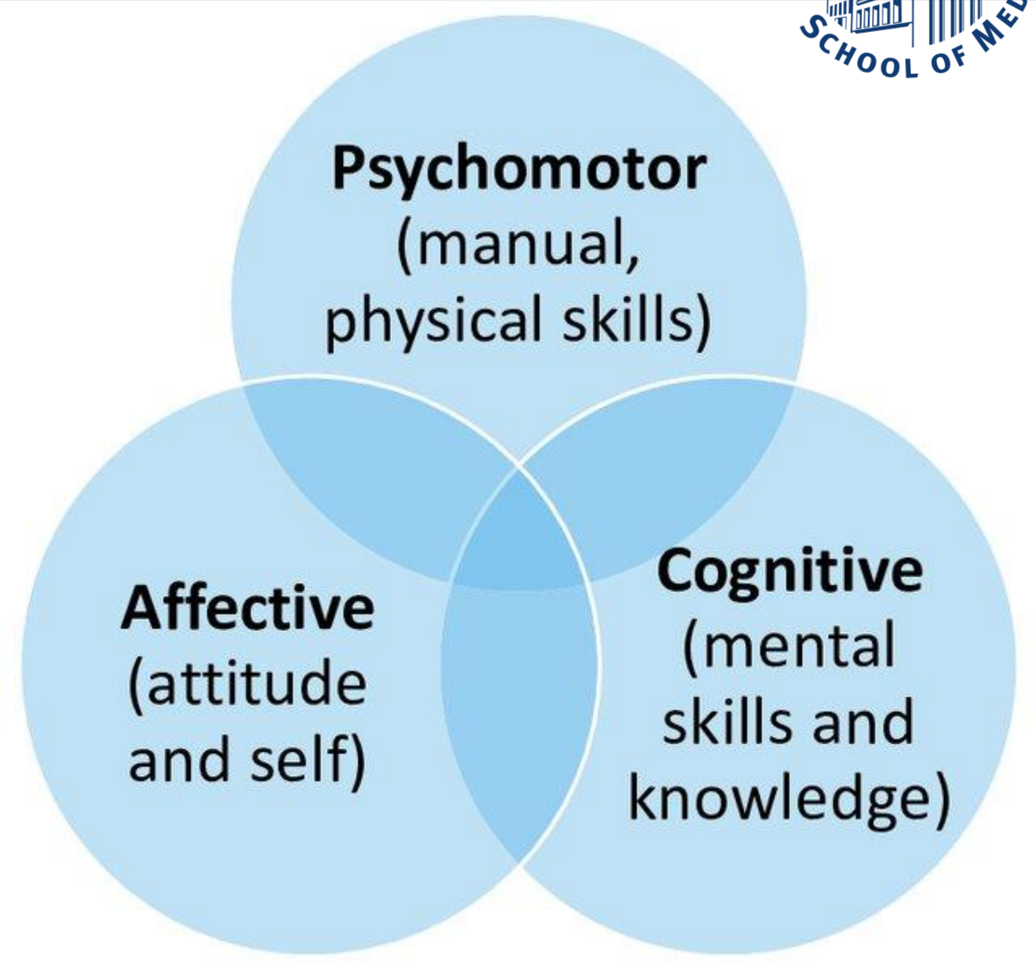


Ongoing plasticity might mean that young people, with **proper training**, might be able to increase the capacity to rapidly and effectively switch between tasks.

Due to the protracted plasticity of the prefrontal cortex adolescents and young people have **great capacity to adapt to changing demands**. Therefore they are early adopters of the latest digital technologies.

Plasticity means that there is **experience expectant brain development**, where loss of proper stimulation will **NOT MAKE CIRCUITRIES BE ORGANIZED FOR OPTIMAL PROCESSING**.





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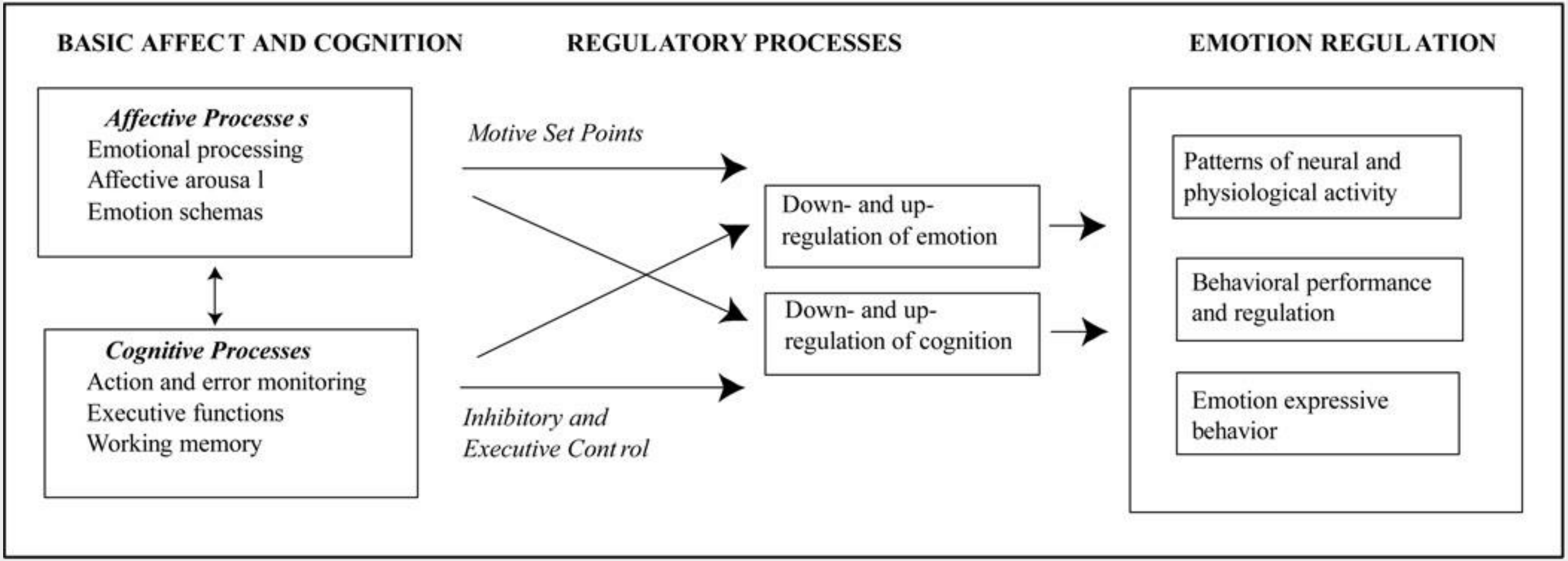

Dennis TA: Neurophysiological markers for child emotion regulation from the perspective of emotion-cognition integration: current directions and future challenges. Dev Neuropsychol. 2010 Feb 12; 35(2): 212–230. doi: 10.1080/87565640903526579, https://europepmc.org/article/PMC/2856094#abstract

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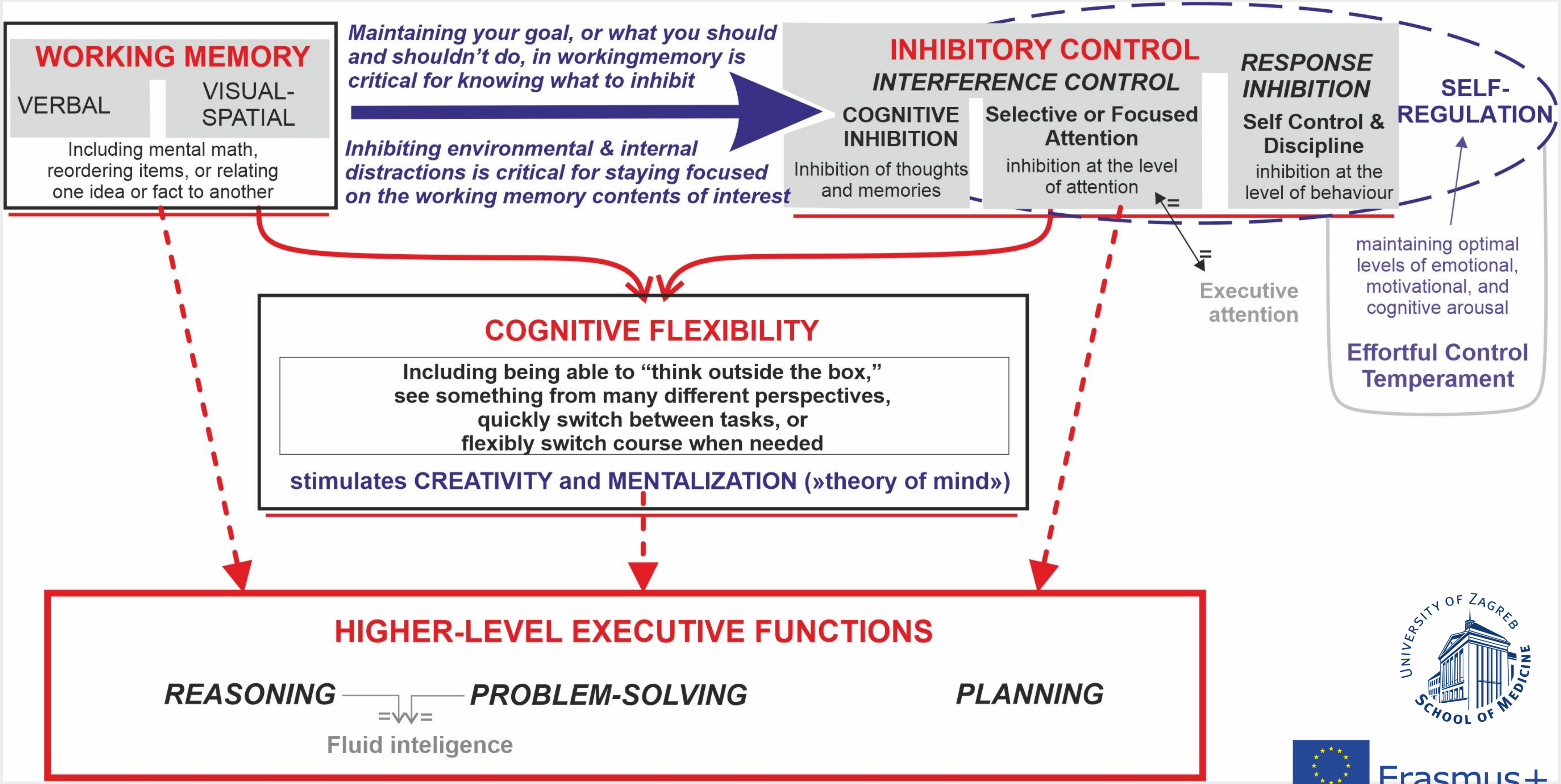
Domain specificity of cognition and examples of component cognitive processes underlying these mechanisms

Domain	Component processes	
Social cognition Responding to emotion-laden stimuli	**Emotion Recognition** Identifying emotions in facial expressions	**Emotional Bias** Information processing biases for positive/negative stimuli
Executive function High level thinking and decision making	**Mental flexibility** Ability to adapt thinking and behaviour	**Planning** Strategic problem solving
	Working memory Strategy	**Response inhibition** Ability to suppress inappropriate responses
Memory Short-term or long-term storage of information	**Episodic memory** Associating an event with a place and time	**Working memory** Holding and manipulating information in mind
	Recognition memory Recognition of visual, object and spatial information	
Attention Attending to specific information and ignoring others	**Sustained attention** Continuous performance and visual sustained attention.	
Psychomotor speed Detecting and responding to the presence of a stimulus	**Choice Reaction Time** Choice reaction time, movement time and vigilance	

https://www.cambridgecognition.com/blog/entry/what-is-cognition



Diamond, Annu. Rev. Psychol. 2013.64:135-168.

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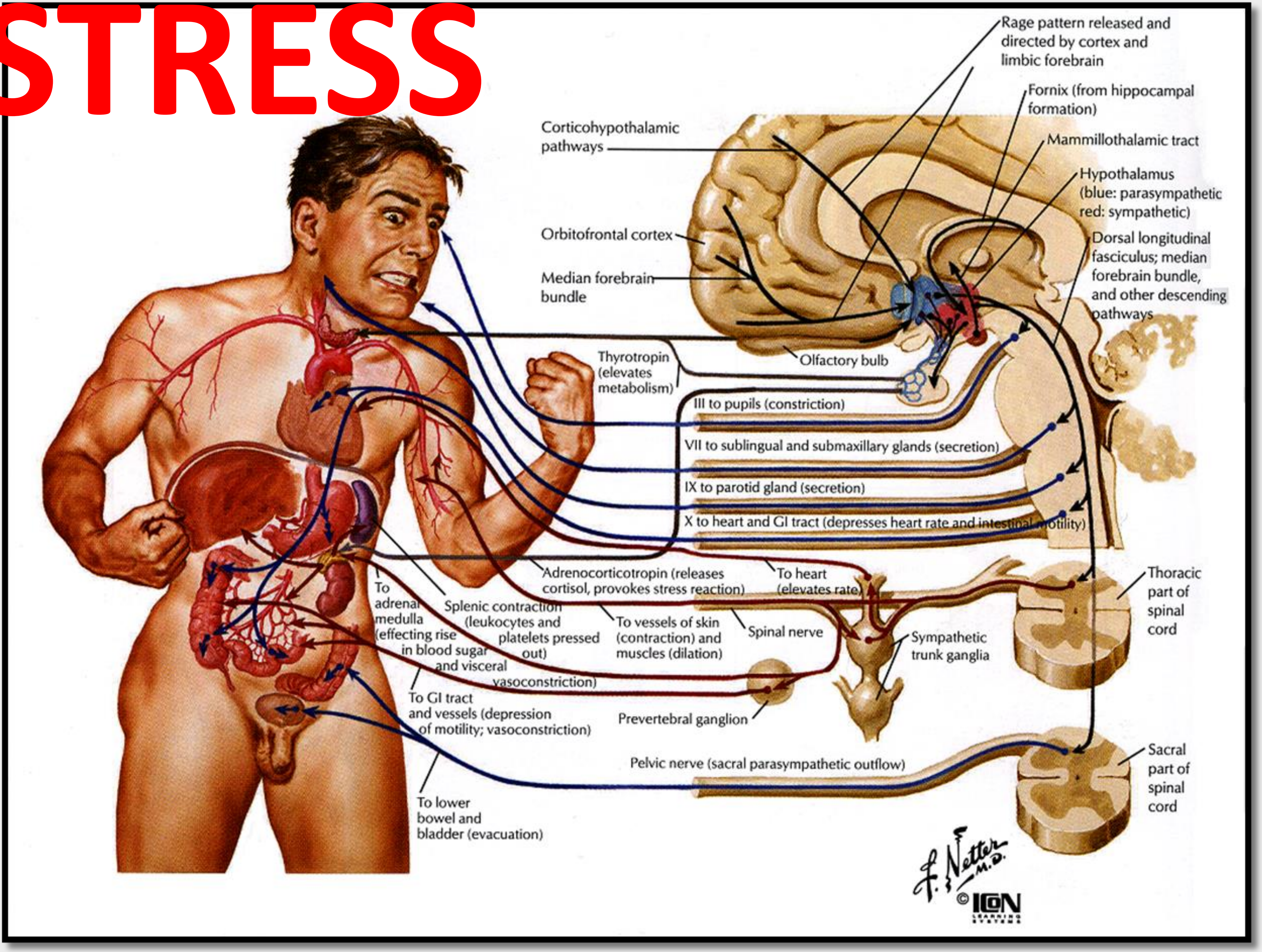

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FUNCTIONS OF FRONTO-LIMBIC CIRCUITRY

- Decision making – frontopolar cortex
- Uncertainity – frontopolar corex
- Multitasking behaviour – frontopolar
- Social cognition - anterior medial prefrontal cortex
- Agressive behaviour - amygdala
- Gambling
- Moral attitudes – dorsolateral cortex
- Charities
- Punishment and reward – orbitomedial cortex

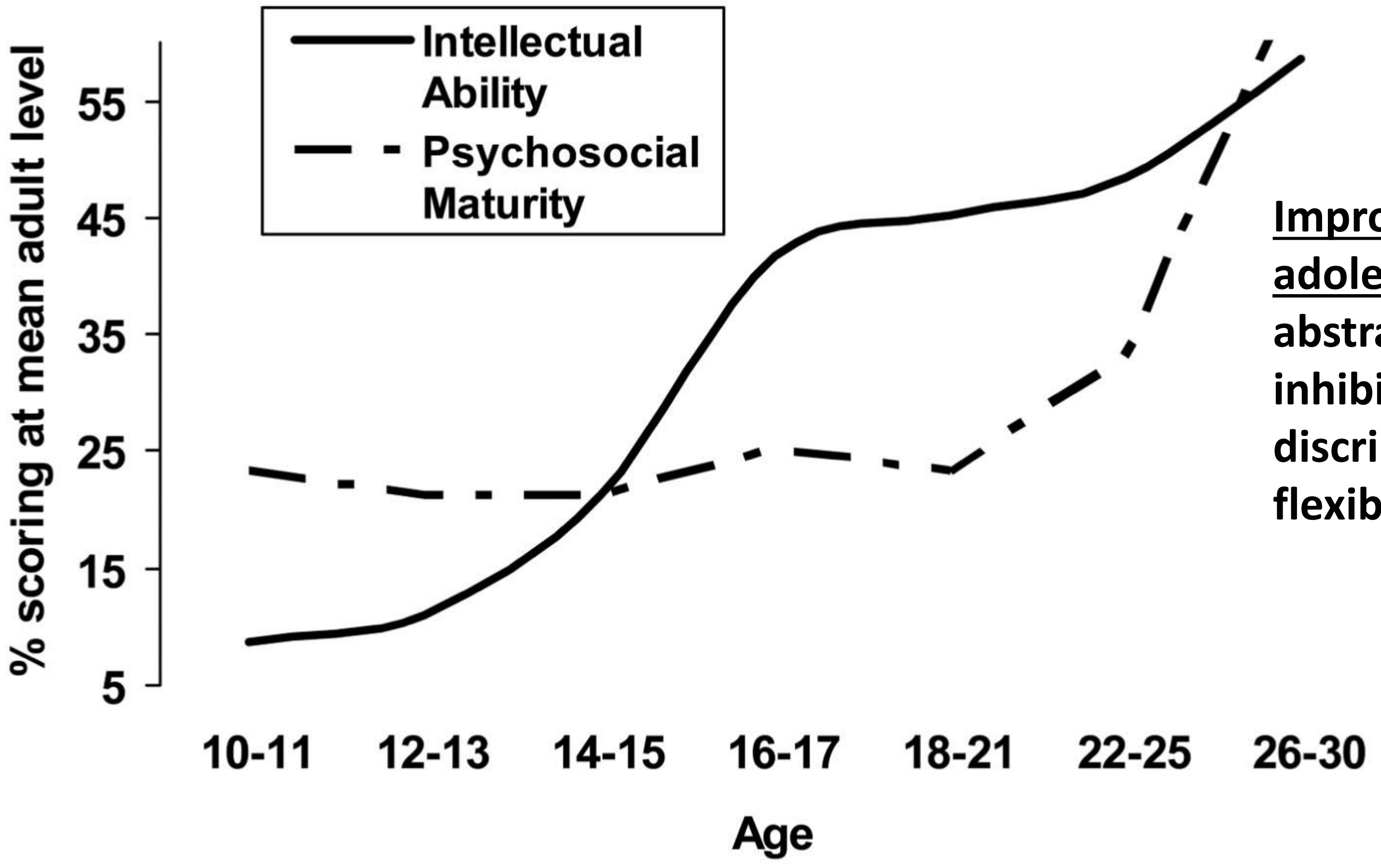

Figure 1.
Proportion of individuals in each age group scoring at or above the mean for 26- to 30- year-olds on indices of intellectual and psychosocial maturity. From Steinberg et al., 2007.

ADOLESCENT FRONTO-LIMBIC DEVELOPMENTAL DELAY

Improvement in following functions occured during adolescence:
abstract reasoning, attentional shifting, response inhibition, processing speed, affective modulation and discrimination of self-concept, mentalizing, cognitive flexibility and working memory.

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- **Childhood to Adolescence**
  - Improved strength, speed, reaction time, mental reasoning abilities
  - Increased resistance to cold, heat, hunger, dehydration, immune function

- **However …..**

- **Overall morbidity and mortality rates increase 200-300% from childhood to late adolescence**
- **Injury and violence are the leading causes of death**

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UNIVERSITY OF ZAGREB SCHOOL OF MEDICINE

LEANbody

Ana

Ivan Vedran

Maura
Marina

Erasmus+

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SVEUČILIŠTE U ZAGREBU MEDICINSKI FAKULTET

UNIVERSITAS STUDIORUM ZAGRABIENSIS MDCLXIX

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Department of Anatomy and Clinical Anatomy
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