Adolescent Development

Learning Outcomes

- LO1 – a comprehensive understanding of the physical, hormonal and cognitive development that occurs during adolescence
- LO1 – understand the research evidence regarding the cognitive changes that occur during adolescence and how they are associated with chronological age and hormone levels (tanner stage).
- LO4 – be able to articulate how the changes that occur during adolescence can interact with environmental variables and the potential impact of this on well-being, social experience, and family dynamics.

Adolescence defined

Divided into three stages:

Early (10-15):

Rapid growth and development of secondary sexual characteristics
Concrete thinking
Developing body image
Frequent mood changes
Struggles with being dependent
Intense friendships
Exploration of sexuality

Middle (14-17):

Brain growth – prefrontal cortex
Moves towards abstract thinking
Creates body image
Risky behaviours; argues with authority
Powerful influence of peer group
Form stable relationships

Late (16-19):

Physically mature
Abstract thinker, plans for the future
Usually comfortable with body image
Family dynamics shift toward equal adult-adult relationship
Less influence of peers – individual friendships and relationships most important
Mutual and balanced sexual relations

Changes in the definition

Adolescence in 1920

Puberty onset – age 14.6 for girls

School leaving age – 14 (UK)

Employment age (full-time) - 14

Teenage pregnancy – approx. 2.5%

Adolescence now

Puberty onset – age 10.5 for girls

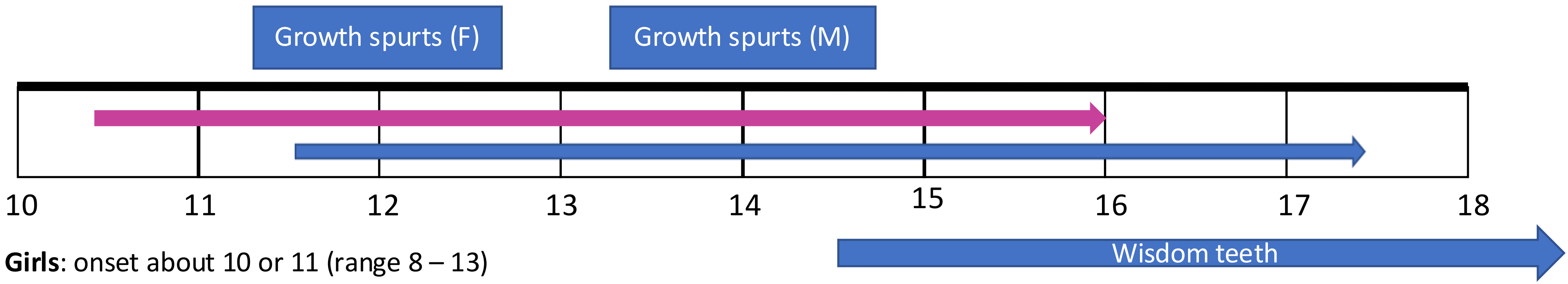
School leaving age – 17 (in Australia)

Employment age (full-time) - 17

Teenage pregnancy – 2.8%

Basic timeline of adolescence - biological

Physical changes



Girls: onset about 10 or 11 (range 8 – 13)

- breast development
- changes in body shape and height
- growth of pubic and body hair
- the start of periods (menstruation)

Boys: onset about 11 or 12 (range 9 – 14)

- growth of the penis and testes (testicles)
- changes in body shape and height
- erections with ejaculation
- growth of body and facial hair
- changes to voice

Increases in weight, height, heart and lung size, muscular strength

Bone growth is faster than muscle development – poor coordination

Increase in appetite and sleep requirements

Year 10 group photo

Puberty onset and obesity

Obese girls, defined as at least 10 kilograms (22 pounds) overweight, had an 80% chance of developing breasts before their ninth birthday and starting menstruation before age 12 – the western average for menstruation is about 12.7 years.

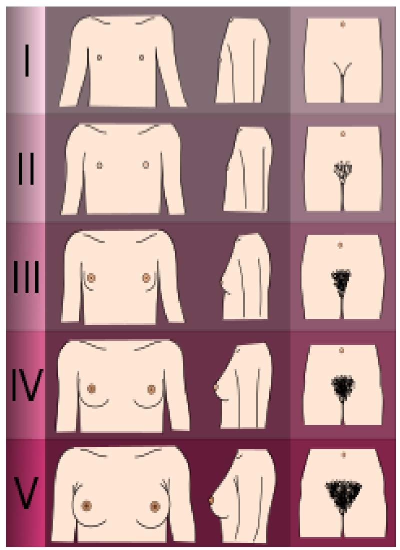
Joyce Lee of the University of Michigan, US, followed 354 girls who were either normal weight, at risk of being overweight, or overweight from age 3 to age 12. Lee found a strong association between elevated body weights at all ages and the early onset of puberty as determined by breast development and the onset of menstruation.

While previous studies have noted a relationship between obesity in girls and early puberty, it remained unclear which condition caused the other. By tracking the girls from such an early age, Lee says, “our study shows that it is increased body fatness that causes the early onset of puberty and not the other way around”.

Basic timeline of adolescence - biological

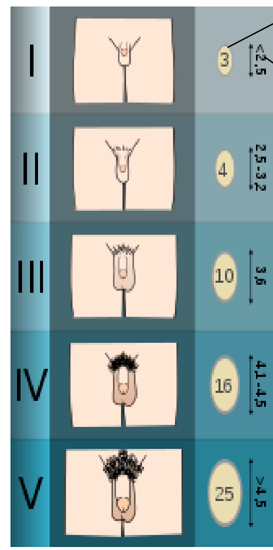
How do you measure pubertal maturation?

Tanner scale - female



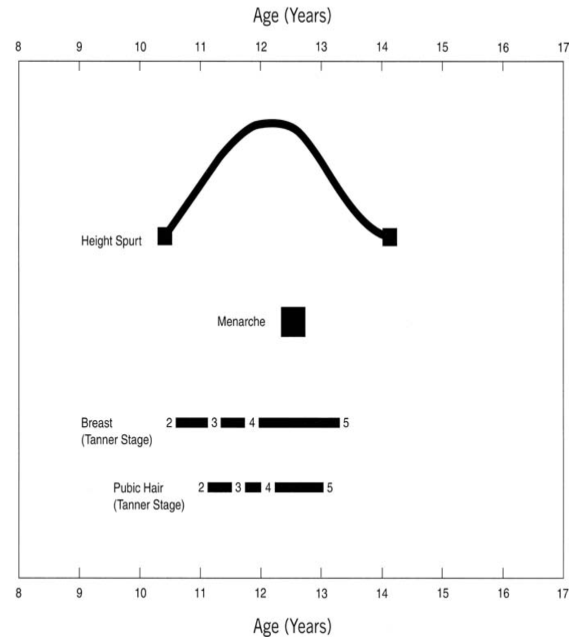
Breast buds form: elevation of breast as a small mound and enlargement of areolar diameter

Tanner scale - male

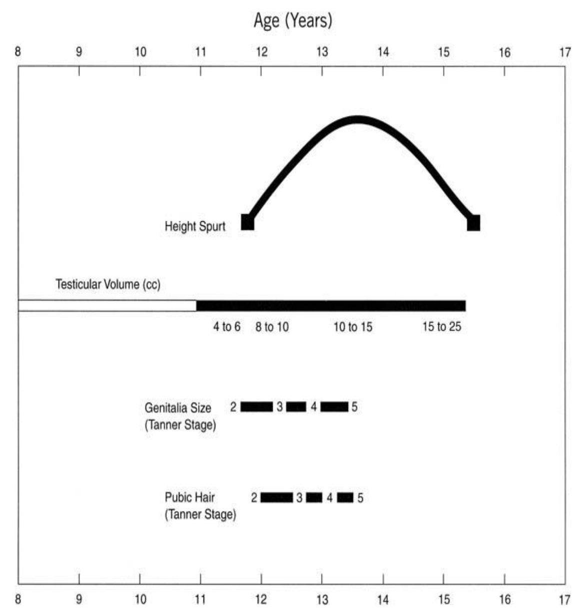


Testicular volume (cc)

Testicular longest dimension (cm)



Age (Years)
8 9 10 11 12 13 14 15 16 17
Height Spurt
Menarche
Breast
(Tanner Stage)
2 3 4 5
Pubic Hair
(Tanner Stage)
2 3 4 5
8 9 10 11 12 13 14 15 16 17
Age (Years)



Age (Years)
8 9 10 11 12 13 14 15 16 17
Height Spurt
Testicular Volume (cc)
4 to 6
8 to 10
10 to 15
15 to 25
Genitalia Size
(Tanner Stage)
2 3 4 5
Pubic Hair
(Tanner Stage)
2 3 4 5
8 9 10 11 12 13 14 15 16 17

Basic timeline of adolescence - biological

Hormonal changes: males

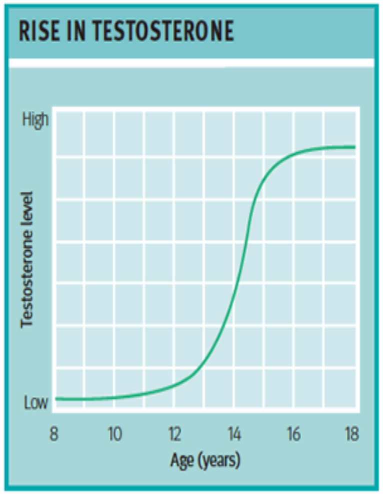
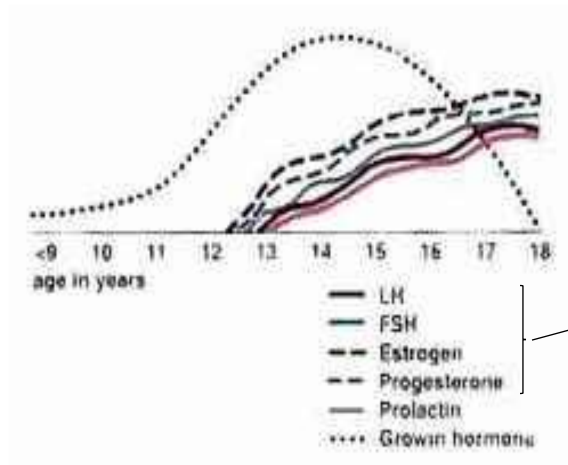


Table 3 T levels by tanner stage and age (19)

Tanner stage and age group	T (ng/dL)
Tanner stage	
4	288 [29-455]
5	326 [144-691]
Age	
13-15	226 [3-507]
16-18	350 [115-691]

Age	Hormone	Normal Range
10 – 11 Years	Total Testosterone	5 to 50 ng/dL
	Free Testosterone	0.6 to 5.7 ng/dL
12 – 14 Years	Total Testosterone	10 to 570 ng/dL
	Free Testosterone	1.4 to 156 ng/dL
15 – 17 Years	Total Testosterone	220 to 800 ng/dL
	Free Testosterone	80 to 159 ng/dL
DeGroot, Leslie, *Endocrinology*, 4th Edition, W. B. Saunders Company, New York, 2001.		

Females



Menstrual cycle

“Individuals become more capable of abstract, multidimensional, planned and hypothetical thinking as they develop from late childhood into adolescence”

That’s great…but…

“Whereas studies of people’s responses to hypothetical dilemmas involving the perception and appraisal of risk show few reliable age differences after middle adolescence, studies of actual risk-taking (e.g. risky driving, unprotected sex, etc) indicate that adolescents are significantly more likely to make risky decisions than are adults”

Why?

Cognitive changes in adolescence

Deductive reasoning

Information processing (including social)

Executive functions

Changes in brain structure with age

Trends in Cognitive Sciences

CellPress

Volume 9, Issue 2, February 2005, Pages 69-74

Cognitive and affective development in adolescence

Laurence Steinberg

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https://doi.org/10.1016/j.tics.2004.12.005

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1. Developments in the prefrontal cortex

Dorsolateral prefrontal cortex: working memory
planning

Ventromedial prefrontal cortex: calibration of risk and reward
e.g. Iowa Gambling Task

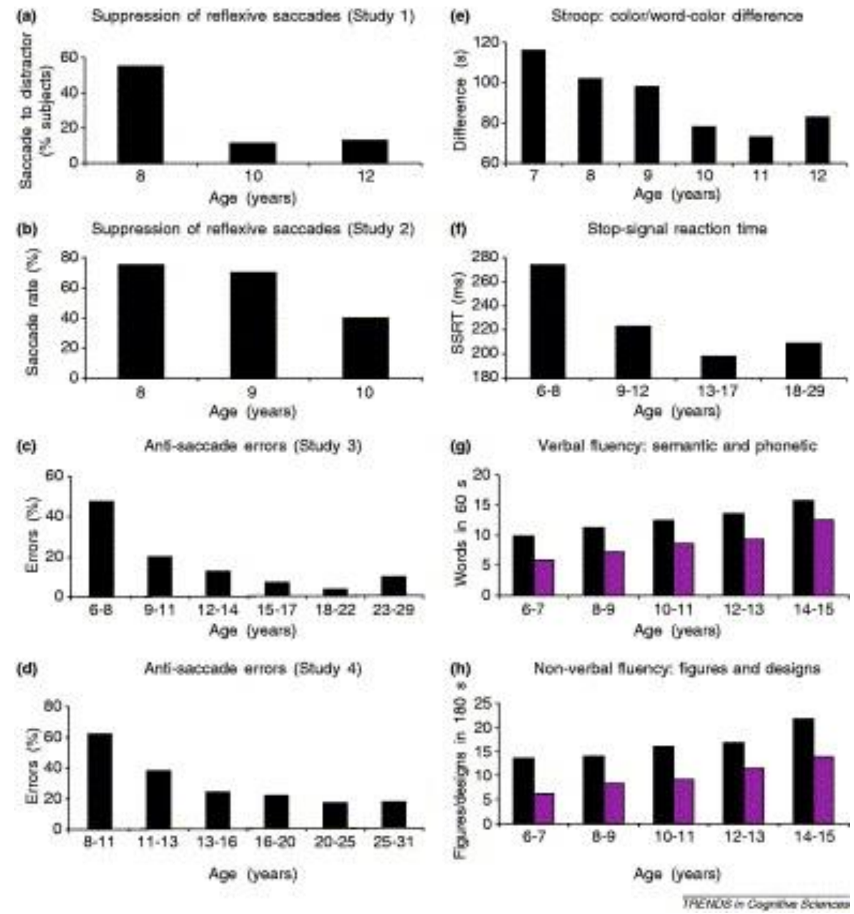

Figure 4. Age-related changes in executive functions. **(a–d)** Results of four studies of response inhibition assessed in the oculomotor domain. **(a)** An unexpected visual stimulus was flashed in the periphery while children were moving their eyes along a dimly illuminated arc; shown is the percentage of 8-, 10-, and 12-yr-old children (24–26 subjects per age group) who were unable to suppress reflexive saccades to the peripheral stimulus [81].
(b) Children were instructed to maintain fixation in the centre of the computer screen while unexpected visual stimuli were flashed in the periphery; shown is the percentage of unsuppressed eye movements made by 8-, 9-, and 10-yr-old children (15–18 subjects per age group) [82]. **(c)** Subjects (12–22 subjects per age group) were asked to gaze at the fixation point and, after the appearance of a peripheral target, look to the opposite side; shown is the percentage of eye movements directed incorrectly towards the actual target ('anti-saccade errors'). In this version of the task, the fixation point remained lit while the peripheral target appeared [83]. **(d)** The same anti-saccade task as **(c)** but here the fixation point disappeared 200 ms before the presentation of the peripheral target, making the task more difficult (19–43 subjects per age group) [84]. **(e,f)** Developmental trends in two other tasks of inhibitory control. In the Stroop task, children (12–33 subjects per age group) were asked to name the ink colour of either 100 patches of the colours red, blue and green or 100 colour names printed in a discrepant ink colour; shown is the difference in the time required to complete the two tasks (colour-words minus colour-patches) [85]. In the Stop-signal task (f), children (29–55 subjects per age group) were told to stop responding with button presses to a visual stimulus (letter X or O) when hearing a tone ('stop' signal); shown is the minimum delay between the onset of stimulus and tone necessary to stop the response, the so called stop-signal reaction time (SSRT) [86]. **(g,h)** Developmental trends in verbal and non-verbal fluency [87]. In the two verbal-fluency tasks (g), children (18–51 subjects per age group) were asked to name fruits (semantic fluency; black bars) or as many words starting with 'm' (phonetic fluency; purple bars) as they could in 60 s. In the two non-verbal fluency tasks, the same groups of children were asked to draw, as fast as possible, different meaningful designs (semantic; black bars) or linear geometric figures (non-semantic; purple bars) as they could in 180 s

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Mapping brain maturation and cognitive development during adolescence

Tomáš Paus

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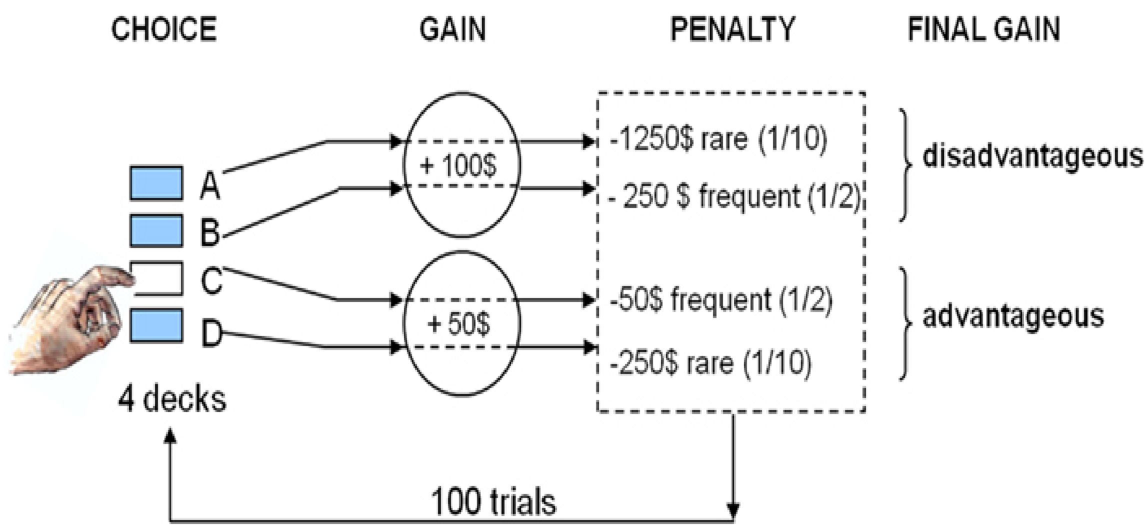
Iowa Gambling Task



6-9 year olds – drew equally from good and bad decks
10-12 year olds and **13-15 year olds** – improved over time. By the final block they were drawing from the good decks about 55% and 60% of the time, respectively
18-25 year olds – drawing from the good deck nearly 75% of the time by the last block

2. Increased efficiency

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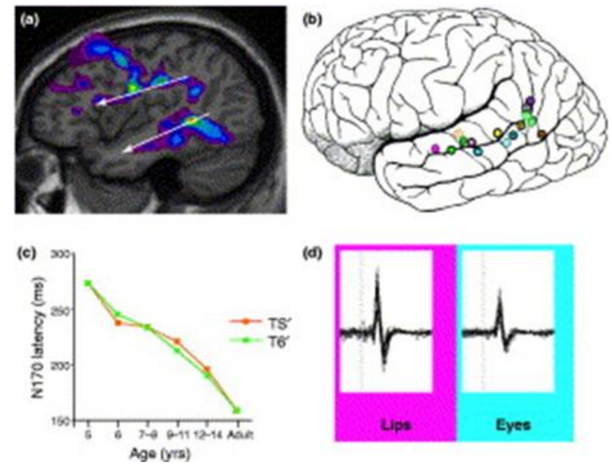
- Myelination and localised synaptic pruning in PFC
    - (both of which increase the efficiency of information processing)



Brain and social cognition. **(a)** Age-related changes in white-matter density along the putative fronto-temporal (top arrow) and the occipito-temporal (bottom arrow) pathways [48]; 36 children and adolescents, aged 10–19 years, were scanned at least twice (average interval of 3.5 yrs). Note that the changes in the fronto-temporal pathway replicate the original cross-sectional data [16] whereas those in the occipito-temporal pathway suggest maturation of a system involved in processing of biological motion. **(b)** Activation of regions along the left superior temporal sulcus during the perception of biological motion by adult subjects [55]. **(c)** Developmental changes in the latency, recorded with electroencephalography, of the cortical response to the presentation of black-and-white photographs of faces (9–14 subjects per age group) [59].

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European Journal of Neuroscience
European Journal of Neuroscience, Vol. 29, pp. 1294–1301, 2009
doi:10.1111/j.1460-9568.2009.06674.x
COGNITIVE NEUROSCIENCE

Functional connectivity during a social emotion task in adolescents and in adults

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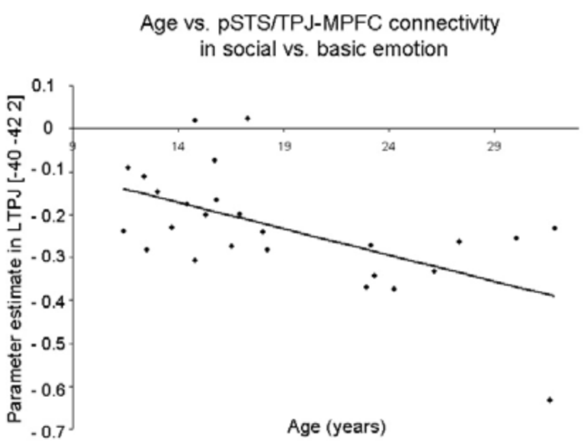


Negative correlation between age and left pSTS ⁄ TPJ–arMPFC connectivity during imagining scenarios resulting in social (embarrassment/guilt) relative to basic emotions (disgust/fear).

An interpretation of the age-related decrease in connectivity is that, in order to accomplish this task, adolescents require not only higher activity in arMPFC but also stronger co-activation of the mentalising system than do adults. This may be because the maturing network in adolescents is less efficient in accomplishing the task. Continuing synaptic elimination and axonal myelination and perhaps developing axonal calibre during adolescence, within regions of the brain involved in mentalising, may act to increase the efficiency of the system.

3. Decreased connectivity between PFC and limbic system

"The interplay between cognitive and emotion-related processes" – social cognition

Important for…
- Peer-peer interactions
- Processing of verbal and non-verbal cues (processing biological motion)
- Discrimination of facial expressions
- Attentional enhancement of the neural response to socially salient stimuli

E.g. maturation of the adolescent's ability to extract quickly the relevant cues from the face of a peer

Two things are happening as age increase during adolescence:
1) The neural systems involved in social information processing are becoming more efficient
2) The influence of the affective systems on the decision-making systems is decreasing

Impact of social environment

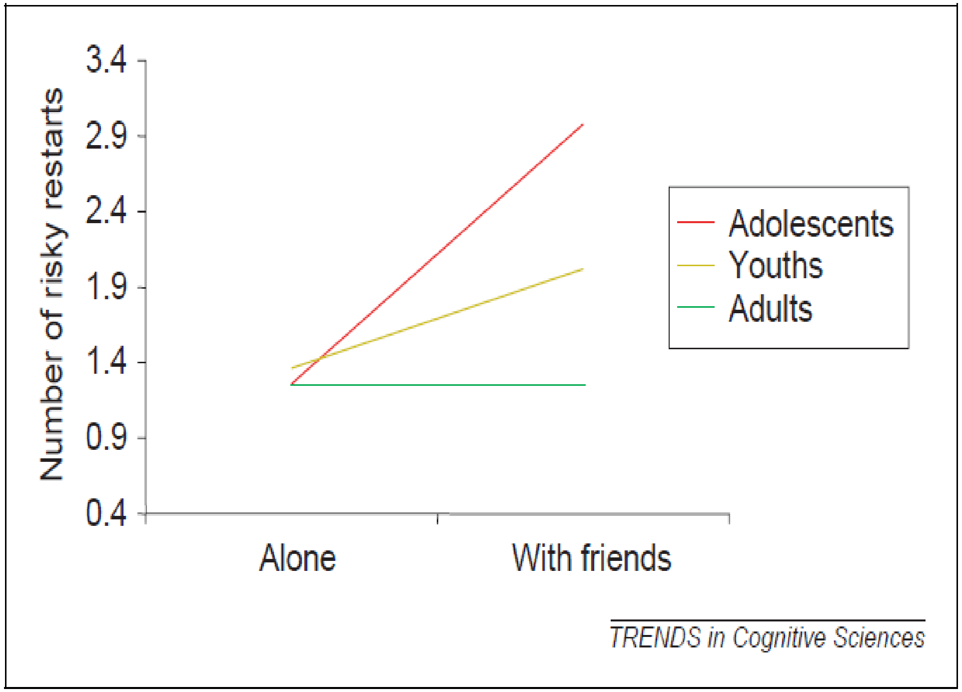
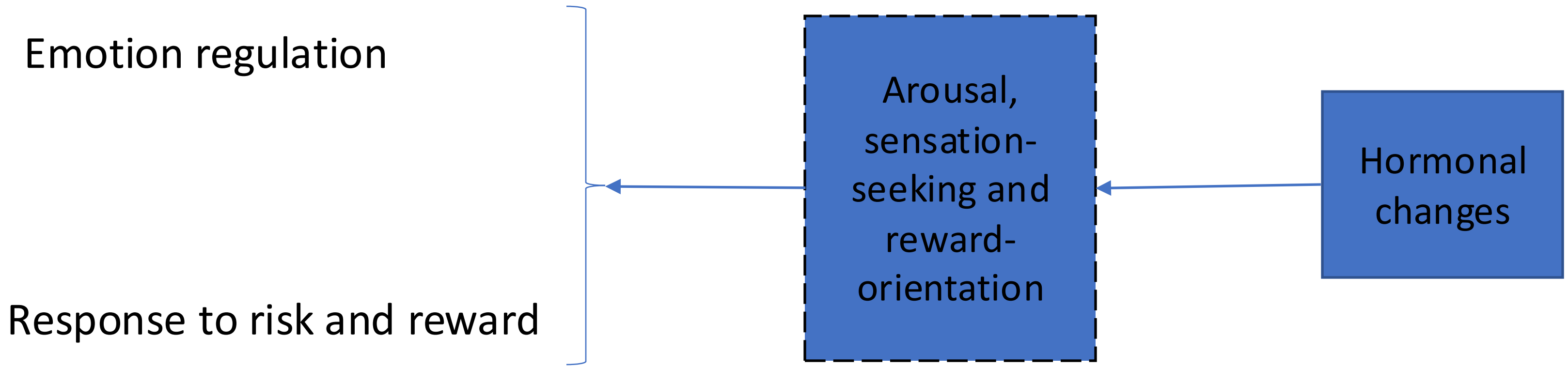


Figure 2. In a study designed to investigate age differences in risk-taking [37], participants were asked to play a computerized game in which they had opportunities to take driving risks, such as continuing to drive after a traffic light had turned yellow in order to drive the car further and earn more points. Individuals were randomly assigned to one of two conditions: playing the game alone, or playing it while two friends were watching and giving advice. The graph shows the number of times individuals risked crashing the car by stopping and then restarting it to try to drive a bit further after the yellow light had appeared. Adolescents (aged 13–16), youths (aged 18–22), and adults (aged 24 and older) demonstrated equivalent degrees of risk-taking when alone, but in the presence of peers, adolescents and youths, but not adults, took more risks.

Socio-emotional changes in adolescence



- Changes in frequency of parent-adolescent conflict more closely linked to pubertal maturation than to age
- In a large group of 11-14 year olds, there was no significant correlation between age and sensation-seeking, but a significant correlation between sensation-seeking and pubertal stage
- There is substantial evidence that adolescents engage in dangerous activities ***despite*** knowing and understanding the risks involved

Effects of estrogen and testosterone on the brain

Organisation:
- Occur pre- and perinatally
- In males, testosterone influences the development of neural circuits
- The absence of testosterone results in a female neural phenotype

Activation:
- Occur at puberty
- Gonadal steroid hormones (estrogen and testosterone) act on dormant neural circuits to elicit adult reproductive behaviours, in context.

The development of regulatory competence

During adolescence, regulatory systems are gradually brought under the control of central executive functions

INTERFACE OF COGNITION AND EMOTION

1. The development of an integrated and consciously controlled “executive suite” of regulatory capacities is a complex and lengthy process. Yet, adolescents confront major, emotion-laden life dilemmas from a relatively early age. E.g. sexual relationships, school assessments

2. Cognitive development (e.g. executive control) generally occurs later than puberty-linked emotional changes

As puberty gets earlier and the gap widens, are future generations of adolescents at greater risk of poor outcomes and psychopathology typical of externalising problems?

POWERFUL ENGINE BUT AN UNLICENCED DRIVER

Why is adolescence so hard?

Layers of changes: physically, cognitively, emotionally

Different rates of change: chronologically versus hormone-linked, cognitively versus emotionally, from peers, from the environment, from society

While all this happens you look like a small adult – and sometimes behave like one too!