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Brain development during adolescence – implications for education

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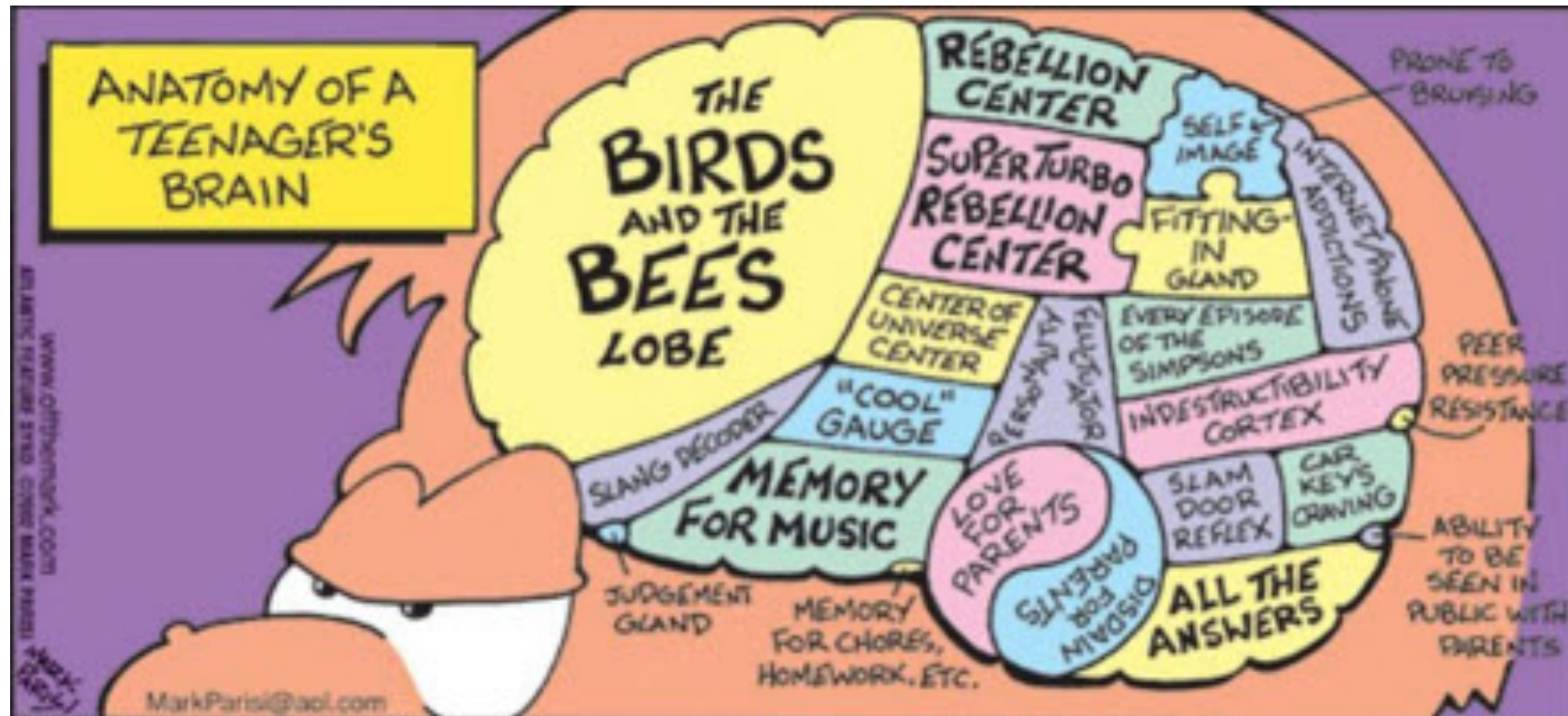
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Which aspects of cognition are relevant to adolescence?



Social cognition & Cognitive control

Social cognition

How we process, store and use information about other people, and how this in turn influences our behaviour, feelings and social interactions

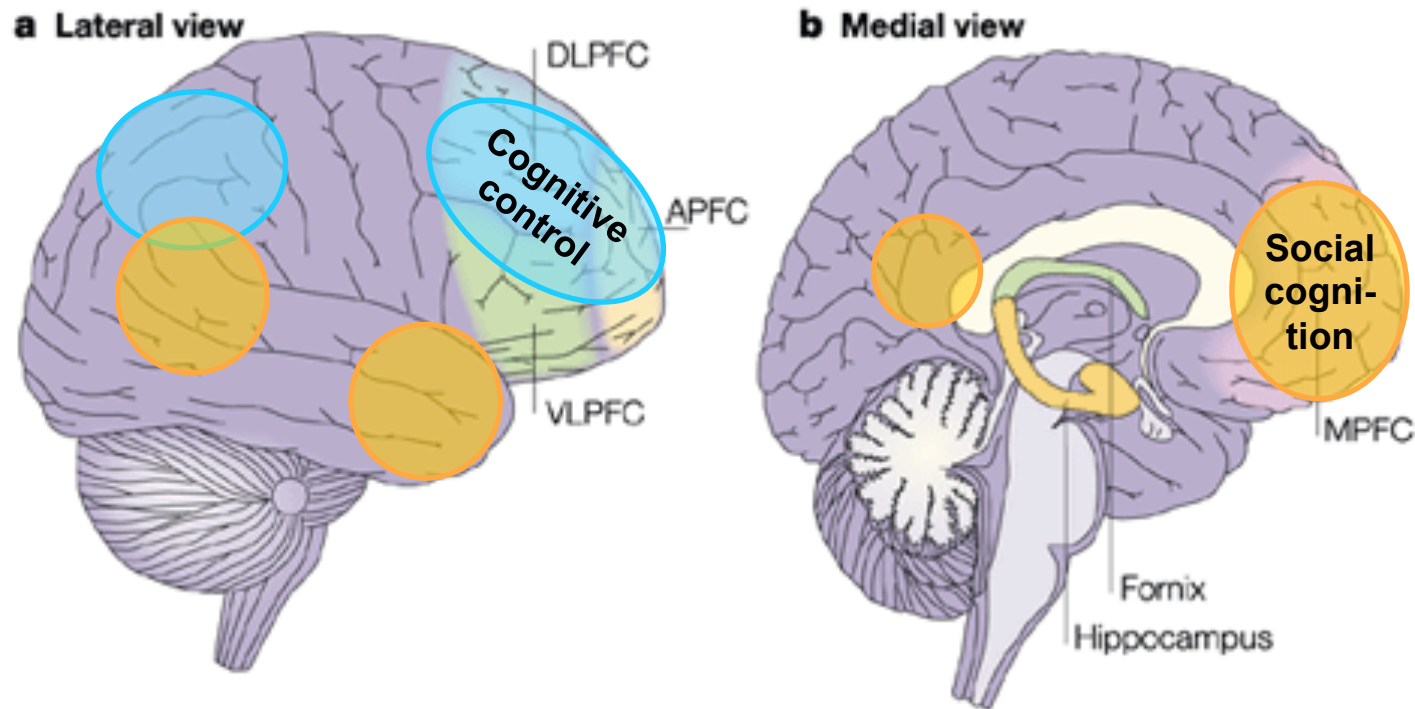


Cognitive control – executive functions

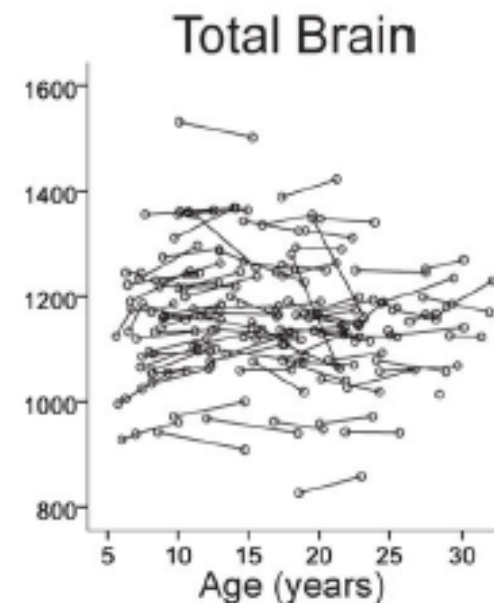
The ability to flexibly adapt one's behaviour in the pursuit of an internal goal by the coordination of a collection of cognitive processes



Two brain networks

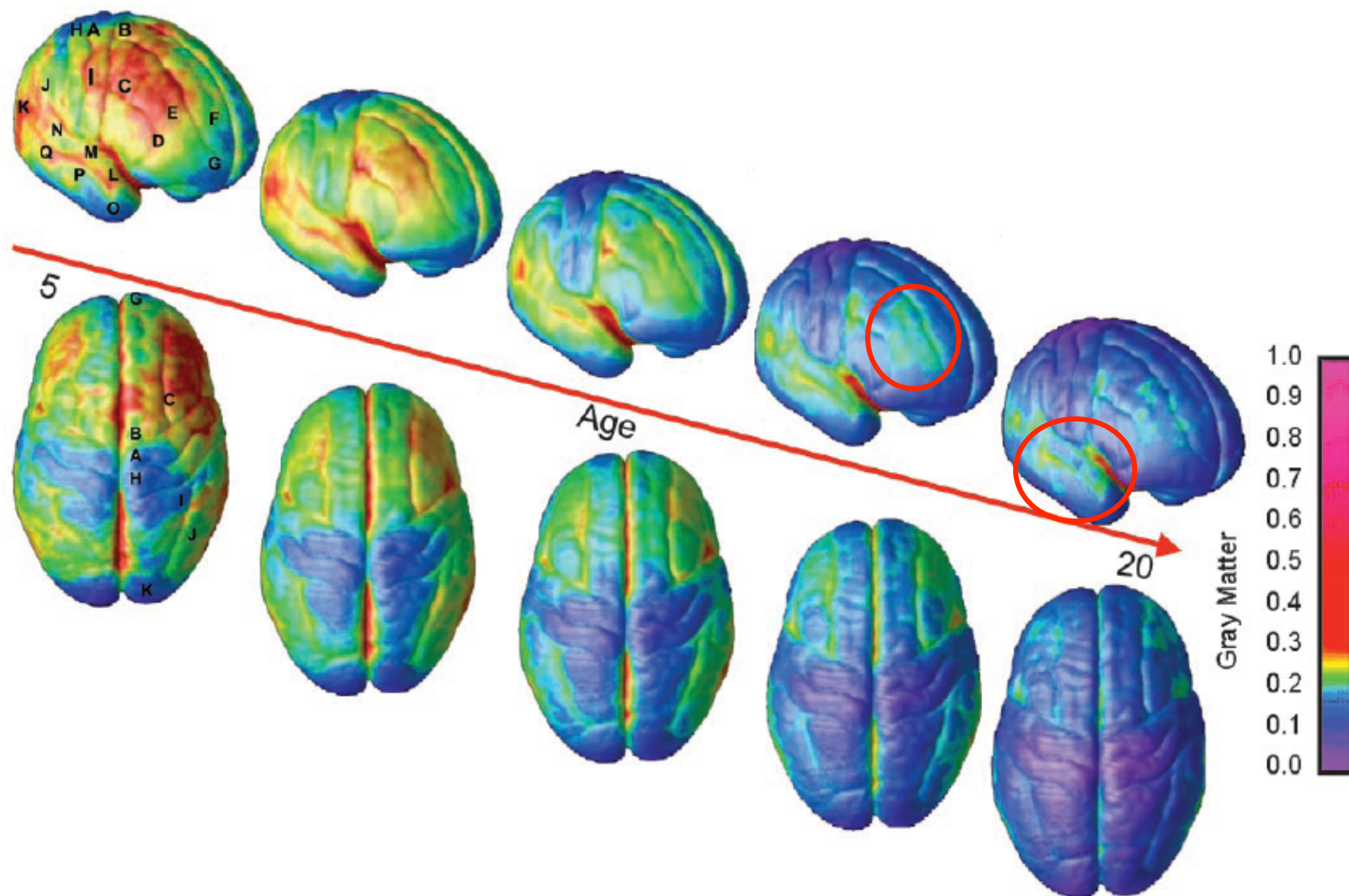


Brain structure development



Corresponds partly to myelination and increasing axon diameter.
> Speeds up signalling between neurons
Facilitates processing speed and learning

Corresponds partly to synaptic reorganisation
> Fine-tuning of grey matter tissue according to experience & environment

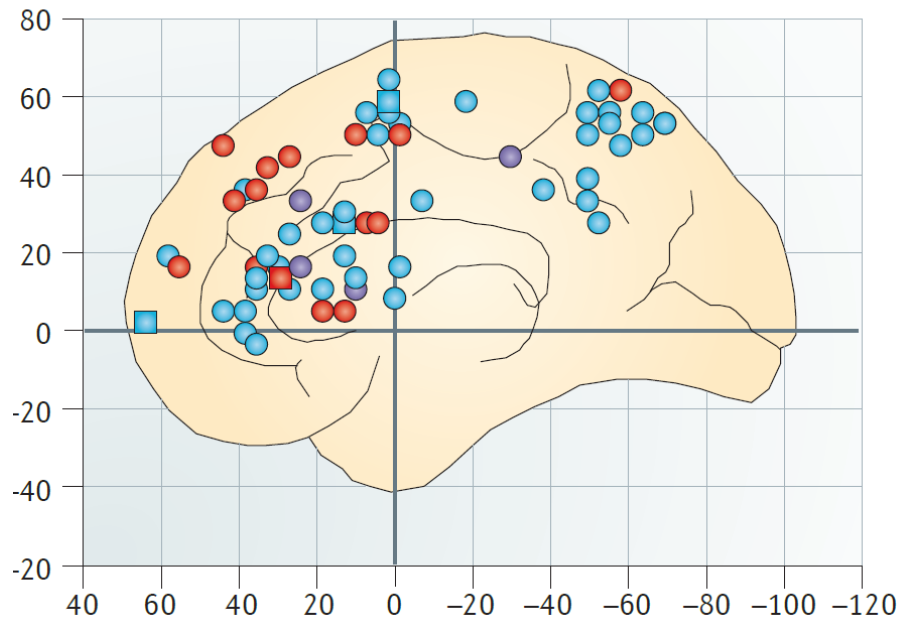


Gogtay et al. *PNAS* 2004

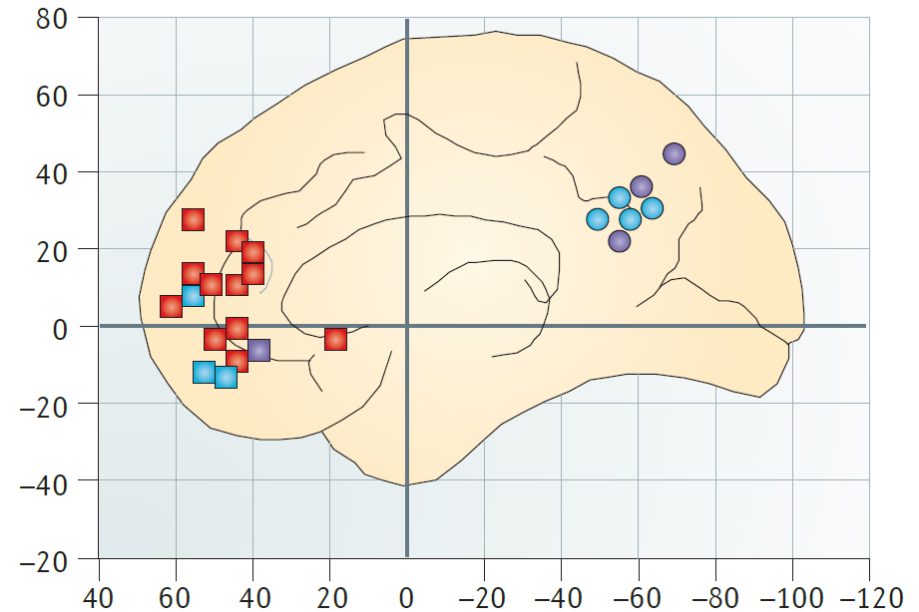
Brain function development

○ Lateral
□ Medial

Working memory, inhibition and task switching



Social reasoning



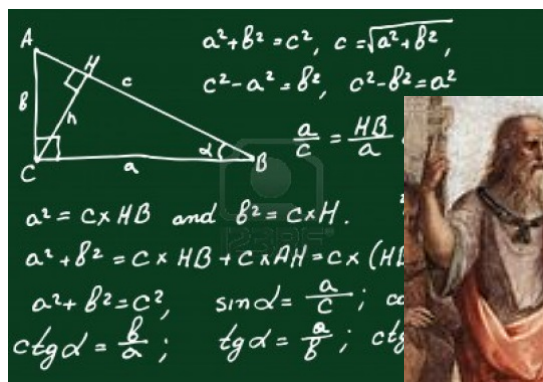
■ ● Increasing across adolescence

■ ● Decreasing across adolescence

■ ● Adolescent transition

Cognitive control during adolescence

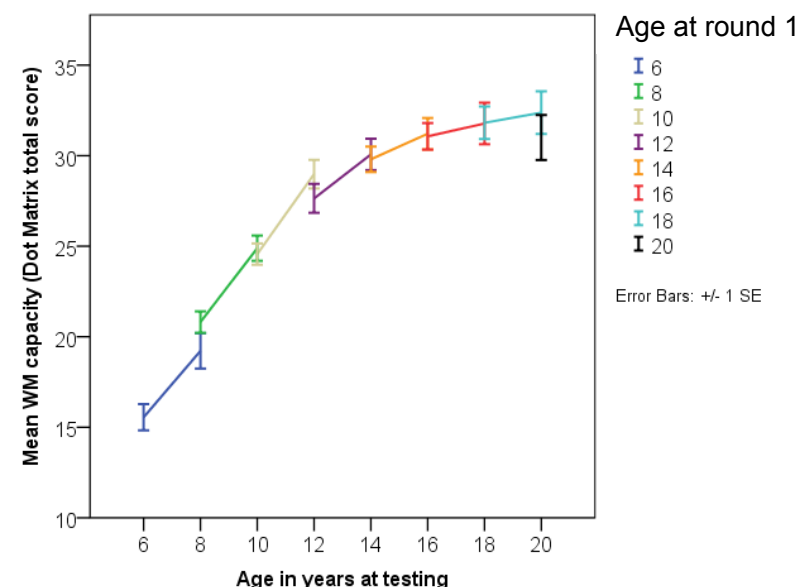
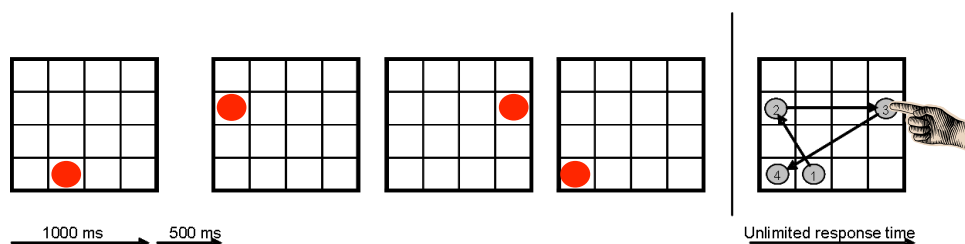
- Control over thoughts and actions
- Crucial to success in most classroom settings:



Development of working memory

- Working memory, the number of items one can keep in mind at the same time is a key limiting bottleneck on the way we can reason, solve problems and learn from everyday events.
- Poor WM leads to reduced educational outcomes (Alloway & Alloway, 2010; Dumontheil & Klingberg, 2012)
- WM continues to mature during adolescence

Behavioural visuo-spatial working memory test (Dot Matrix, AWMA)



Dumontheil et al., *Biological Psychiatry* 2011

Implications for education

- Can we train executive functions and improve educational outcome?
 - Working memory can be trained via computerised programs
 - But transfers to other tasks and to academic performance have not been reliably observed
- Who benefits best from training?
 - E.g. genetic polymorphisms (DRD2, DAT)
- Does training need to be implemented in a classroom or academic context?
 - Training of working memory in a virtual reality setup replicating the school and classroom environment (Gathercole et al.)
 - Training the application of inhibitory control in a maths and science context (Mareschal et al.)

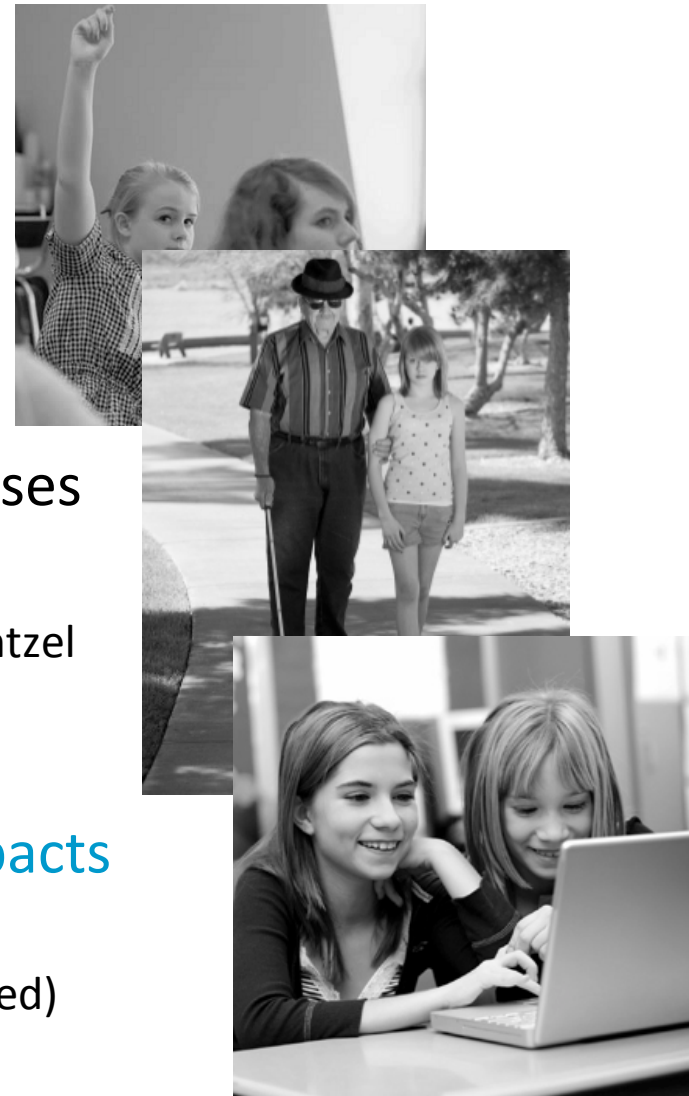
Social cognition during adolescence

- Adolescents do not take into account the perspective of another individual as often as adults (Dumontheil et al., *Dev Science* 2010)
- and perform less well on test of affective theory of mind than adults (Sebastian et al., *SCAN* 2012)
- But adolescents, compared to children, spend more time with their peers and have more complex relationships (Brown, *Handbook of Adolescent Psychology* 2004)
- and they are particularly susceptible to peer influence (Berndt, 1979; Steinberg & Silverberg, 1986; Steinberg & Monahan, 2007).



Peer influence during adolescence

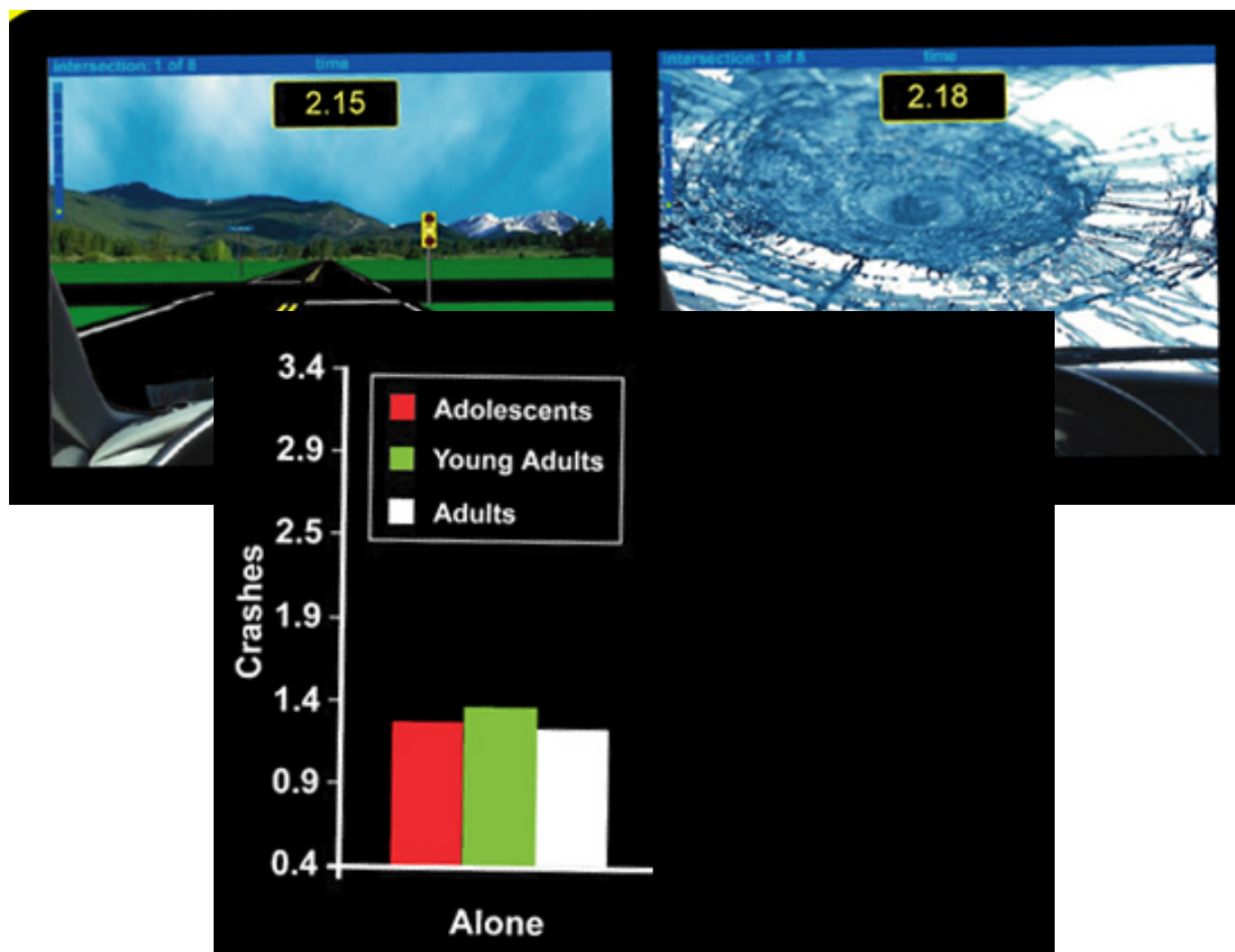
- Academic performance and motivation improve when students spend time with academically high achieving peers (Ryan, 2001).
- Adolescents' prosocial behaviour increases when they spend time with friends with higher levels of prosocial behaviour (Wentzel et al. 2004).
- Peer or adult presence has complex impacts on performance of reasoning tasks (Wolf, Bazargani, Kilford, Dumontheil & Blakemore, submitted)



Peer influence during adolescence

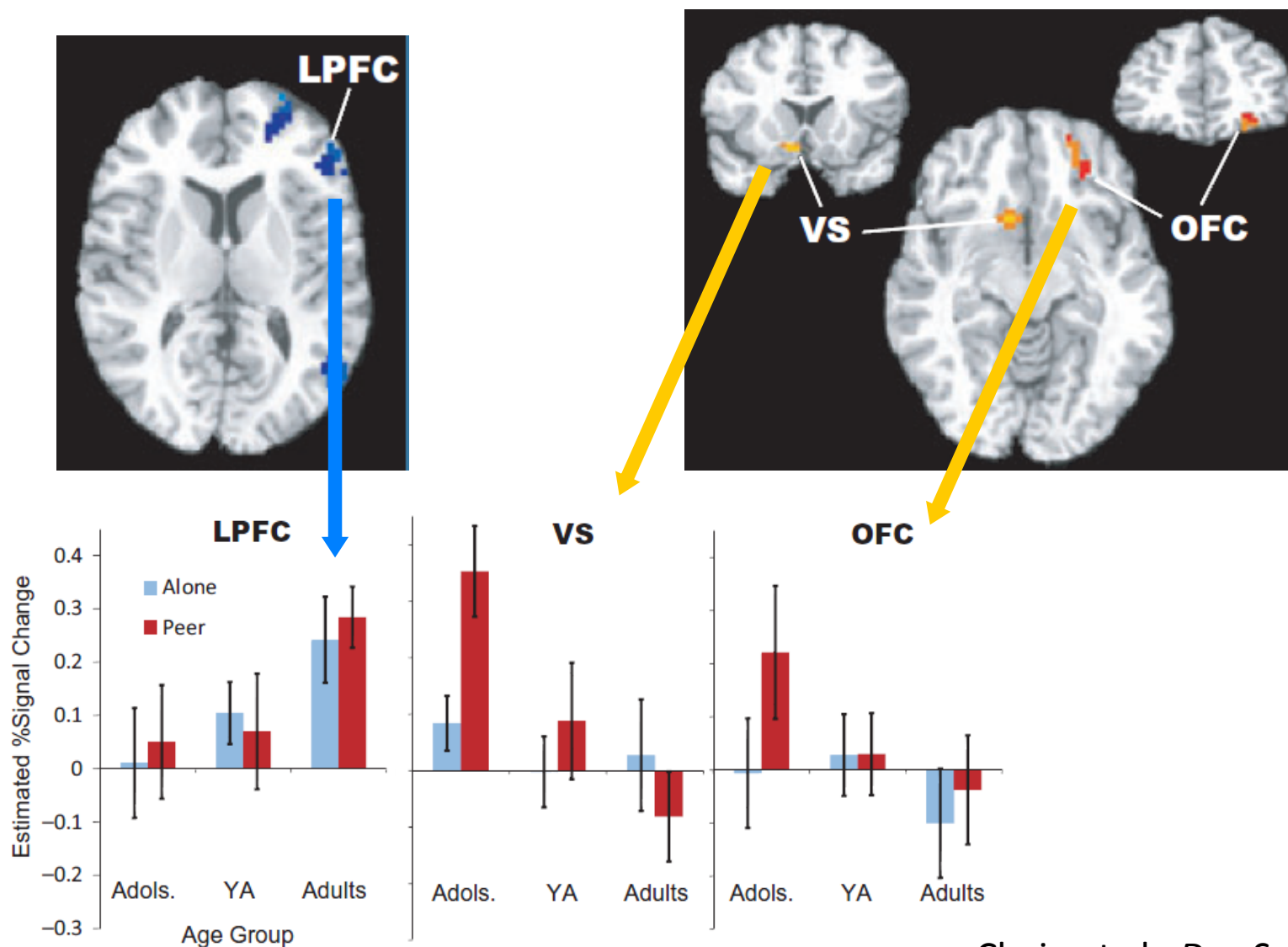
- Adolescent girls are more sensitive to social exclusion (Sebastian et al., *Brain and Cognition* 2010; Sebastian, Tan, Roiser, Viding, Dumontheil, Blakemore, *NeuroImage* 2011)
- Adolescents mostly commit crimes when they are in company of their peers, whereas adults tend to be alone (Erickson and Jensen 1977; Zimring 1998).
- Risk-taking behaviour





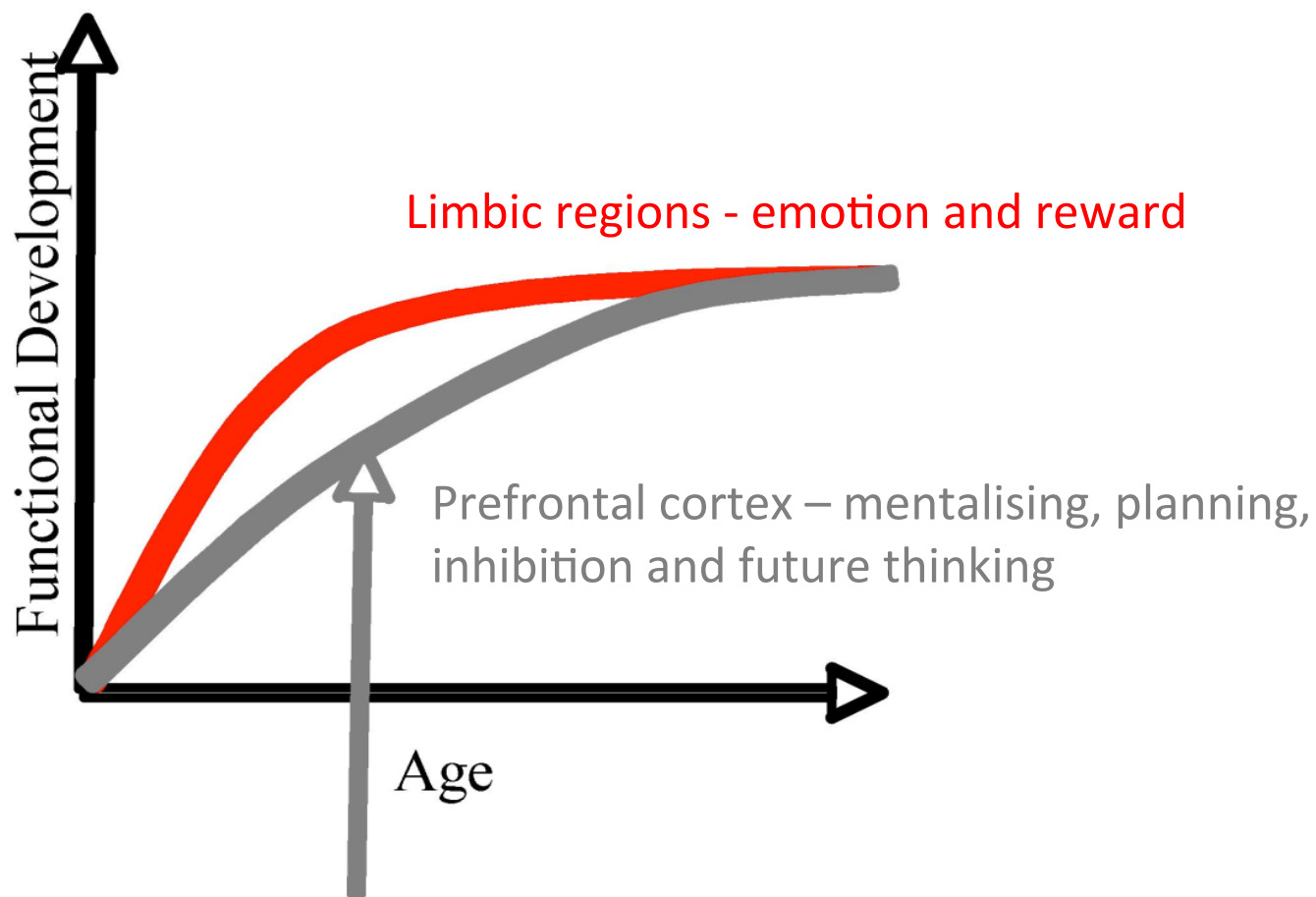
Steinberg et al., 2008

Neural substrates of peer influence on risk taking



Chein et al., *Dev Science* 2011

Mismatch between prefrontal and limbic system development in adolescence



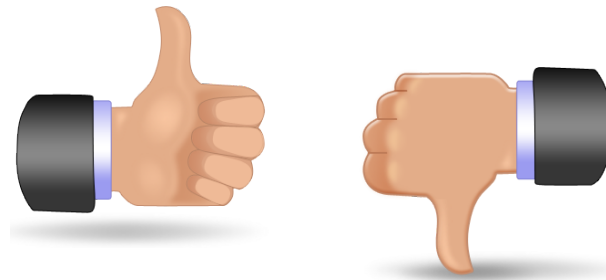
Casey, Getz & Galvan *Developmental Review* 2008

Implications for education

- How does the classroom social environment impact academic performance?
 - Specific sensitivity of adolescents
 - How can this sensitivity be used positively?
 - How does this relate to grouping in the classroom?
- Can increased risk-taking be used to promote certain aspects of academic or sport performance?
 - Teachers say that adolescents are not really risk-taking in the classroom
 - But sport is typically seen as a good field for the expression of some adolescents' specific behaviour

Processing of reward and feedback during adolescence

- Adolescent performance on an inhibitory control task improves and frontal cortex activation (precentral sulcus) heightens when a reward can be won (Geier et al. *Cerebral Cortex* 2010)
- Adolescent become more able to process and learn from negative feedback (van Duijvenvoorde et al. *Journal of Neuroscience* 2008)



Implications for education

- Does the importance and benefit of positive and negative feedback varies according to pupils' ages?
 - Less learning from negative feedback in childhood
- Can rewards play a role within an academic context?
 - What type of rewards? Social, monetary etc.
 - Cf. Paul Howard-Jones EEF-Wellcome Trust funded project.

Self-regulation

- Voluntary control of thought, emotion, and action
- “Systematic efforts to direct thoughts, feelings and actions, toward the attainment of one’s goals” (Zimmerman, 2000)
- Frees individuals from reactive responding
- Predicts academic achievement, social competence, adult health and wealth (Bull et al., 2008; Carlson & Wang, 2007; Mischel et al., 2010; Moffitt et al., 2011)

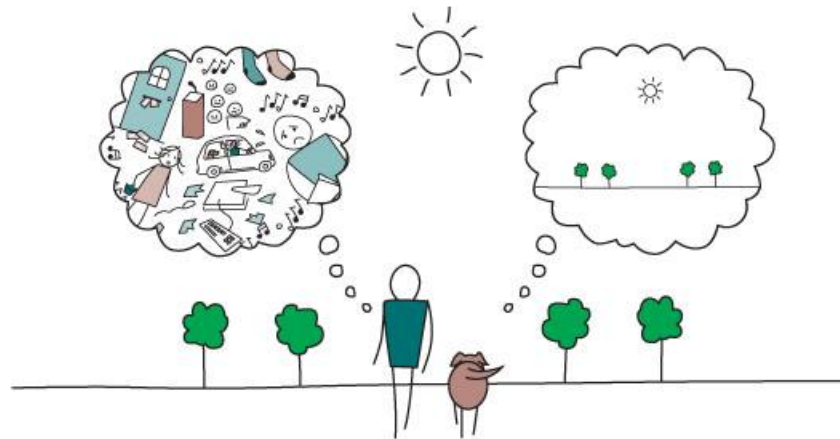
Self-regulation training during adolescence

- Fostering self-regulation, i.e. non-reactivity and emotion regulation may be particularly important during adolescence,
- A period when emotional regulation is particularly challenging
- And failure to regulate emotions has important consequences, e.g. mood disorders, risk taking.



Mindfulness

- A type of awareness that involves attending to moment-to-moment experiences in a nonjudgmental and nonreactive way (Kabat-Zinn, 2003; Lutz et al., 2007)



Mind Full, or Mindful?


- Mindfulness training seems to have similar effects on attentional control and resistance to emotional distractors in adolescents and adults

Lyons, Zelazo, Sommerfeldt, Blakemore, Dumontheil (in preparation)

Dumontheil & Lyons (in preparation)

Mindfulness in schools

The Mindfulness in Schools Project




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Conclusions

- Adolescence a period of ongoing behavioural, structural and functional changes
- In particular in the domains of social cognition, cognitive control, and reward processing > self-regulation
- This has impacts on school performance and well-being more broadly
- Intervention and teaching approaches targeted at adolescents in particular may be beneficial



Thank You



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