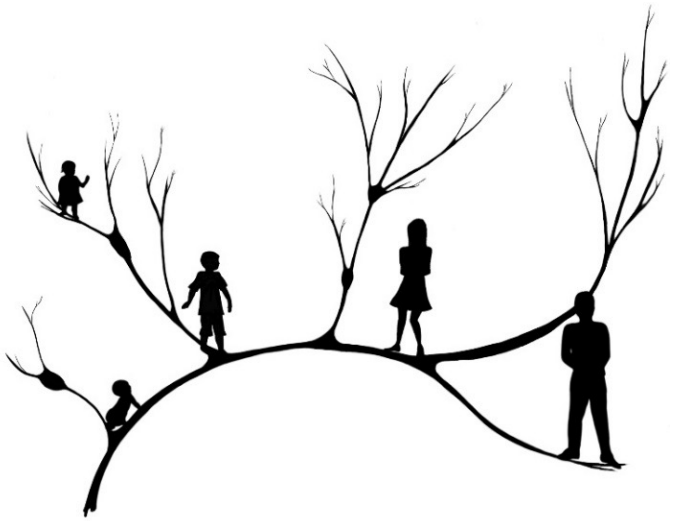
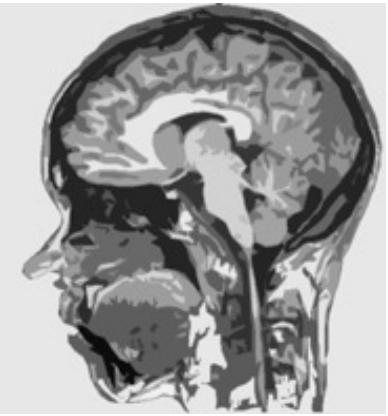
The Adolescent Brain

Dr Emma J Kilford

Postdoctoral Research Fellow
University College London





7th Mediterranean Maudsley Forum 2022
Tuesday 24 May

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What is Adolescence?

Adolescence… … derives from the Latin *adolescere* — to **grow up**

"… is a period of **physical, psychological** and **social transition** between **childhood** and **adulthood**" (Spear, 2000)

"begins with the onset of **puberty** and ends with the assumption of a **stable adult role**" (Damon, 2004)

The age of adolescence

Lancet Child Adolesc Health 2018

Susan M Sawyer, Peter S Azzopardi, Dakshitha Wickremarathne, George C Patton

Adolescence is the phase of life stretching between childhood and adulthood, and its definition has long posed a conundrum. Adolescence encompasses elements of biological growth and major social role transitions, both of which have changed in the past century. Earlier puberty has accelerated the onset of adolescence in nearly all populations, while understanding of continued growth has lifted its endpoint age well into the 20s. In parallel, delayed timing of role transitions, including completion of education, marriage, and parenthood, continue to shift popular perceptions of when adulthood begins. Arguably, the transition period from childhood to adulthood now occupies a greater portion of the life course than ever before at a time when unprecedented social forces, including marketing and digital media, are affecting health and wellbeing across these years. An expanded and more inclusive definition of adolescence is essential for developmentally appropriate framing of laws, social policies, and service systems. Rather than age 10–19 years, a definition of 10–24 years corresponds more closely to adolescent growth and popular understandings of this life phase and would facilitate extended investments across a broader range of settings.

a definition of 10–24 years corresponds more closely to adolescent growth

Adolescent Behaviour

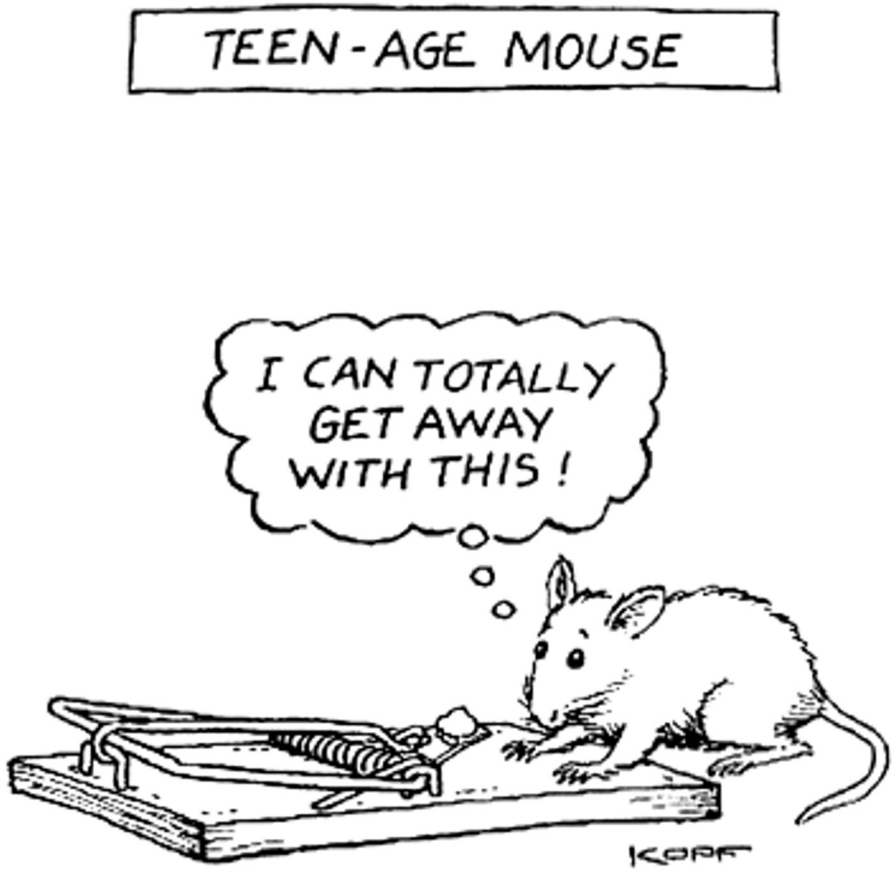
The term **‘teenager’** was first used in 1941

However, some **adolescent-typical** behaviours are **common** across **species, cultures** and **history…**

- Risk taking
- Social re-orientation

Photo from the play ‘Brainstorm’

Adolescent Risk Taking



'Arrest them and fine the parents, this is serious' - Police backed over warning to ASB youths in pandemic

Thousands of people have shared a warning issued by police in Yorkshire warning parents that their kids will be arrested if they gather in large groups to commit antisocial behaviour during the coronavirus pandemic.

By Alex Evans
Sunday, 22nd March 2020, 8:39 am
Updated Sunday, 22nd March 2020, 9:44 am

'Bored' teenage driver locked up after ramming police car in Black Country chase

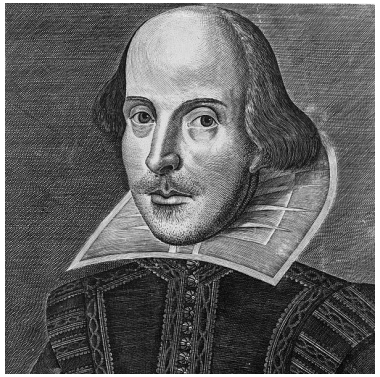
By John Scott | Sandwell | News | Published: Feb 7, 2020

> A teenage tearaway who took his aunt's car without permission before leading police on a 13-minute pursuit refusing to stop has been locked up for 12 months.

Adolescence – A Long History

"I would there were **no age between ten and three-and-twenty**, or that youth would sleep out the rest; for there is nothing in the between but getting wenches with child, wronging the ancientry, stealing, fighting."

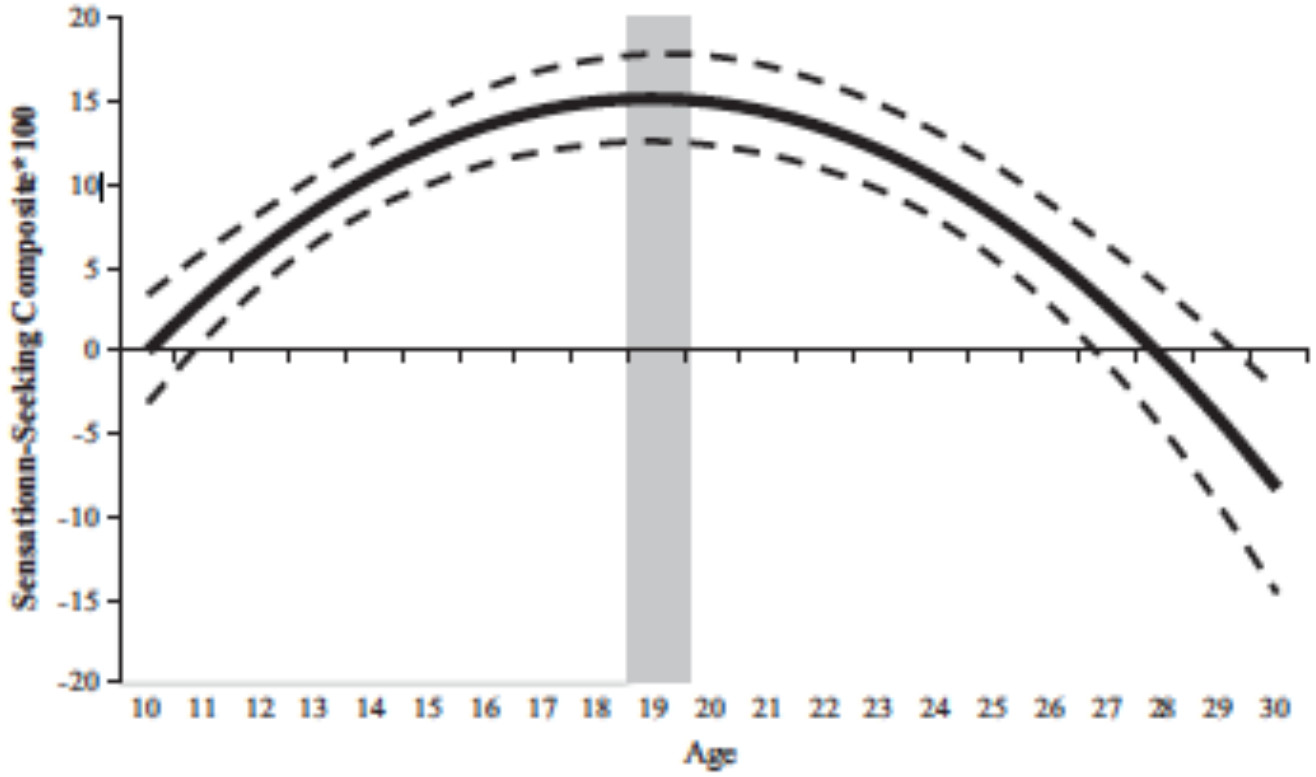
Shakespeare
The Winter's Tale, III.iii



a definition of 10–24 years corresponds more closely to adolescent growth

Risk-Taking around the World

Across cultures risk-taking propensity peaks in late adolescence



Over **5000** participants from **11 different countries,** aged **10–30 years**

Sensation-seeking composite measure created from:

- Cognitive tasks that assess the **propensity to take risks** to earn rewards
- Self-report questions (e.g. *'I like doing things just for the thrill of it'*)

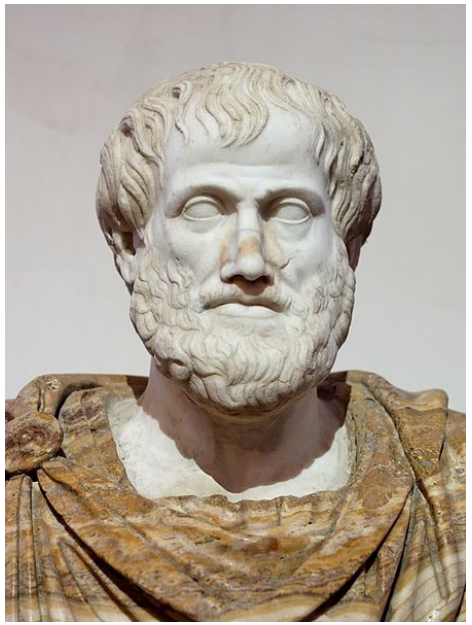
Steinberg et al. *Dev Science* (2017)

A Period of Social Re-Orientation

Adolescents begin to **spend more time** with their **friends** than their parents, compared to children

"…passionate, irascible, and apt to be carried away by their impulses … **the age when people are most devoted to their friends.**"

Aristotle, 350 BCE



The Risky Adolescent Mouse

Adolescent (but not adult) mice drink more alcohol when with other mice

Social context is important

Logue et al. (2014)

Why study Adolescence?

Adolescent-typical behaviours are **adaptive** developmental processes, assisting the transition to an **independent adult role**

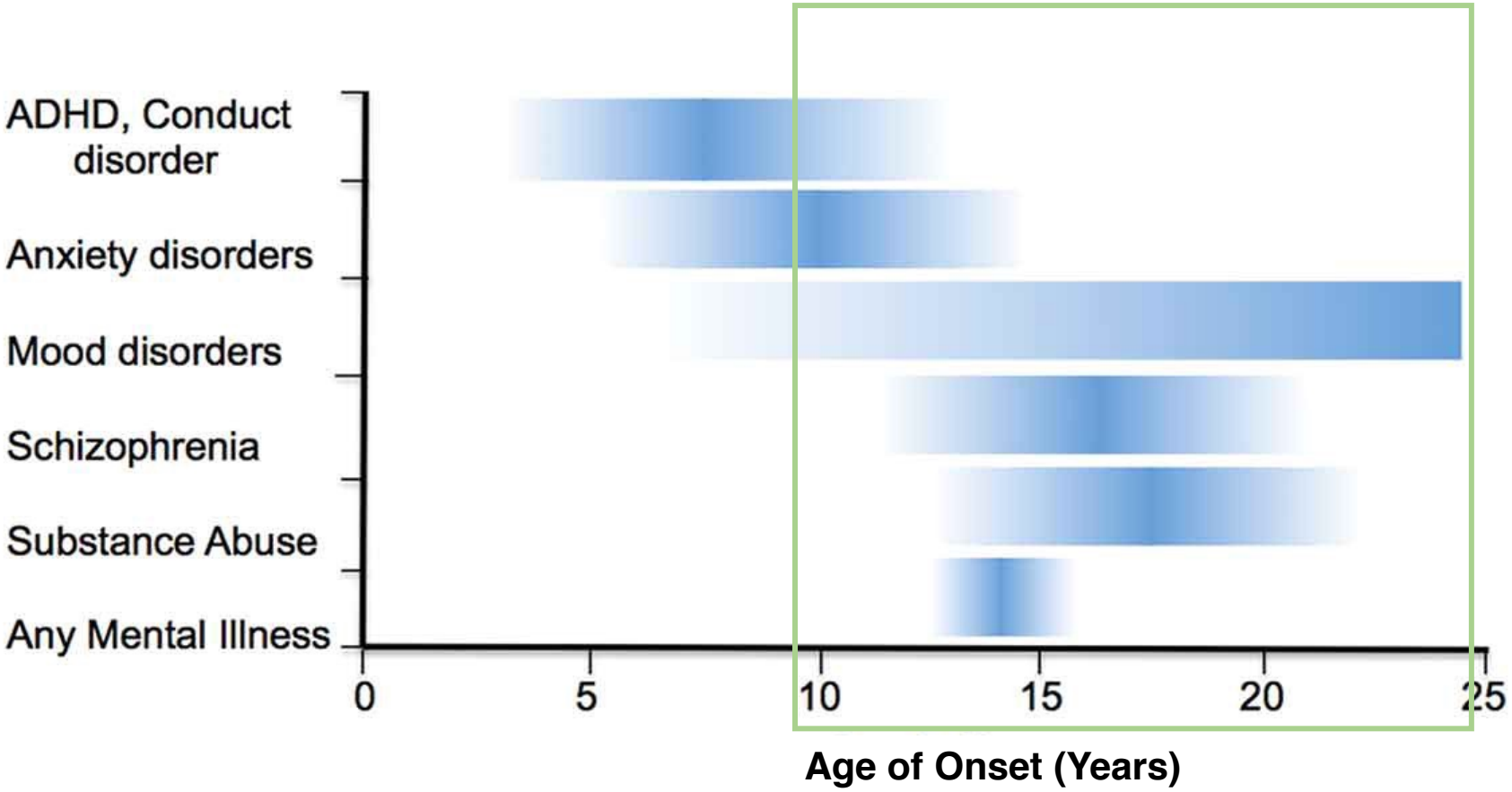
- Taking risks increases **exploration**, **innovation**, learning and **creativity**

- Social changes facilitate **new relationships**, increased intimacy and development of mature **self-awareness**

But adolescence is also a time of increased **vulnerability**

Adolescence and Mental Health

75% of adult mental disorder has its onset before 24 years (Kessler et al. 2005)

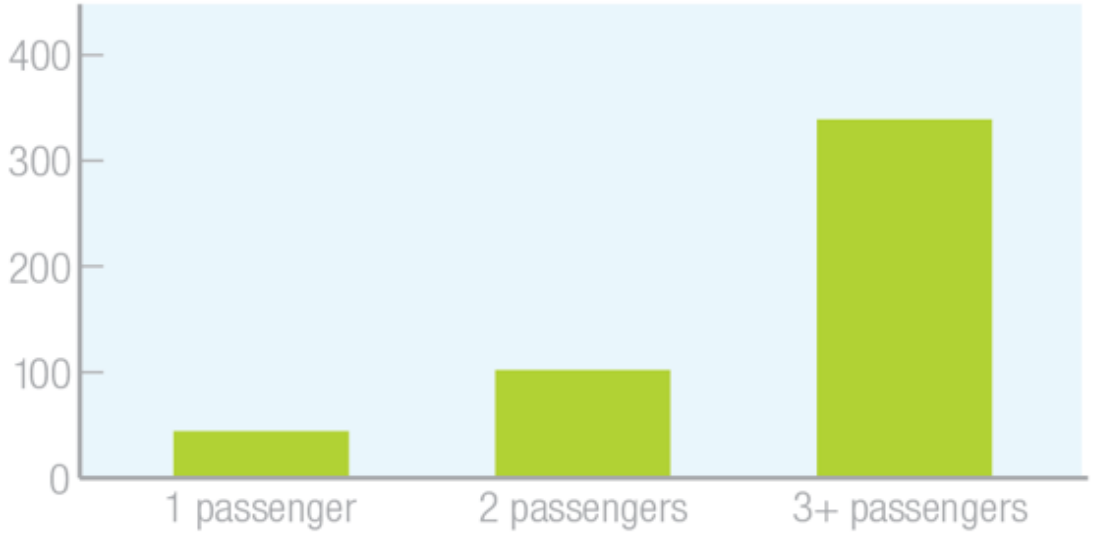


Powers & Casey (2015)

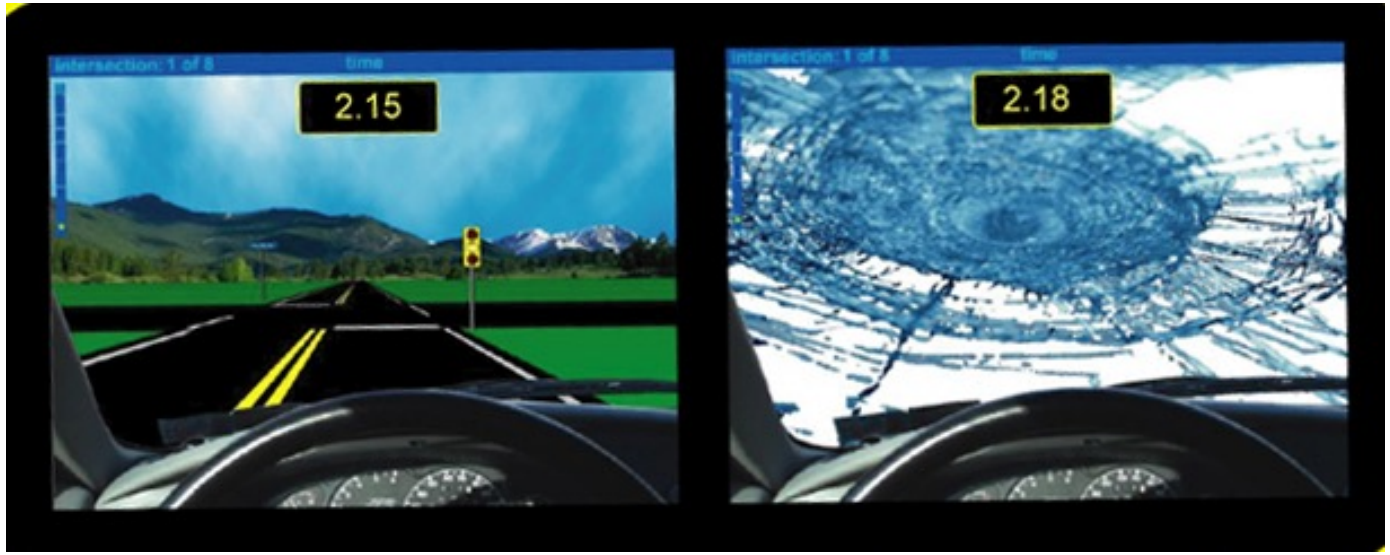
Adolescent Risk Taking and Mortality

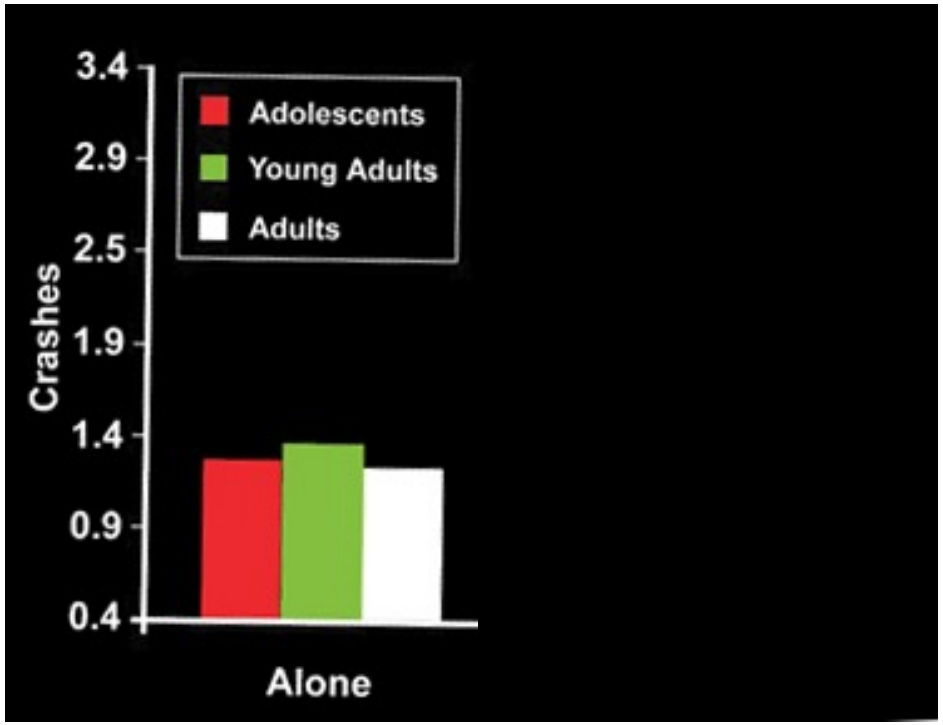
Leading cause of mortality in people aged 10-24 years is accidents, mostly caused by risk taking (Viner et al. 2011)

Percentage increase in death risk with passengers versus no passengers, for drivers under 21 years
(AAA Foundation, 2017)



Peer Influence on Risk Taking





Driving simulator game: playing alone or being watched by two friends

Three groups: Adolescents (13-16y)
Young adults (17-24)
Adults (25-40)

Gardner & Steinberg (2005)

Why study Adolescence?

Adolescent-typical behaviours are associated with both **opportunity** and **vulnerability**, and this often **persists** throughout **adulthood**

Understanding neurocognitive **mechanisms** underlying behavioural changes in adolescence, and how they **vary** both **within individuals over time** and **between different individuals** may provide insight into why adolescence is a period of elevated vulnerability, who may be most at risk, and how best to design effective **interventions**

The Adolescent Brain

Cognitive Neuroscience – the study of how are brains are involved in cognition – the **mental processes** that underlie behaviour, thought and experience and the **brain systems** that support these **mechanisms**

Very little used to be known about brain development **past infancy**

nation. It is one of the later stages of maturation, beginning usually late in embryonic life or early in postnatal life after the projection neurons are well in place, and continuing for considerable periods of time (into childhood, in the case of humans).

Neuroscience Textbook (1995)

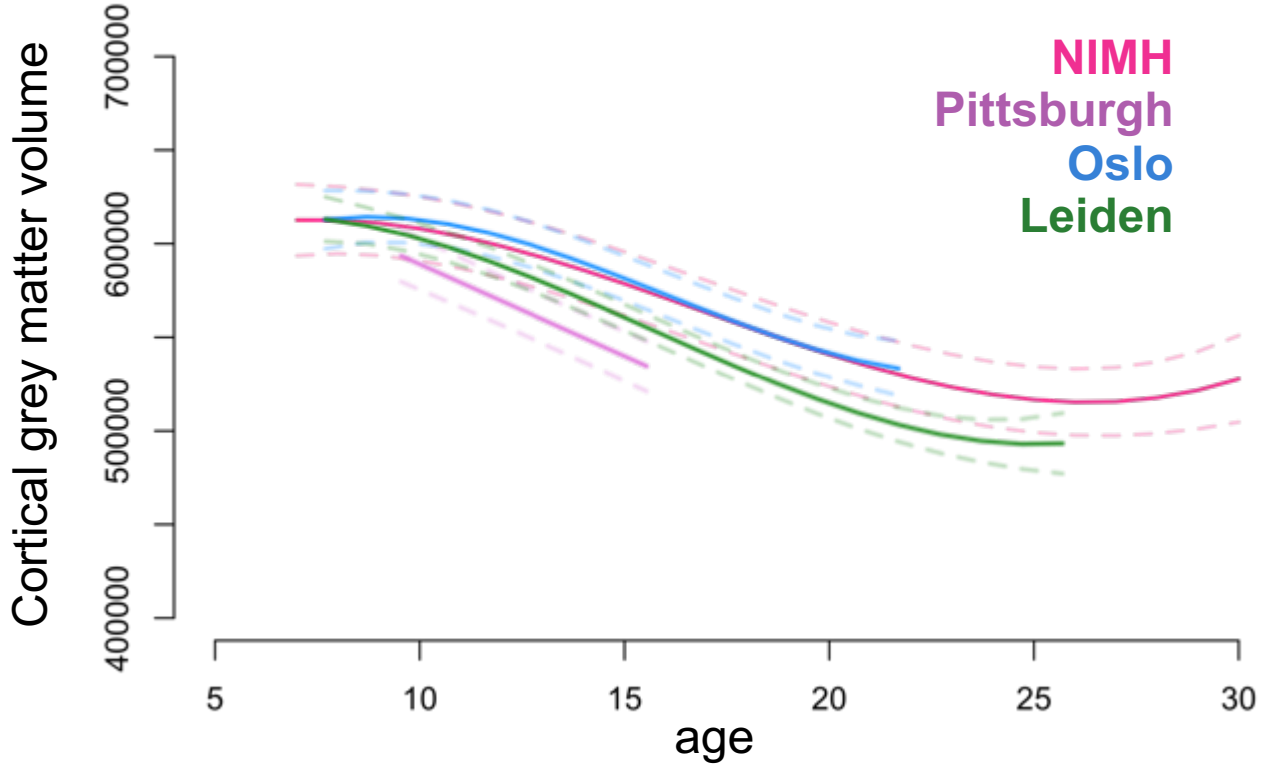
Structural Brain Development

Structural brain development in four cohorts

Total N = 391 participants
Each participant scanned between 2 and 7 times

Mills et al. (2016) *Neuroimage*

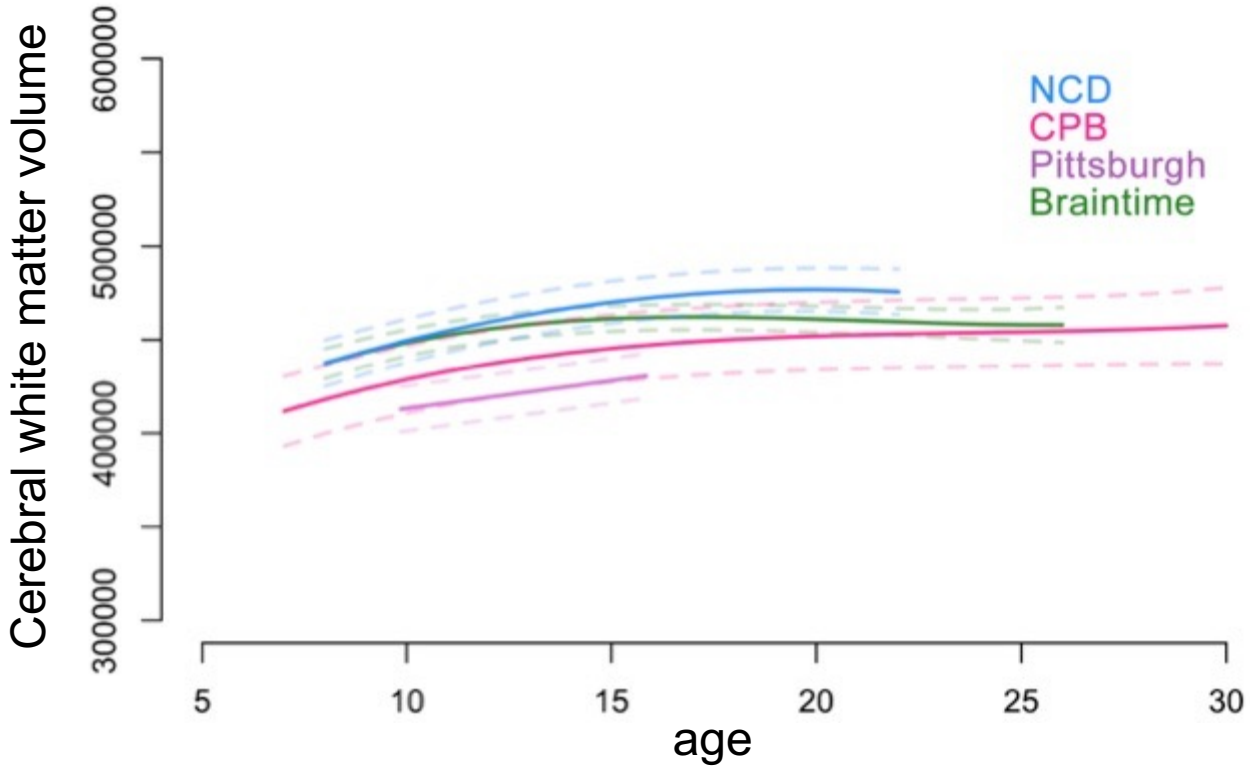
Cortical Grey Matter Volume



Grey matter volume decreases around 1.5% annually during adolescence

Mills et al. (2016) *Neuroimage*

Cortical White Matter Volume



White matter volume increases up to 1% annually during adolescence

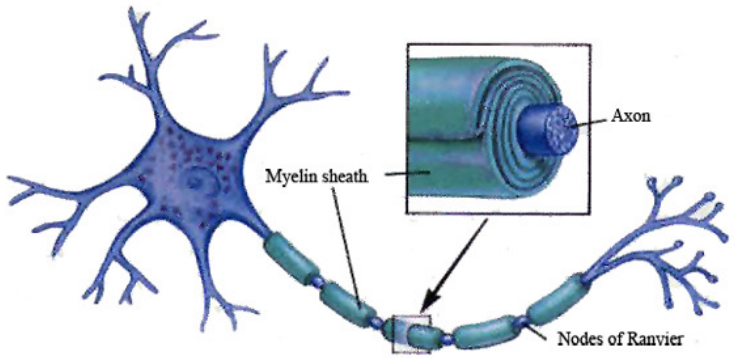
Mills et al. (2016) *Neuroimage*

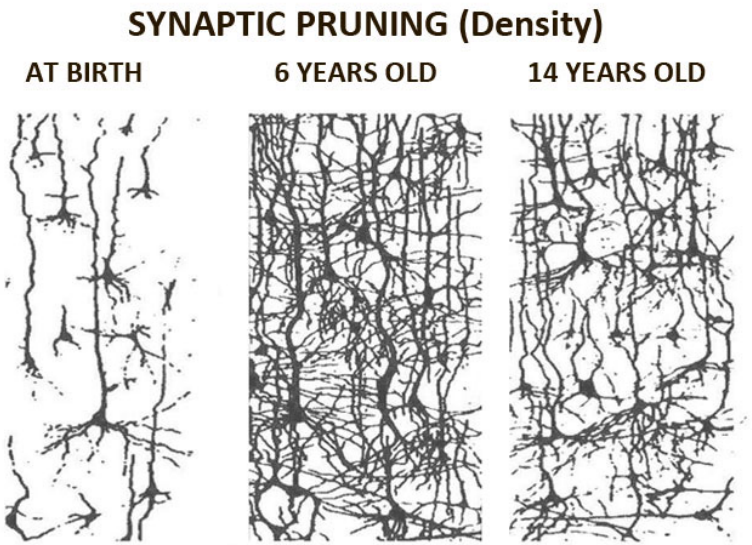
Why?

Why does Grey Matter decrease and White Matter increase during adolescence?

Myelination
Axonal growth
} → Increases WM, Decreases GM

Synaptic pruning → Decreases GM

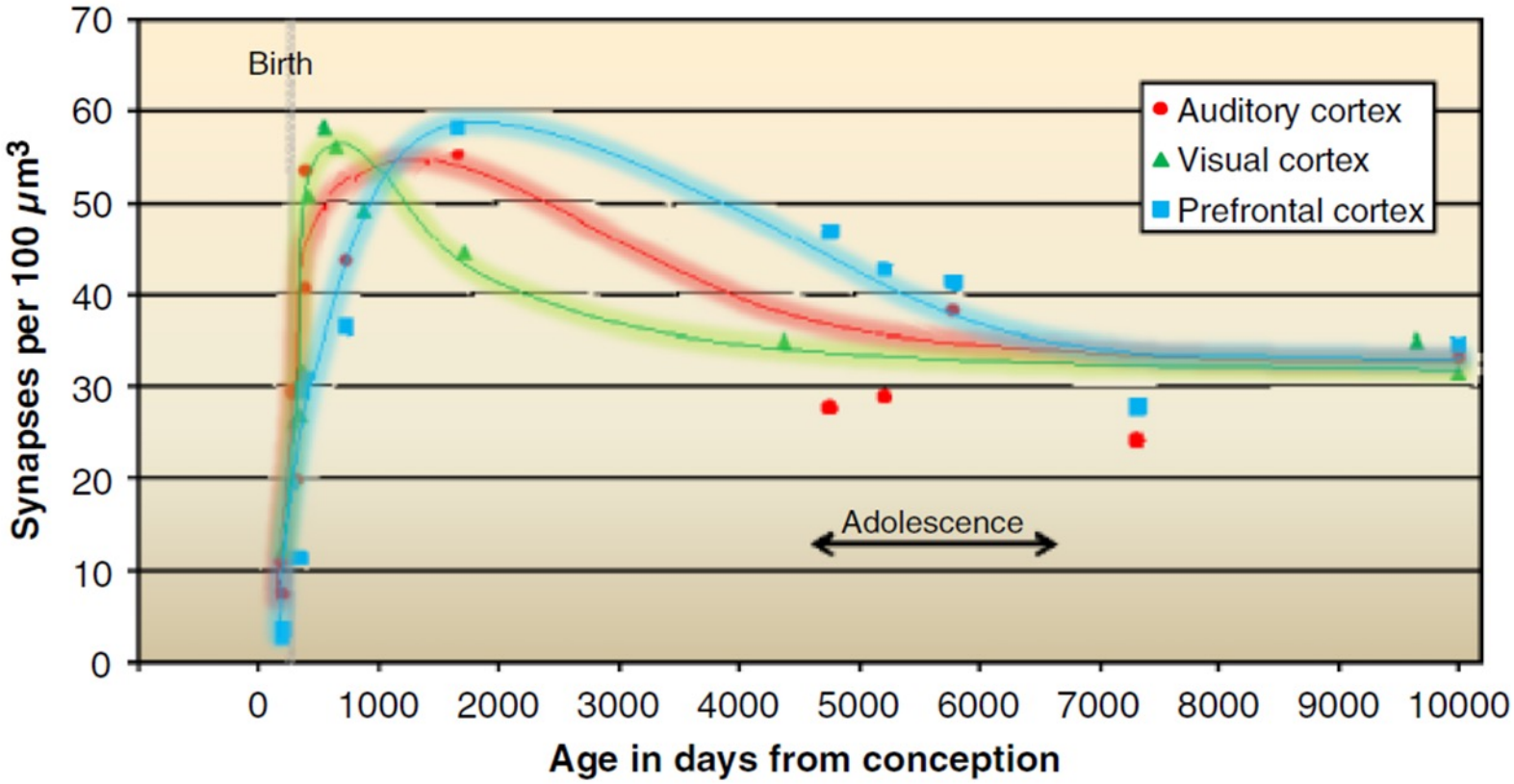




Conel (1939-1967)

Region Specific Development

Developmental trajectories are **not uniform** across the brain



Synaptic pruning in prefrontal cortex continues during adolescence

Data from Huttenlocher & Dabholkar (1997), replotted in Thomas & Johnson (2008)

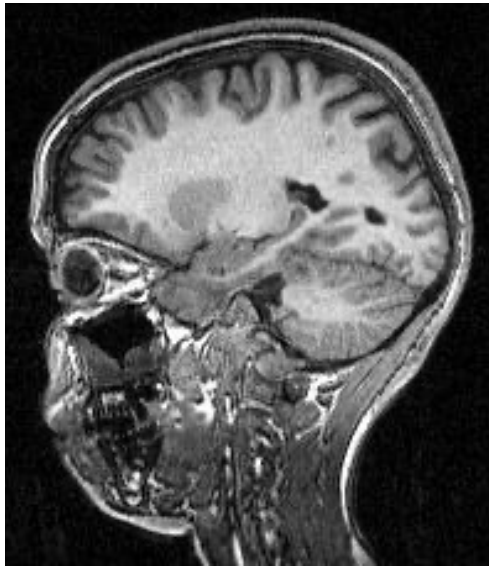
Neurocognitive Development

Developmental trajectories are **not uniform** across the brain

Prefrontal Development - Cognitive control
The ability to **flexibly** adapt and guide behaviour in the pursuit of a goal through the **coordination** of a collection of processes – e.g. **regulation, working memory, inhibition**

Subcortical Development - Motivational-affective processing
Mechanisms of emotional reactivity, motivation and reward and punishment sensitivity

Development of the Social Brain - Social cognition
How we process, store and use information **about people**



Social Cognition

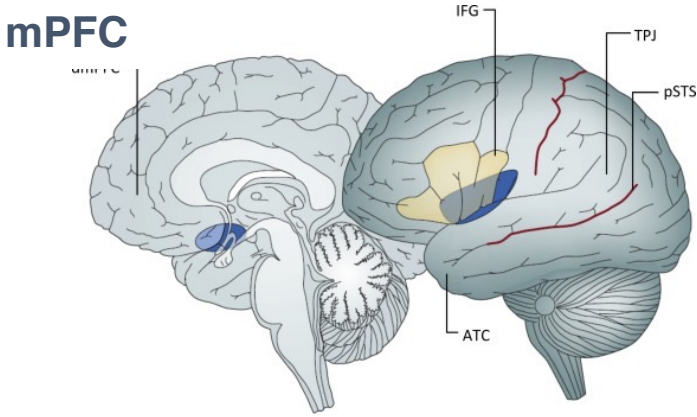
Spontaneous helping behaviours in 18-month-olds

Warneken &Tomasello , *Science* 2006

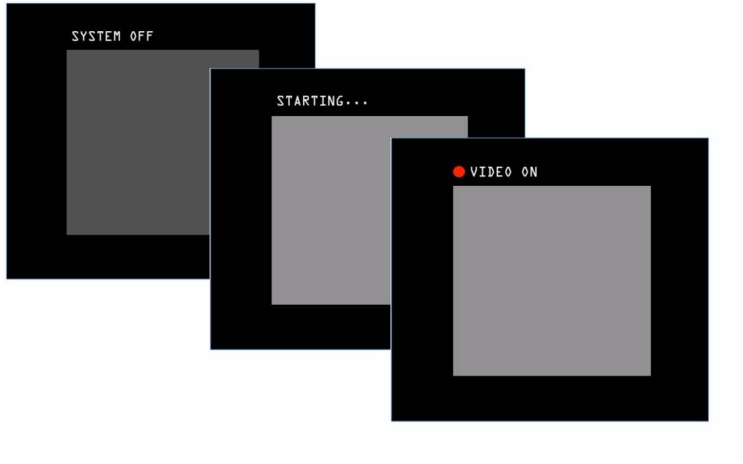
The Social Brain

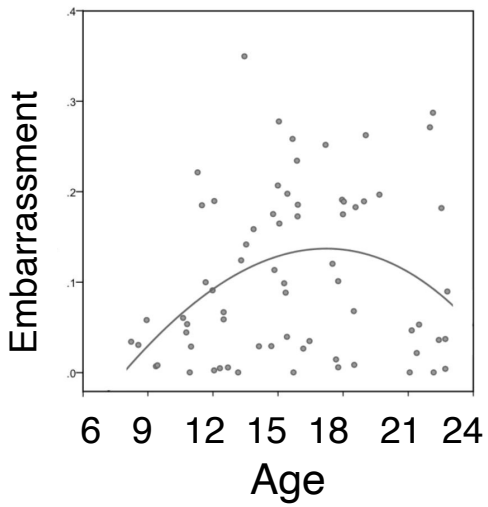
The prefrontal cortex is a key part of the **social brain network**

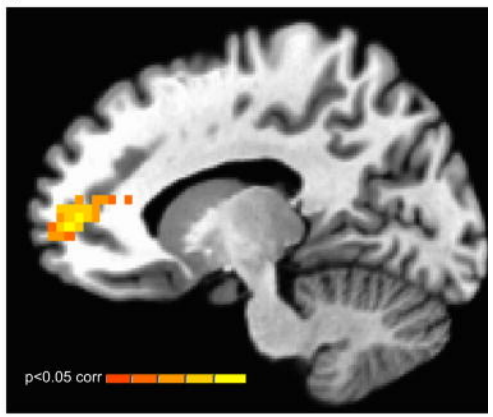
Adolescents show **greater activity** in the **medial prefrontal cortex** than adults across a wide range of **fMRI tasks** that involve thinking about **mental states** (Blakemore, 2008)

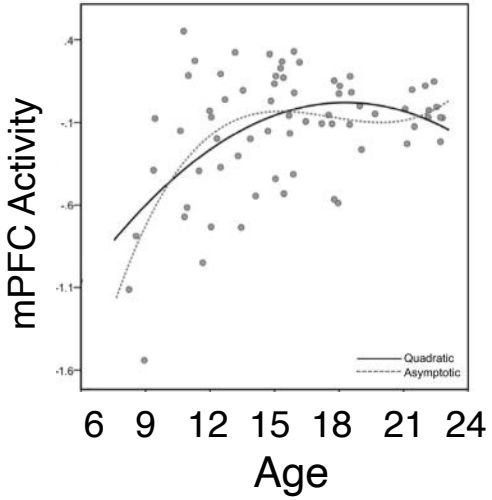


Blakemore (2008) *Nat Rev Neurosci*









Somerville et al. (2013) *Psych Science*

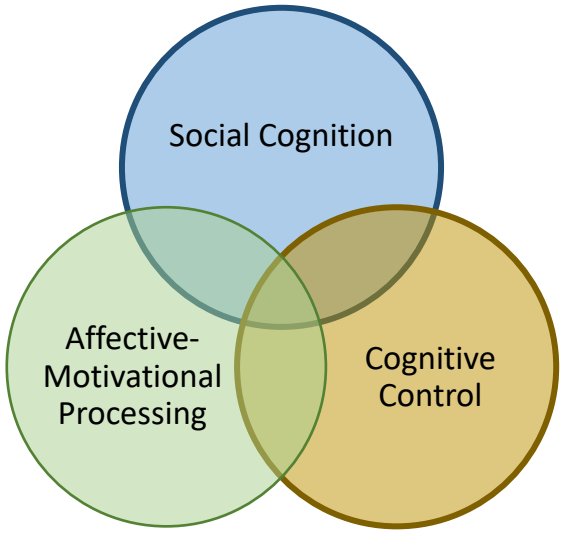
Interacting Systems

Cognitive control, motivational-affective processing and **social cognition** and the neural systems that support them, show **continued** development throughout adolescence and into the 20's

Successful transition to adulthood thus requires the **refinement** and **integration** of these processes in increasingly complex social contexts

Many **adolescent-typical** behaviours involve **interactions between** these processes and neural systems

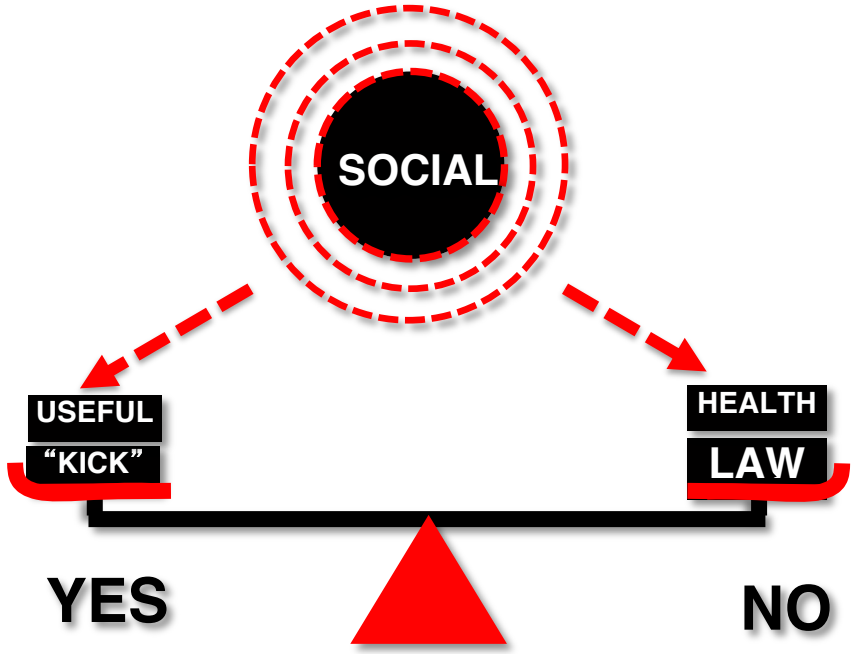
- Sensitivity to social exclusion



Reviewed in Kilford et al. (2016) *Neurosci & Biobehav Rev*

Avoiding Social Risk

Avoiding social risk might matter more to adolescents than avoiding other types of risk



Blakemore & Mills (2014) *Annual Review of Psychology*
Blakemore (2018) *Current Directions in Psych Science*

Social Exclusion and Mental Health

Longitudinal studies suggest peer rejection often predict adolescent depression
(Cicchetti & Bukowski, 1995; Nolan et al., 2003)

Experimental studies suggest evidence for a complex, bi-directional relationship between peer rejection and depression

Prospective Relations Between Rejection and Depression in Young Adolescents

Susan A. Nolan
Seton Hall University

Cynthia Flynn and Judy Garber
Vanderbilt University

Journal of Personality and Social Psychology
2003, Vol. 85, No. 4, 745–755

DEPRESSION AND ANXIETY 30:809–821 (2013)

Review

THE ROLE OF PEER REJECTION IN ADOLESCENT DEPRESSION

Belinda Platt, MSc,* Kathrin Cohen Kadosh, PhD, and Jennifer Y. F. Lau, PhD

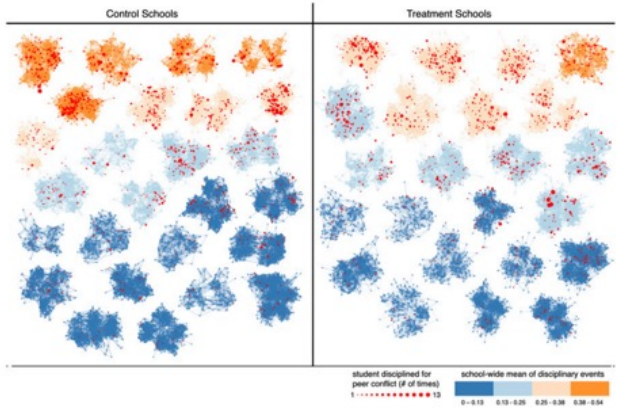
Platt et al. *Depression & Anxiety* (2013)

Peer-Led Interventions

Randomised peer-led anti-bullying intervention in 56 middle schools

Incidents in control schools

Incidents in peer-led schools



Student conflict was reduced by 25% over one year in schools in which interventions were led by students

Effect was stronger when the students leading the campaigns were more highly connected

Trends in Cognitive Sciences

Science & Society

Peer Influence in Adolescence: Public-Health Implications for COVID-19

Jack L. Andrews,[1] Lucy Foulkes,[1] and Sarah-Jayne Blakemore[1,2,*]

Paluck et al. *PNAS* (2015)

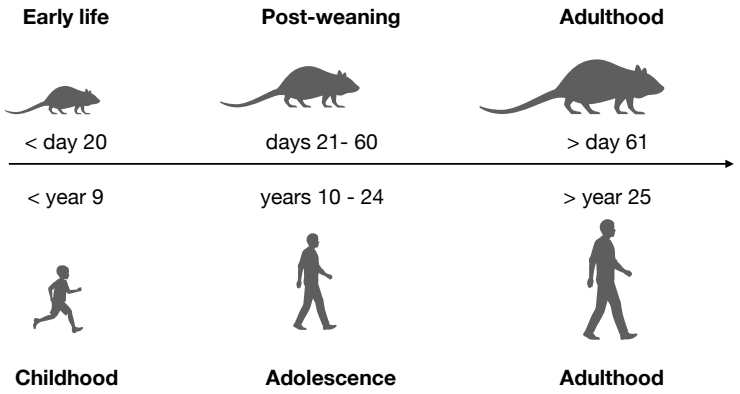
Andrews et al (2020) *Trends in Cognitive Sciences*

Adolescence as a Sensitive Period?

Could there be ‘windows’ of increased vulnerability?

A Critical Period for Social Isolation in the Rat

DOROTHY F. EINON
M. J. MORGAN
Psychological Laboratory
University of Cambridge
Cambridge, England



Social deprivation in **adolescent** rats has **different effects** on neural and behavioural development than deprivation in early life or adulthood

Einon & Morgon (1977); Van Hoeve et al. (2013); Burke et al (2017)

Einon & Morgon (1977); Van Hoeve et al. (2013); Burke et al (2017)

Social Isolation in Adolescence

Loneliness is associated with mental health problems, substance abuse and physical illness

Effects of social isolation and social distancing on adolescent brain, behaviour and mental health?

ONS survey: 2020 Coronavirus and the social impacts
'My well-being is being affected (e.g. boredom, loneliness, anxiety and stress)'

- 60% of 16-29 year-olds agreed with this statement
- 32% of 70+ year-olds agreed with the statement
- 53% of 16-29 year-olds who answered yes said they were lonely (vs 36% of 70+ year-olds).

16 to 24-year-olds report highest loneliness levels in UK
(Hammond, 2019: BBC survey)


BBC | BBC Account | Home | News | Sport | Weather

NEWS

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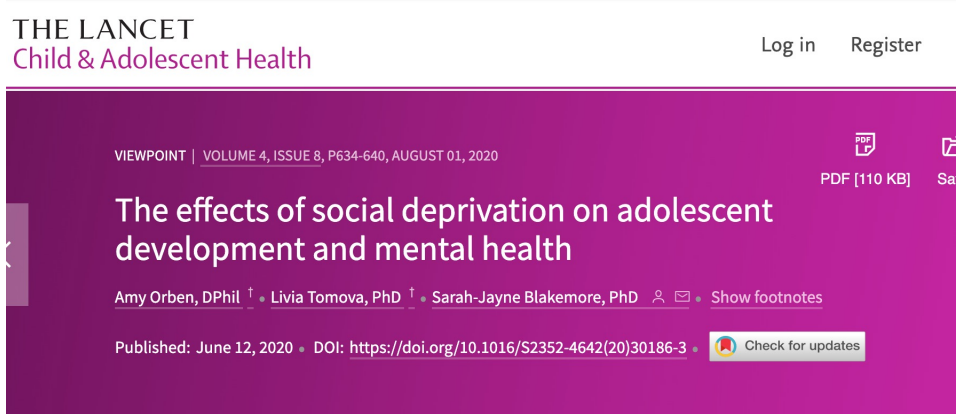
Family & Education | Young Reporter | Global Education

Lockdown loneliness reaches record levels

By Sean Coughlan
BBC News


THE LANCET
Child & Adolescent Health

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VIEWPOINT | VOLUME 4, ISSUE 8, P634-640, AUGUST 01, 2020

PDF [110 KB]

The effects of social deprivation on adolescent development and mental health

Amy Orben, DPhil † • Livia Tomova, PhD † • Sarah-Jayne Blakemore, PhD • Show footnotes

Published: June 12, 2020 • DOI: https://doi.org/10.1016/S2352-4642(20)30186-3 • Check for updates

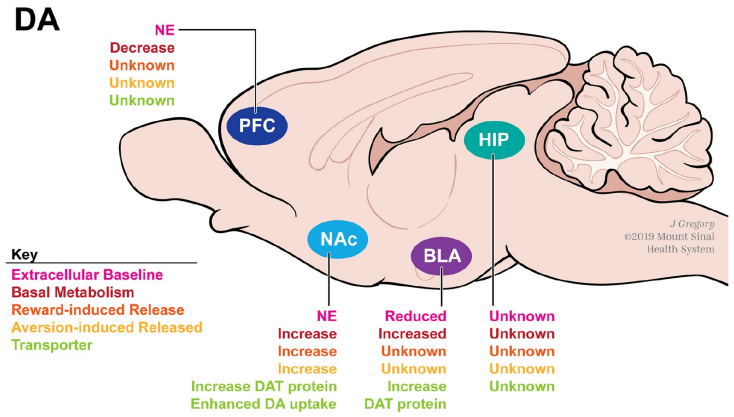
Social Isolation and Adolescence

Long-Term Behavioral Effects of Post-weaning Social Isolation in Males and Females

Deena M. Walker[1], Ashley M. Cunningham[1], Jill K. Gregory[2] and Eric J. Nestler[1*]

[1]Department of Neuroscience and Friedman Brain Institute, Icahn School of Medicine at Mount Sinai, New York, NY, United States

[2]Academic IT: Instructional Technology Group, Icahn School of Medicine at Mount Sinai, New York, NY, United States



Social isolation rearing in adolescent rodents results in:

Dysregulation of dopamine and serotonin systems

Structural changes in brain e.g. reduced pruning in frontal cortex

Changes in reward processing and learning

Anxiety

Substance abuse and addiction

Walker et al. (2019) *Frontiers in Behavioural Neuroscience*

Social Media in Adolescence

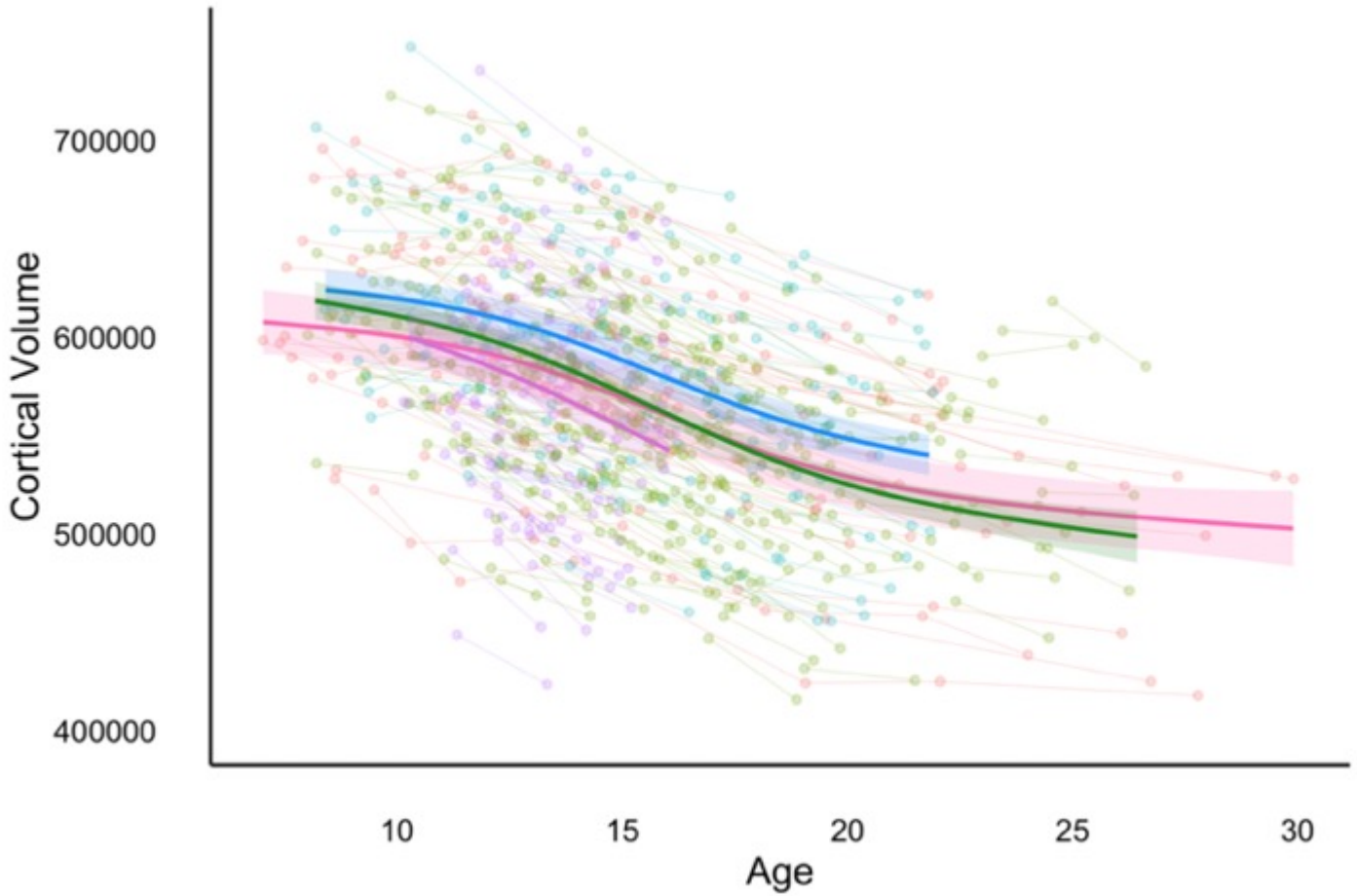
- Isolation studies are in rodents
- Lockdown is not social isolation
- Digital means of social connection might mitigate effects of social distancing
- Need to move away from measures of screen time to thinking about usage, and broader context in which usage is embedded

Alice, 15, had also started playing Fortnite with a girl she knew from drama classes, whom she referred to as her 'gamer friend'. She said they tended to play on her phone on occasional weekday evenings on 'duos' mode (which enables two players to compete against one another), while simultaneously FaceTiming on her iPad. She argued they had become better friends as a result.

Offcom survey (2020)

Orben et al. (2020) *Lancet Child & Adolescent Health*

Individual Differences



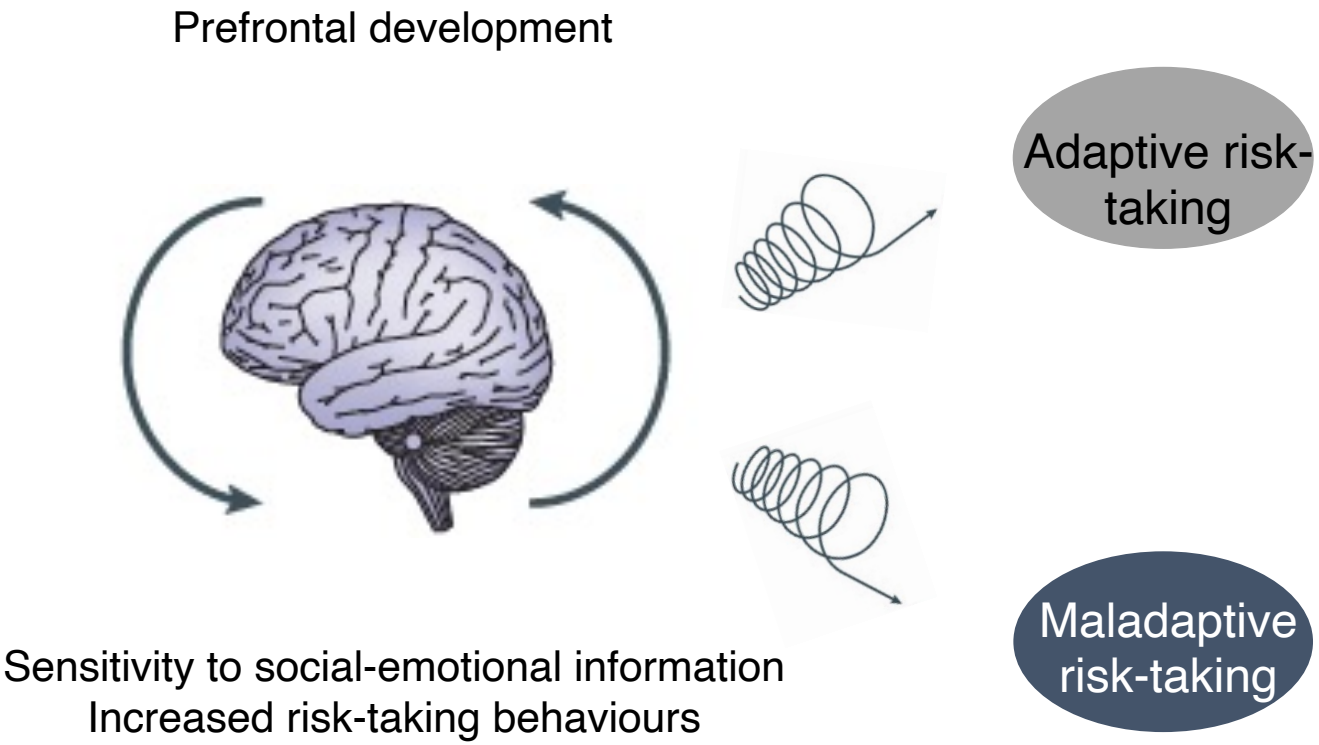
There is no ‘average’ adolescent

Foulkes & Blakemore (2018) *Nature Neuroscience*

Individual Differences in Mechanisms

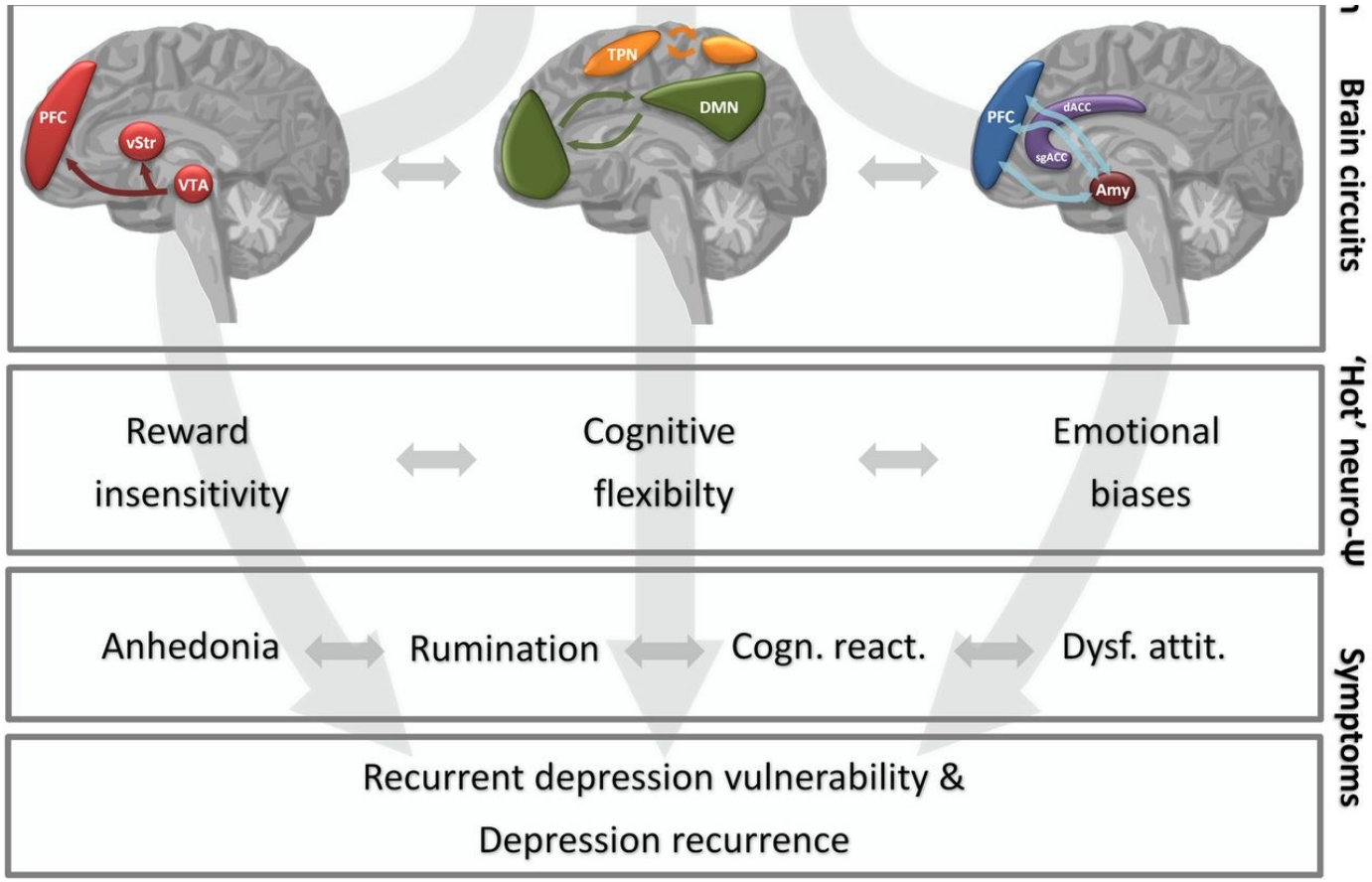
Different cognitive mechanisms can lead to the same behavioural outcome

Need to understand *which* Mechanisms are altered, *how* they are altered, in a specific individual in order to intervene effectively



Crone & Dahl (2012)

Levels of Analysis

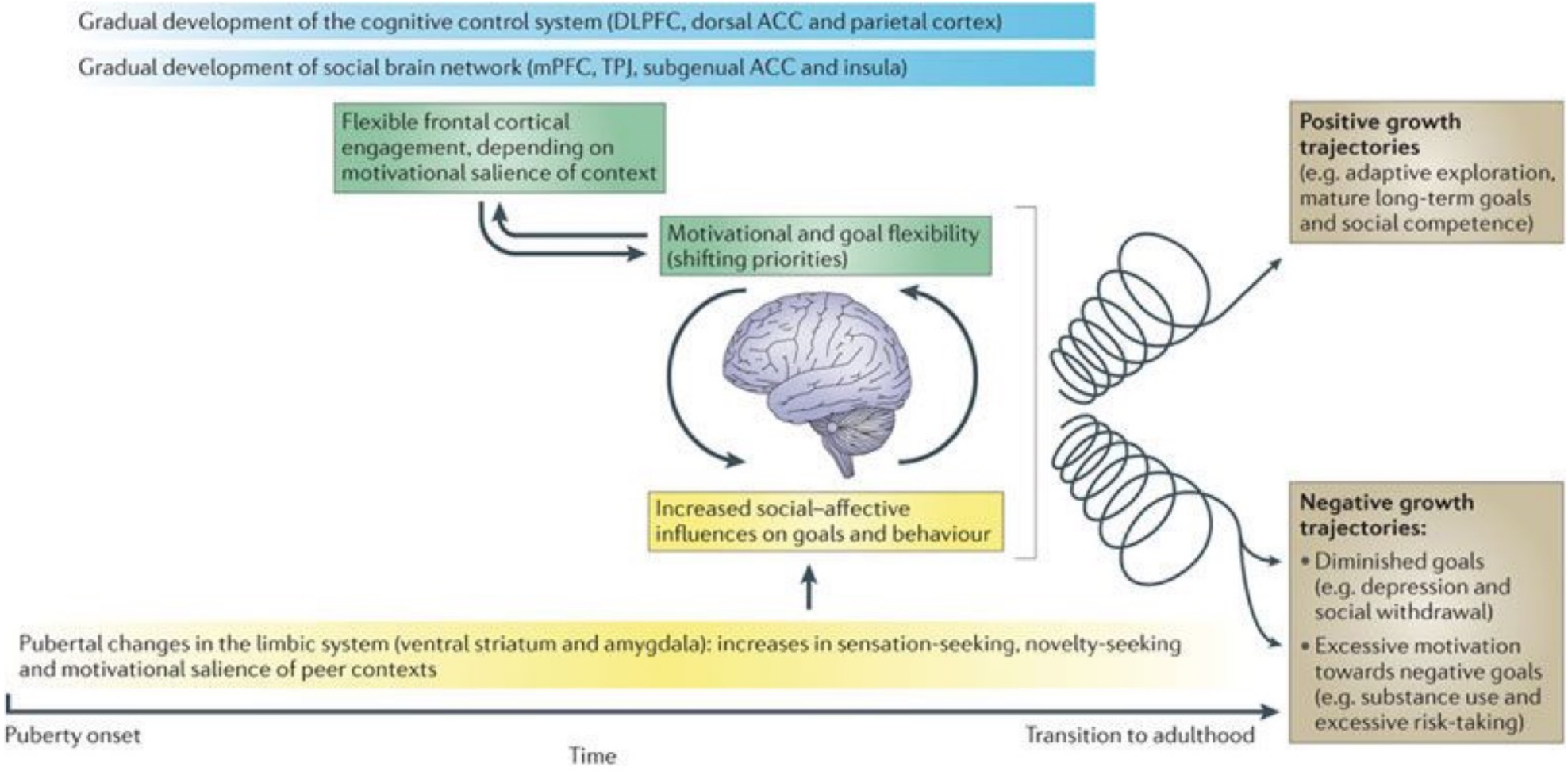


Different neurocognitive mechanisms can lead to the same symptom outcomes

Need to understand *which* mechanisms are altered, *how* they are altered, in a specific individual in order to intervene effectively

Mocking et al, 2003

Integrated Model of Development



Crone & Dahl (2012)

Developing New Treatments

MRC/Wits-Agincourt Unit
Rural Public Health and Health Transitions

>>DOBAT

ABOUT PROJECT

Digital delivery of Behavioural Activation to overcome depression and facilitate social and economic transitions of adolescents in LMICs

Using Immersive Virtual Reality to Increase levels of Self-Compassion in Patients with Depression

Summary

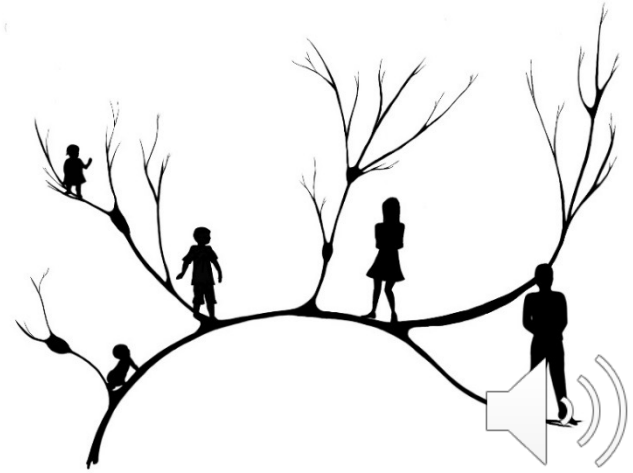
Social context is an important determinant of **adolescent typical behaviour**

The **brain** continues to develop **substantially** throughout adolescence

The **prefrontal cortex** is involved in a **diverse** range of cognitive processes which show continued **development** and **integration** during adolescence

Adolescence may be a **sensitive period** of development, conferring both **vulnerability** and **opportunity**

Individual differences in development are huge
– there is no average adolescent



Thanks & Questions

Developmental Cognitive Neuroscience Group

Prof Sarah-Jayne Blakemore

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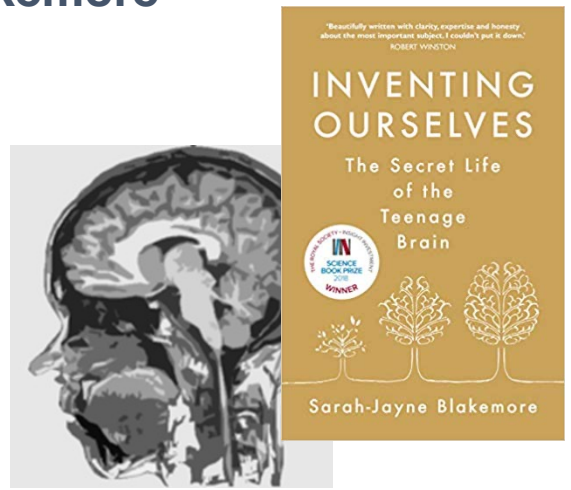
Dr Gabriele Chierchia
Jovita Leung
Madeleine Moses-Payne
Dr Amy Orben
Blanca Piera Pi-Sunyer
Dr Susanne Schweizer
Dr Livia Tomova
Emily Towner



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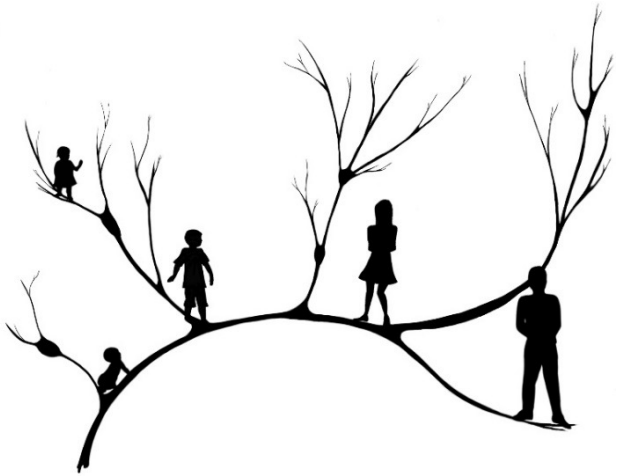

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