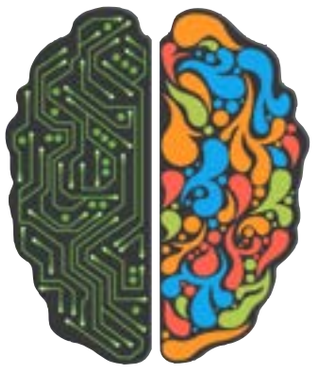
Football and

The Teenage Brain



Colin Higgs, Ph.D.

March 5, 2016: Guelph, Ontario

The most complex 2 Kg in the known universe

At 4 weeks post-conception, neurons are being formed at a rate of 250,000

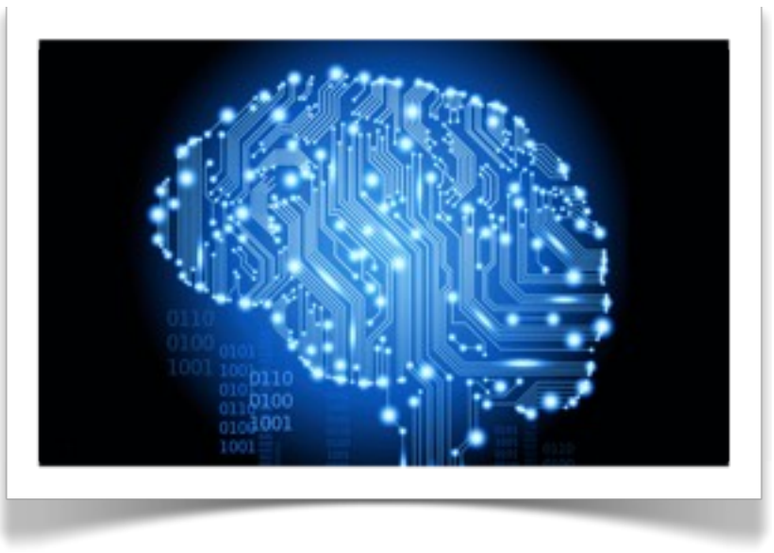
per minute

Contains 100 billion neurons

90% of adult size by age 9

Caveat emptor

- I'm not a "brain" expert.
- This is a rapidly changing field - with new discoveries every day.
- While the science is solid - the implications of the science are less so.
- This is about what happens in general - not what happens to specific individuals.



What do we know?

Teenagers

Hang-out with peers

Take risks

Talk-back

Drink, smoke, take drugs

Sleep in

Make bad decisions

Are difficult to get to school

Engage in risky
sexual behaviour

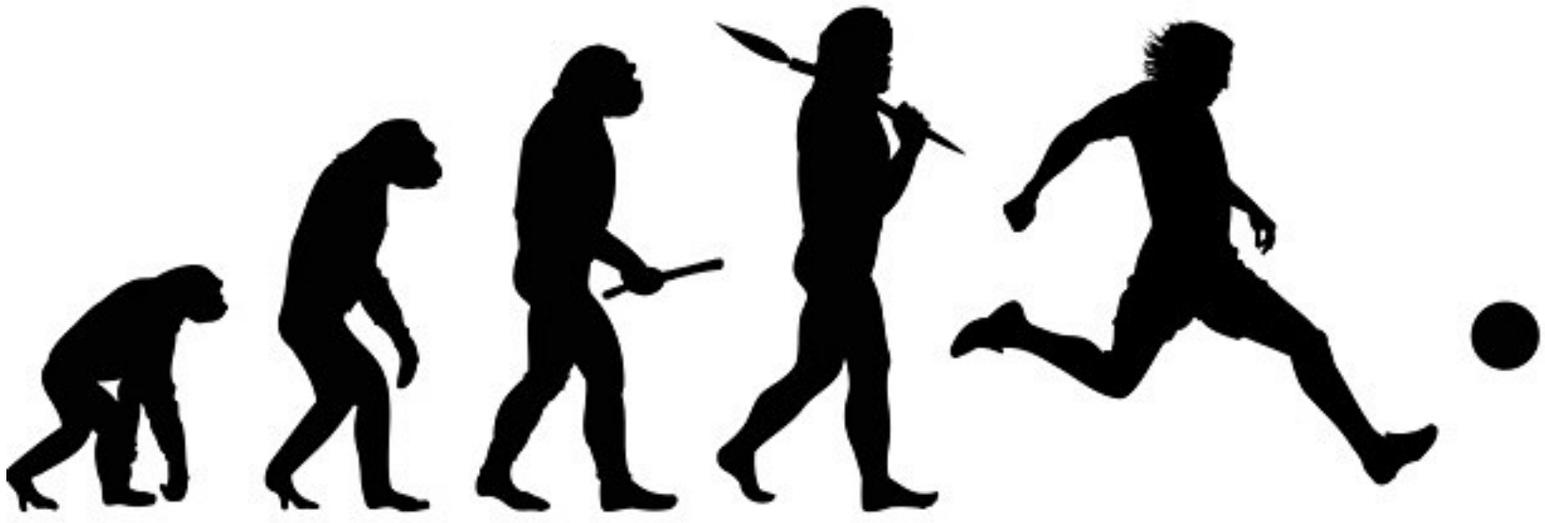
New thinking

When a baby can't walk - we don't think of them as "defective"

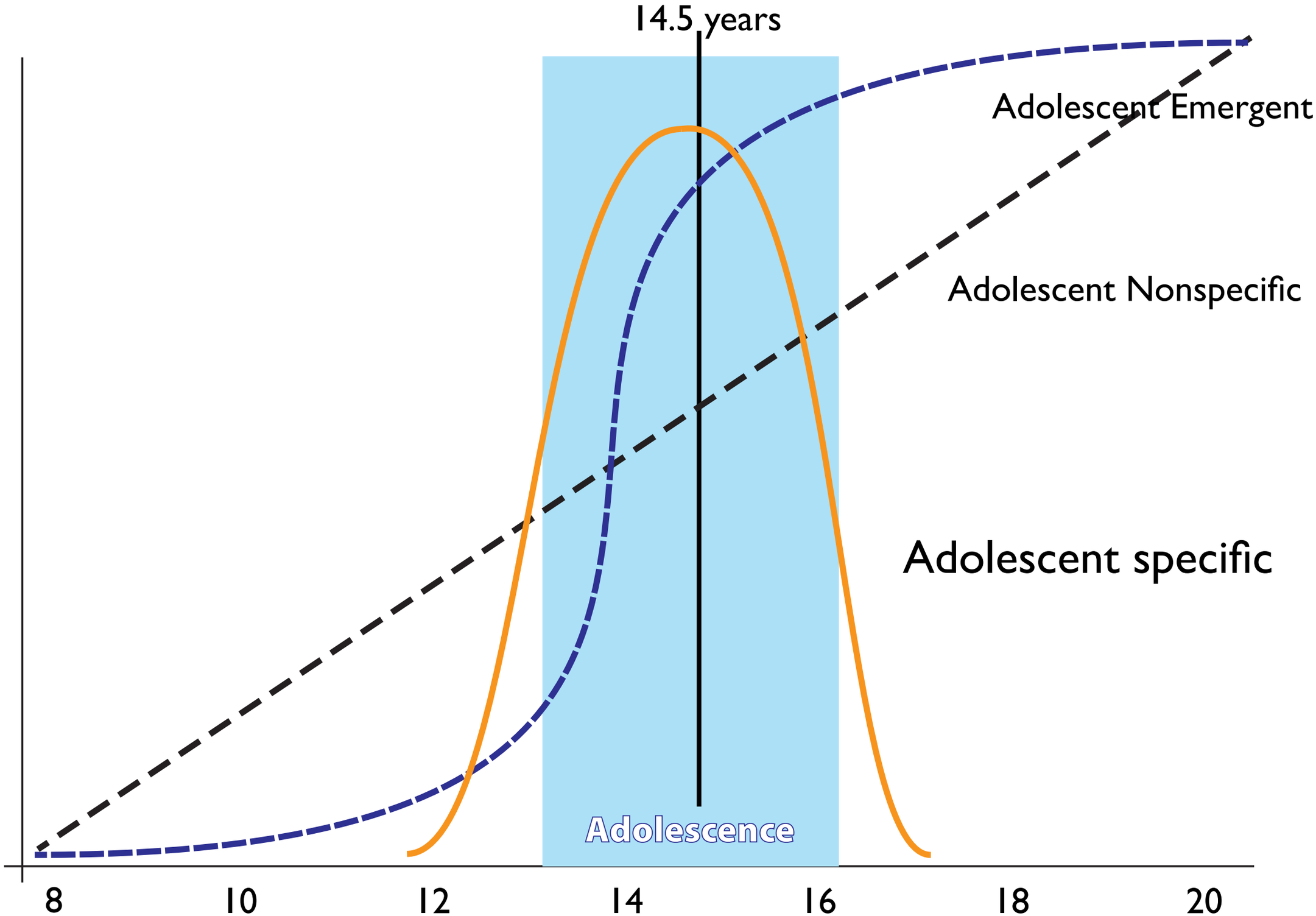
The "negative aspects" of adolescent decision making are perhaps **NECESSARY** for passage into adulthood.

Evolutionary perspective

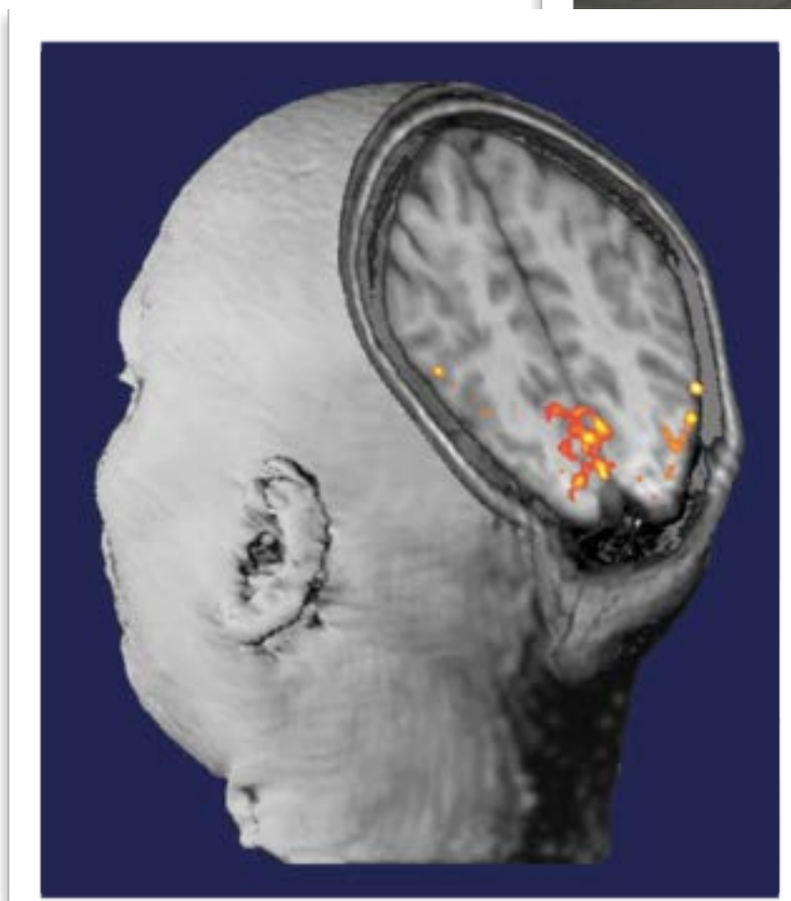
- To become adults
  - Need to break the bond with parents - become independent.
  - Find reproductive partners.
  - Live in a much wider "world".
- Adolescent behaviour is "**good for those who survive!**"



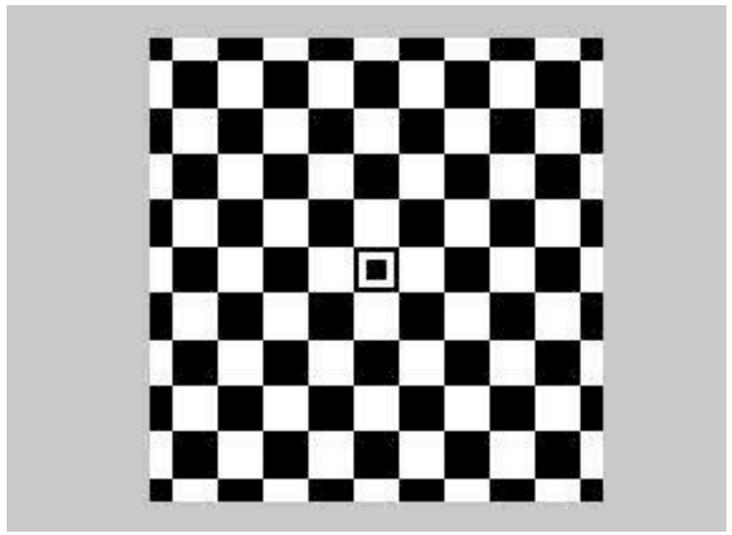
Three types of brain development

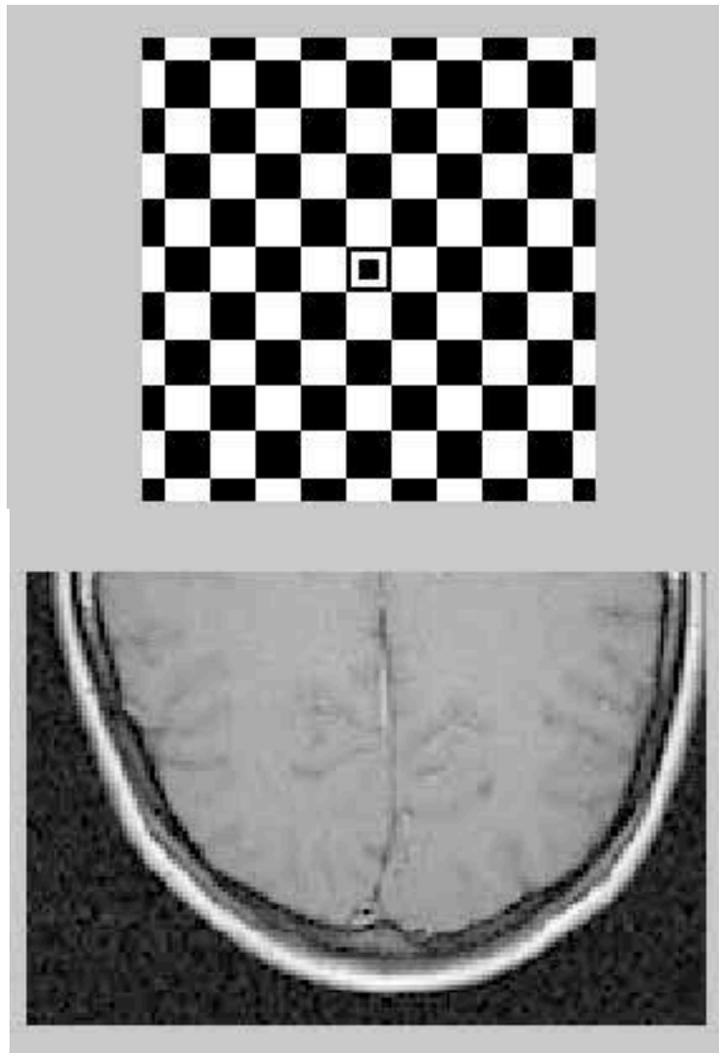


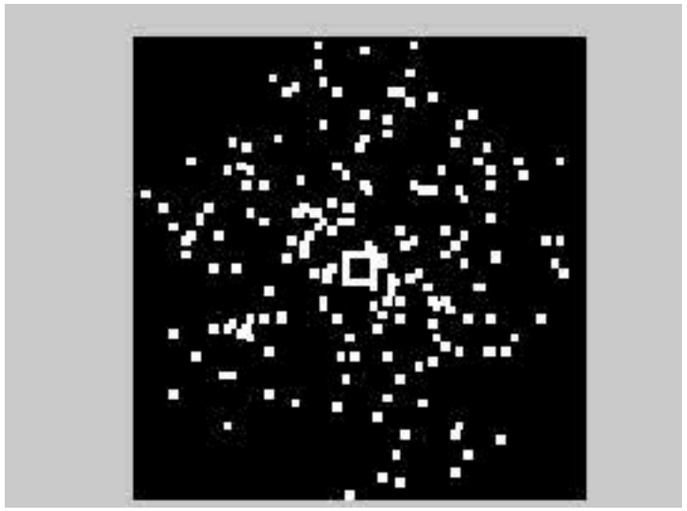
Learning about what happens in the brain.

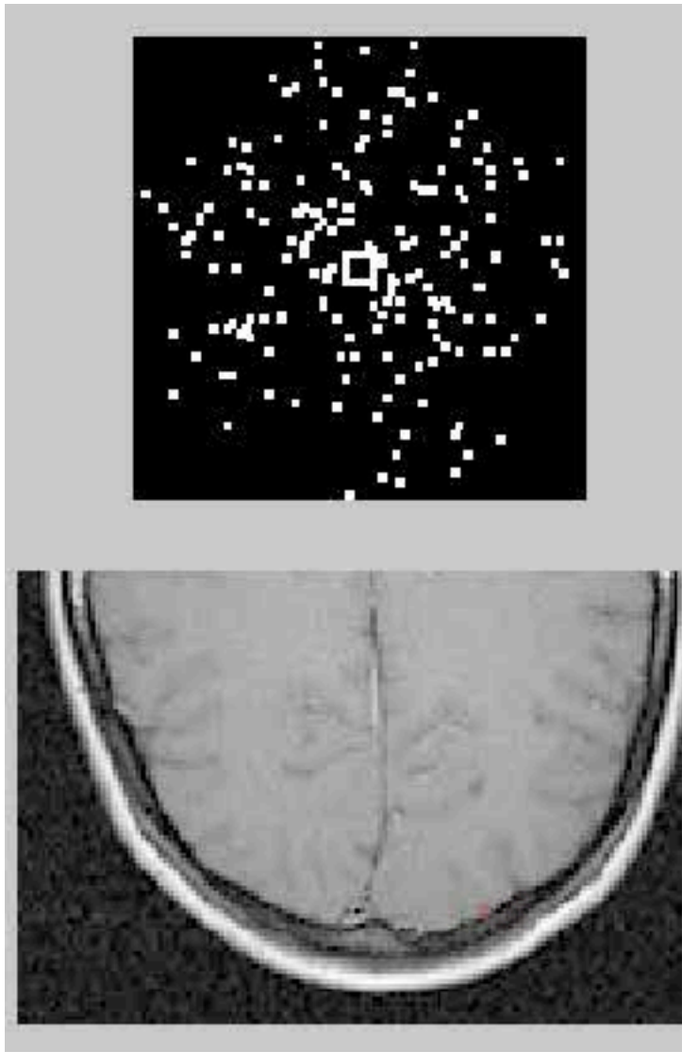


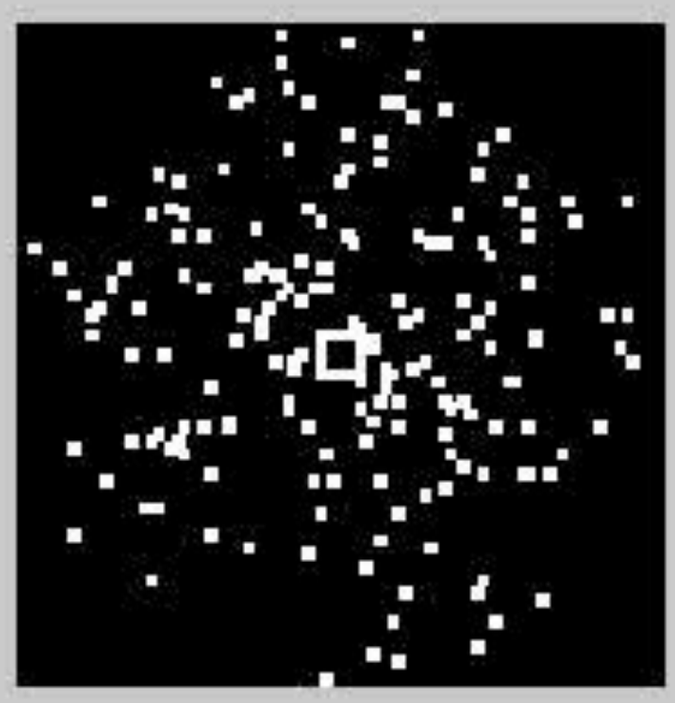
fMRI

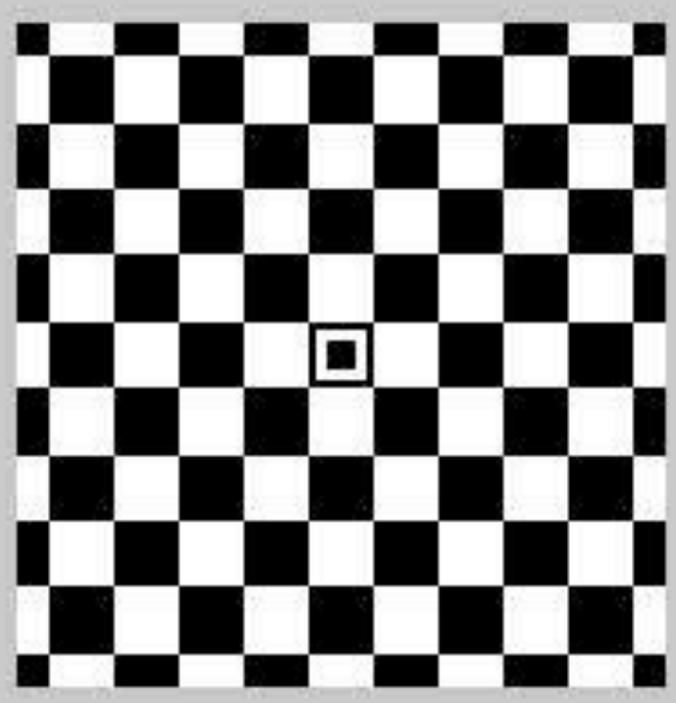


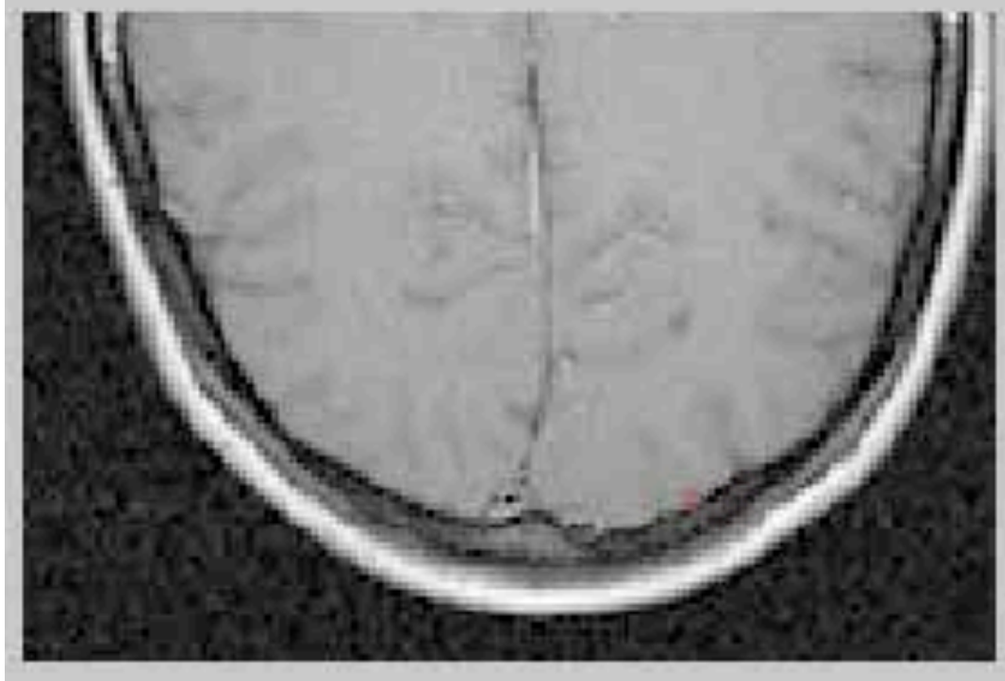


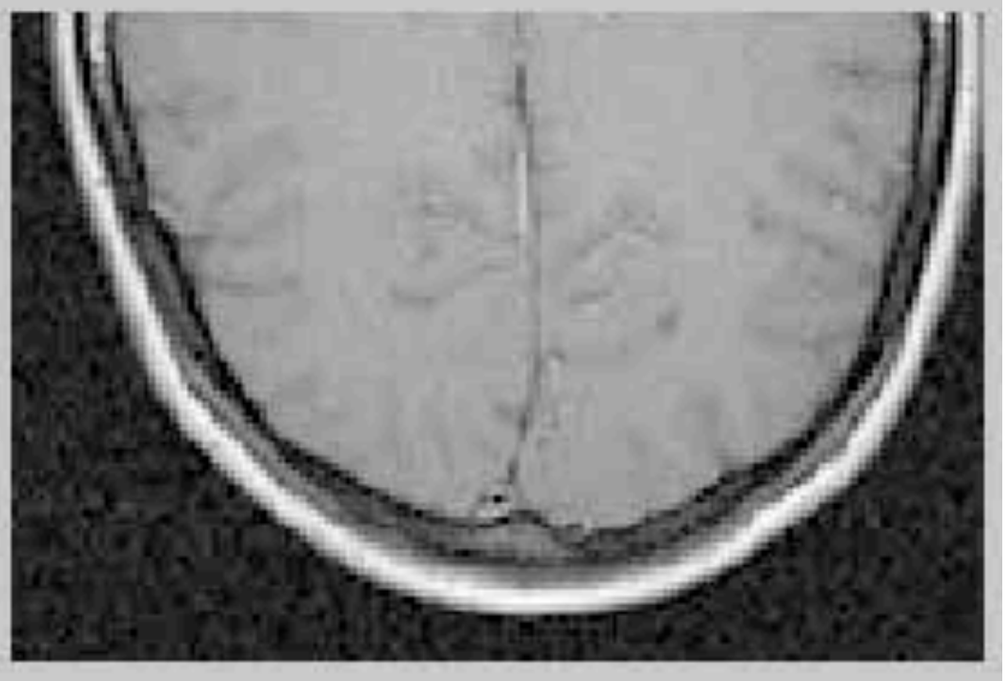


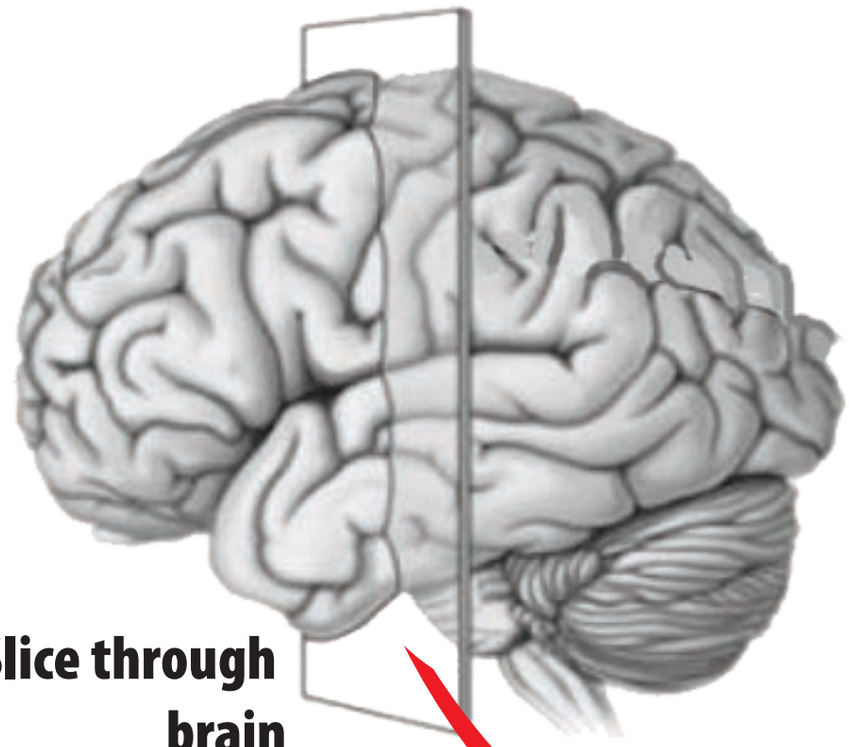








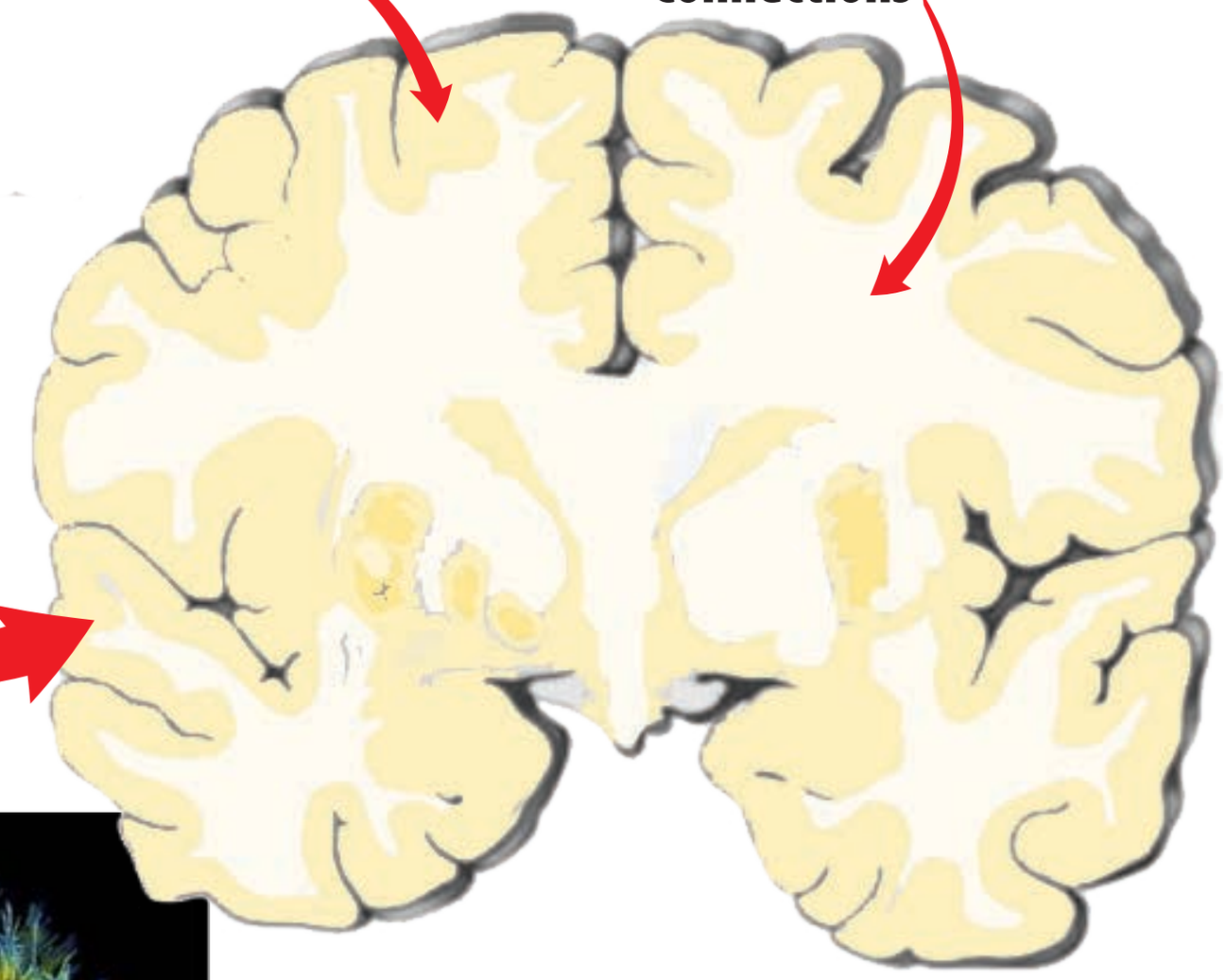


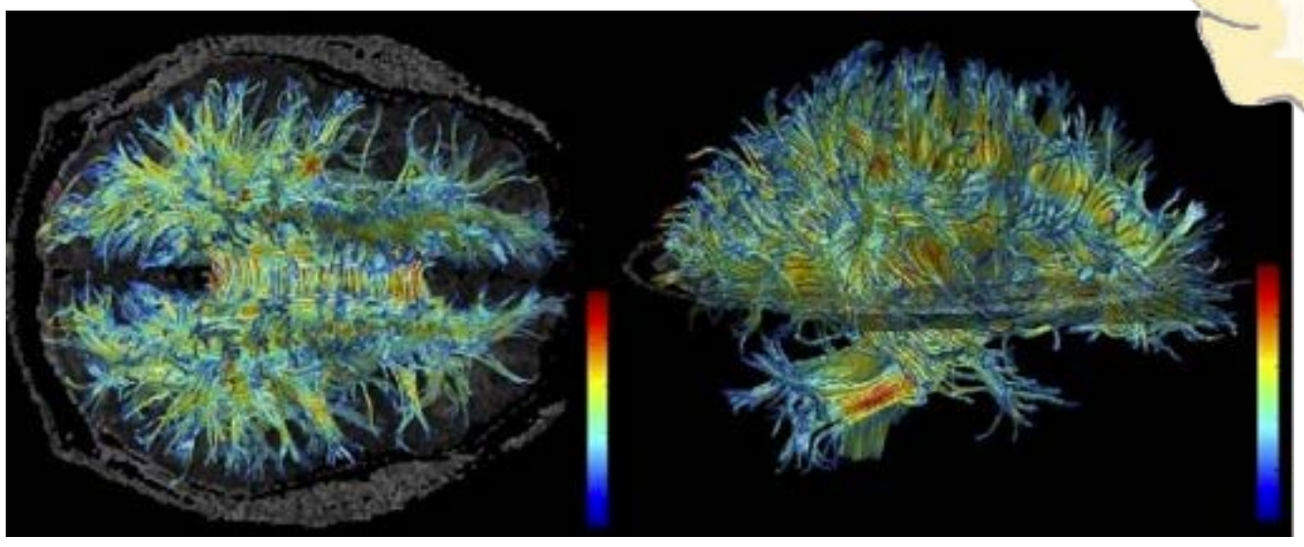


Slice through brain

Grey matter active cells

White matter Connections





Grey and white matter

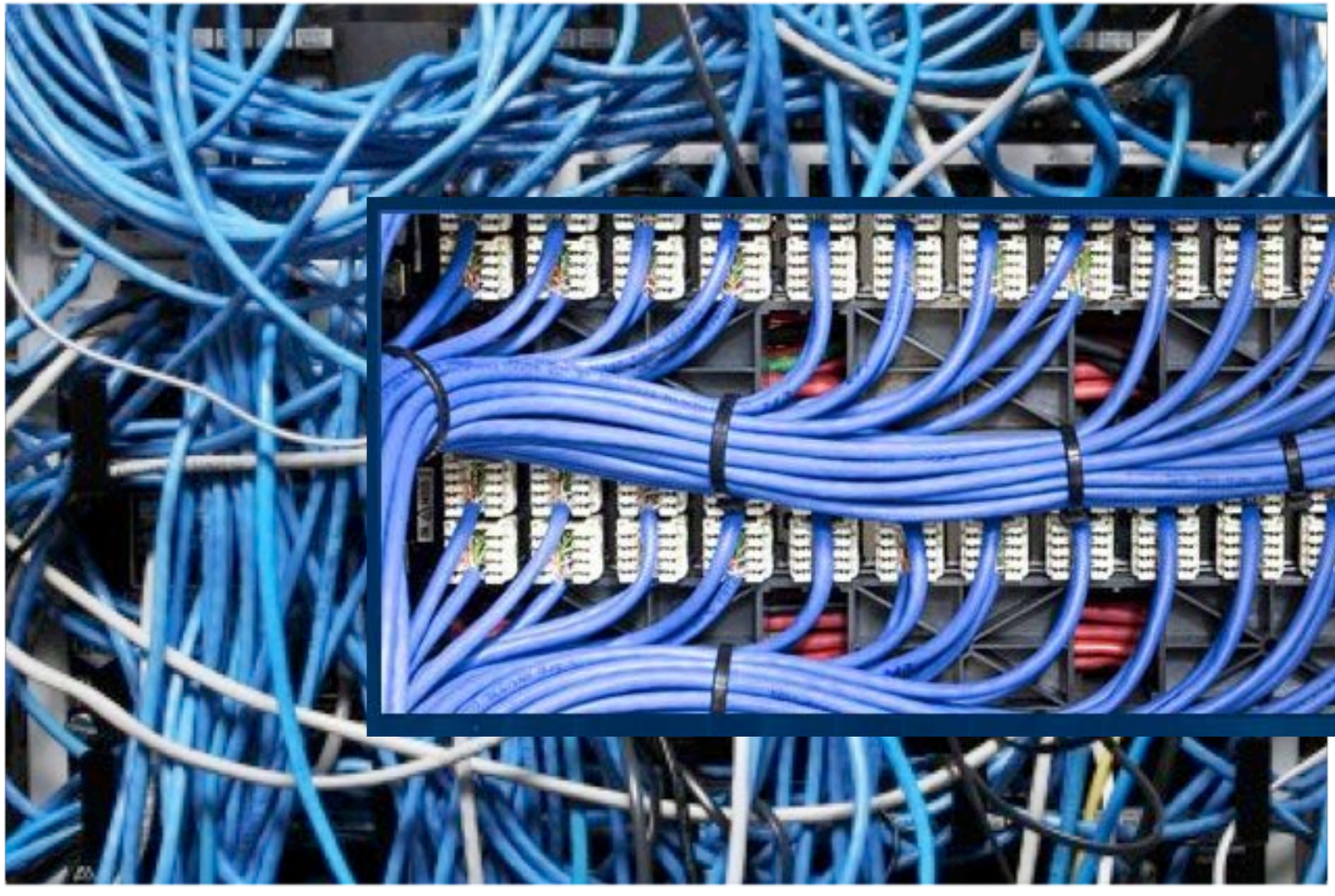
Colour	Contains	Purpose
Grey	Brain cells	"Thinking"
White	Myelin	Connecting

Physical activity associated with higher white matter integrity in 9-10 year olds. PLUS a thinning of grey matter.

"The Role of Aerobic Fitness in Cortical Thickness and Mathematics Achievement in Preadolescent Children) *PLOS ONE*.

What does this mean?

From



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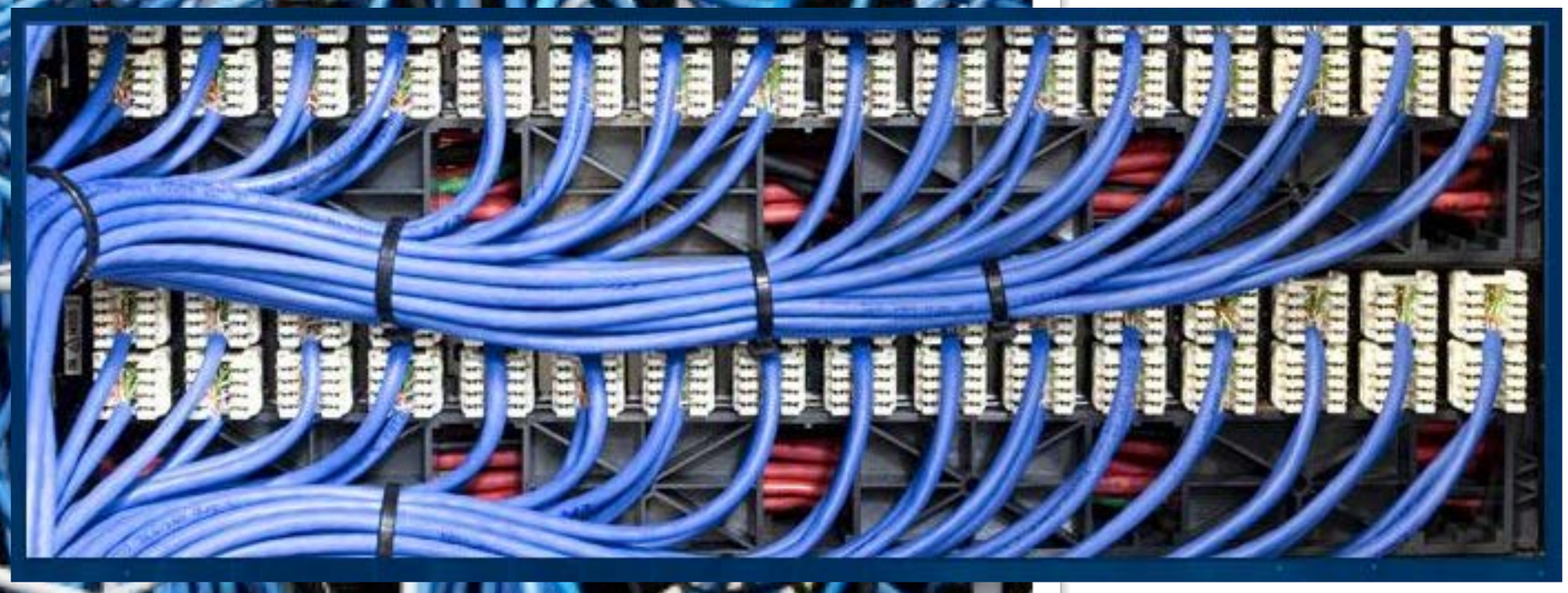
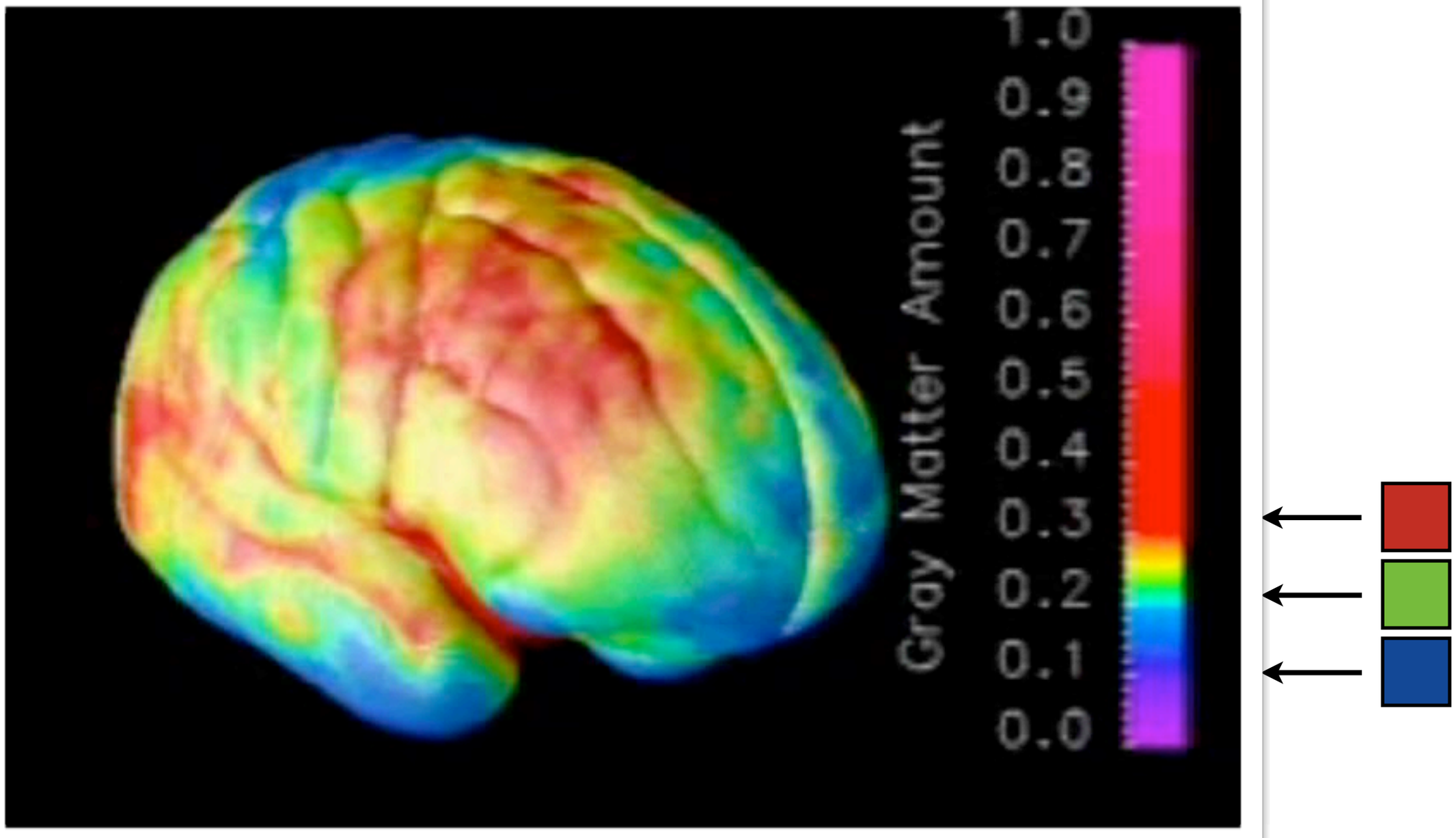


Pruning and consolidating



Environment

Pr e

Increase

Early

Mid

Decrease

Late

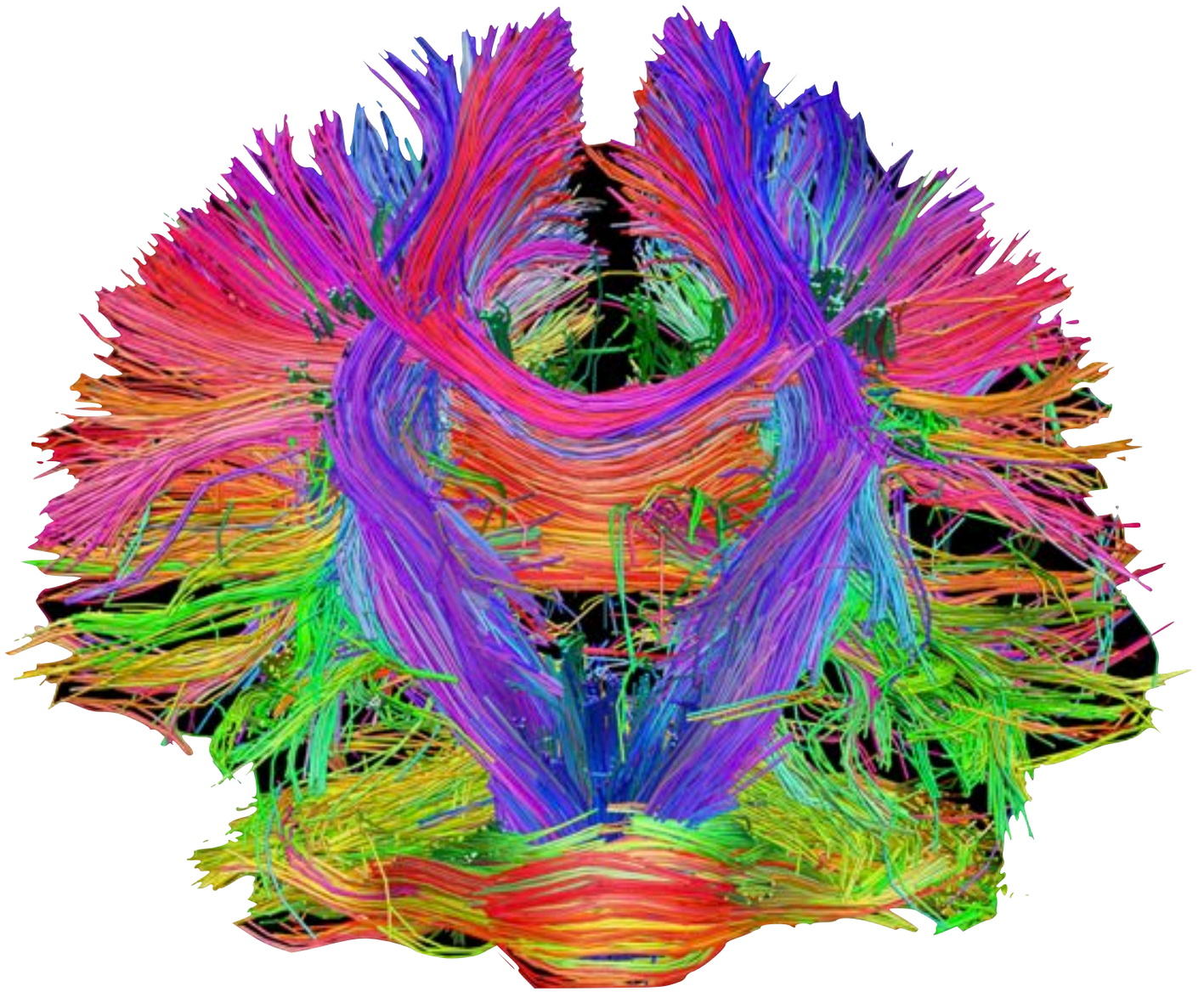
Genetics

Football Implications

- Keep as many brain circuits as possible because if the are not used: then pruned.
  - Maintain wide variety of activities outside football (even though they are not pursued for H.P.)
  - Time for many different skills and drills and opportunities for creativity
  - Not a good time to be overly specialized - NOT same drills all the time!

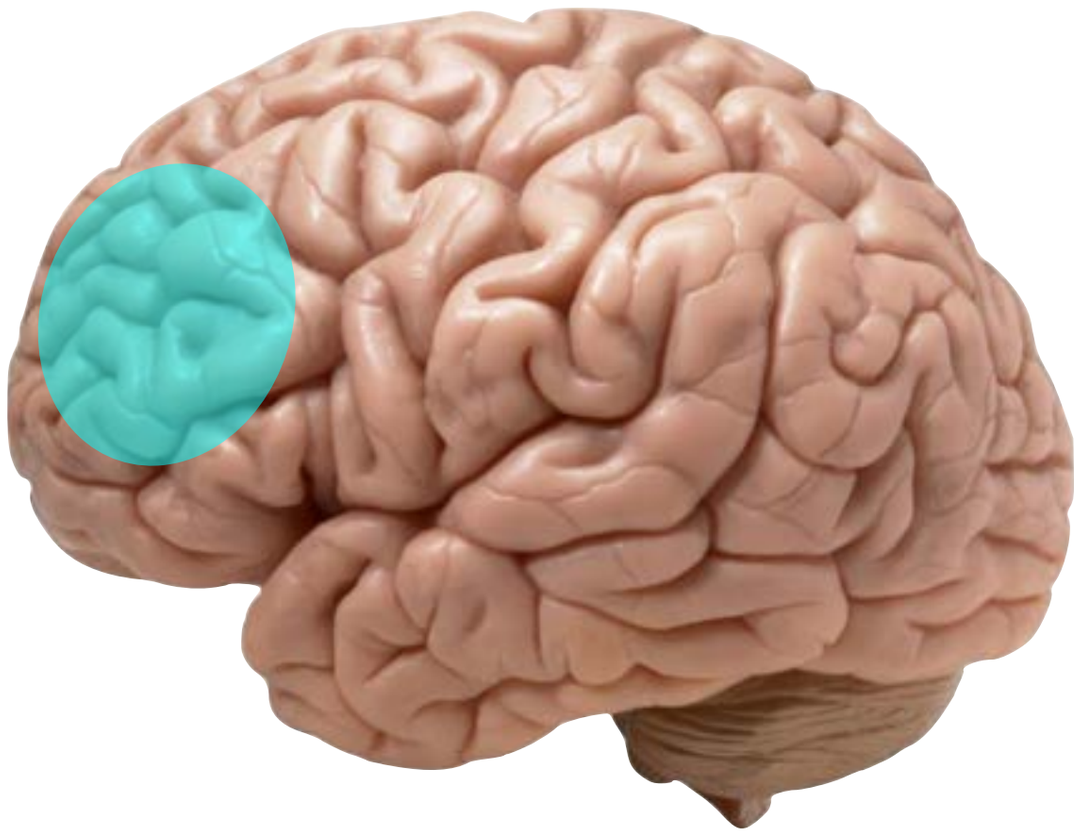
Wiring in the teenage brain

- Four areas of major concern
  - Pre-Frontal Cortex
  - Amygdala
  - Striatum
  - Corpus Callosum



Prefrontal Cortex

- Executive function
- Logical thought, prediction of consequences
- Analysis of risk



Executive Function

- Self regulation: Inhibition control
- Working memory
- Cognitive flexibility

Working Memory

- The capacity to hold and work with multiple bits of information at the same time.

Keeping track of all the aircraft

Sport for Life

Working Memory Sport

Sport for Life

Cognitive flexibility

- Ability to switch easily and quickly between different ways of thinking - seeing things from a different perspective, or adapting behaviour

Focus on screen (inside) then outside

Cognitive flexibility in sport

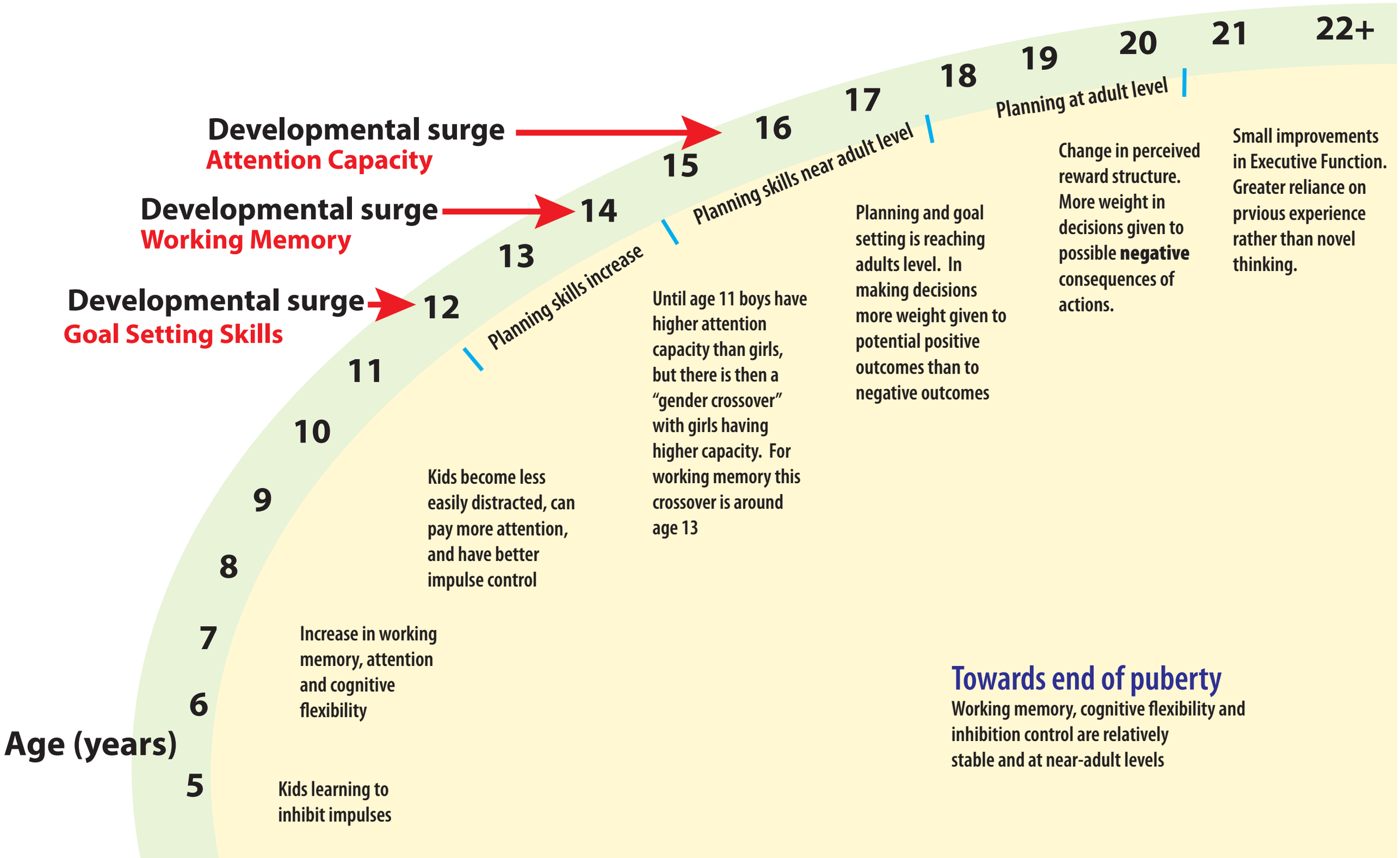
- Internal focus - body position during shot preparation then external focus - "where is the goalie?"

Inhibition control

- Ability to interrupt an automated response, control the body, and resist distractions - to do what is best in the long-run.

Sport for Life

Inhibition control in Sport

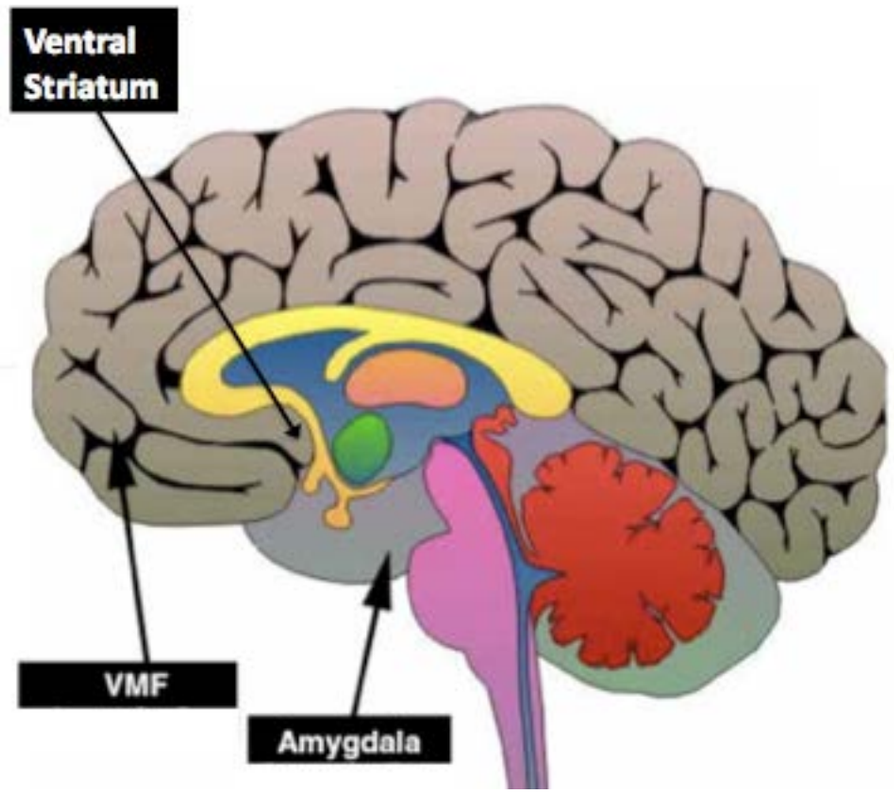

Developmental surge
Attention Capacity
Developmental surge
Working Memory
Developmental surge
Goal Setting Skills
Age (years)
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22+
Planning skills increase
Planning skills near adult level
Planning at adult level
Kids learning to inhibit impulses
Increase in working memory, attention and cognitive flexibility
Kids become less easily distracted, can pay more attention, and have better impulse control
Until age 11 boys have higher attention capacity than girls, but there is then a "gender crossover" with girls having higher capacity. For working memory this crossover is around age 13
Planning and goal setting is reaching adults level. In making decisions more weight given to potential positive outcomes than to negative outcomes
Change in perceived reward structure. More weight in decisions given to possible negative consequences of actions.
Small improvements in Executive Function. Greater reliance on prvious experience rather than novel thinking.
Towards end of puberty
Working memory, cognitive flexibility and inhibition control are relatively stable and at near-adult levels

Teen Decision Making

- No difference in risk assessment between adults and teens.
- So why do teens make bad decisions?

Teen decision making

- Running red lights
  - Alone - same as adults
  - With friends - take higher risks



Teen - Adult Differences

Run Red light - Save time!

Driving Alone

Driving with Friends

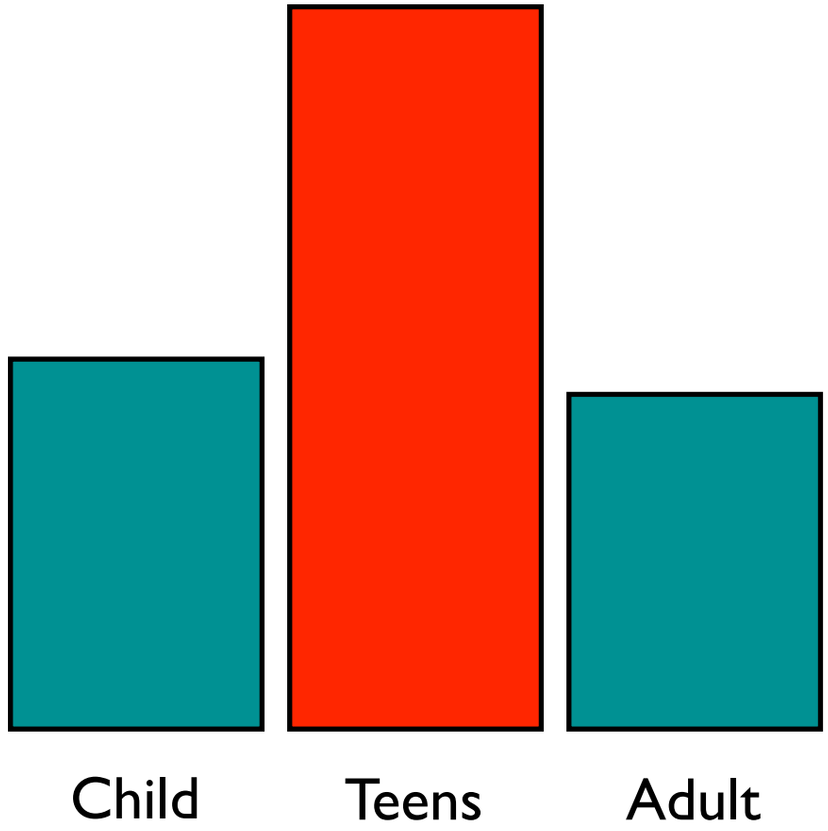
Summary of risk taking

- Teens assess risk the same as adults (in both cases overestimate negative consequences), but
- In presence of peers their brains generate higher levels of reward chemicals (dopamine) for success.

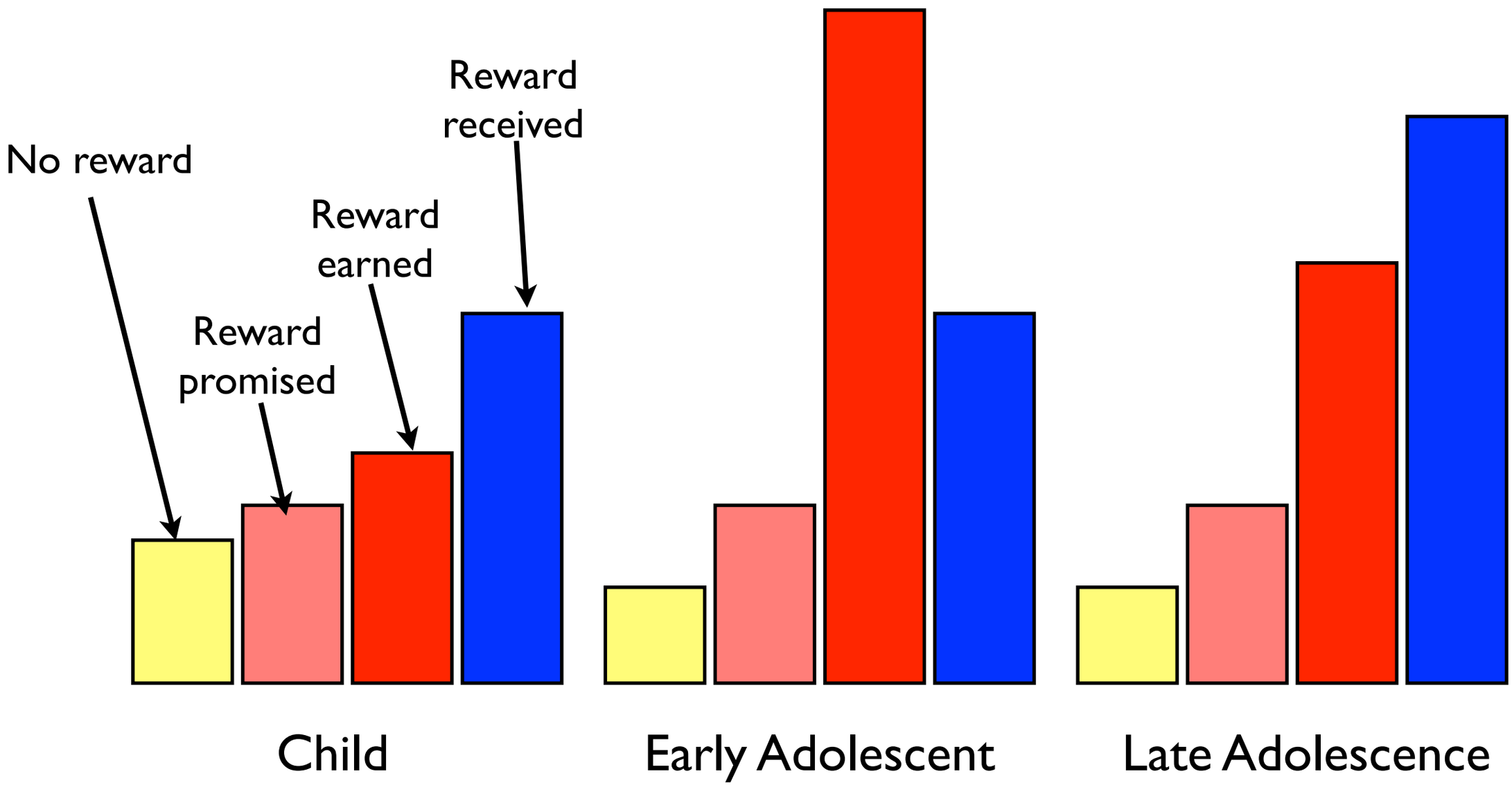
Football Implications

- If you want to stamp out a particular behaviour
  - Find ways to reduce the "reward"(especially from peers) for successful high-risk tactical or strategic decisions.
- Don't focus on the risks associated with particular actions - teens already "get it"

Stimulus response of teens



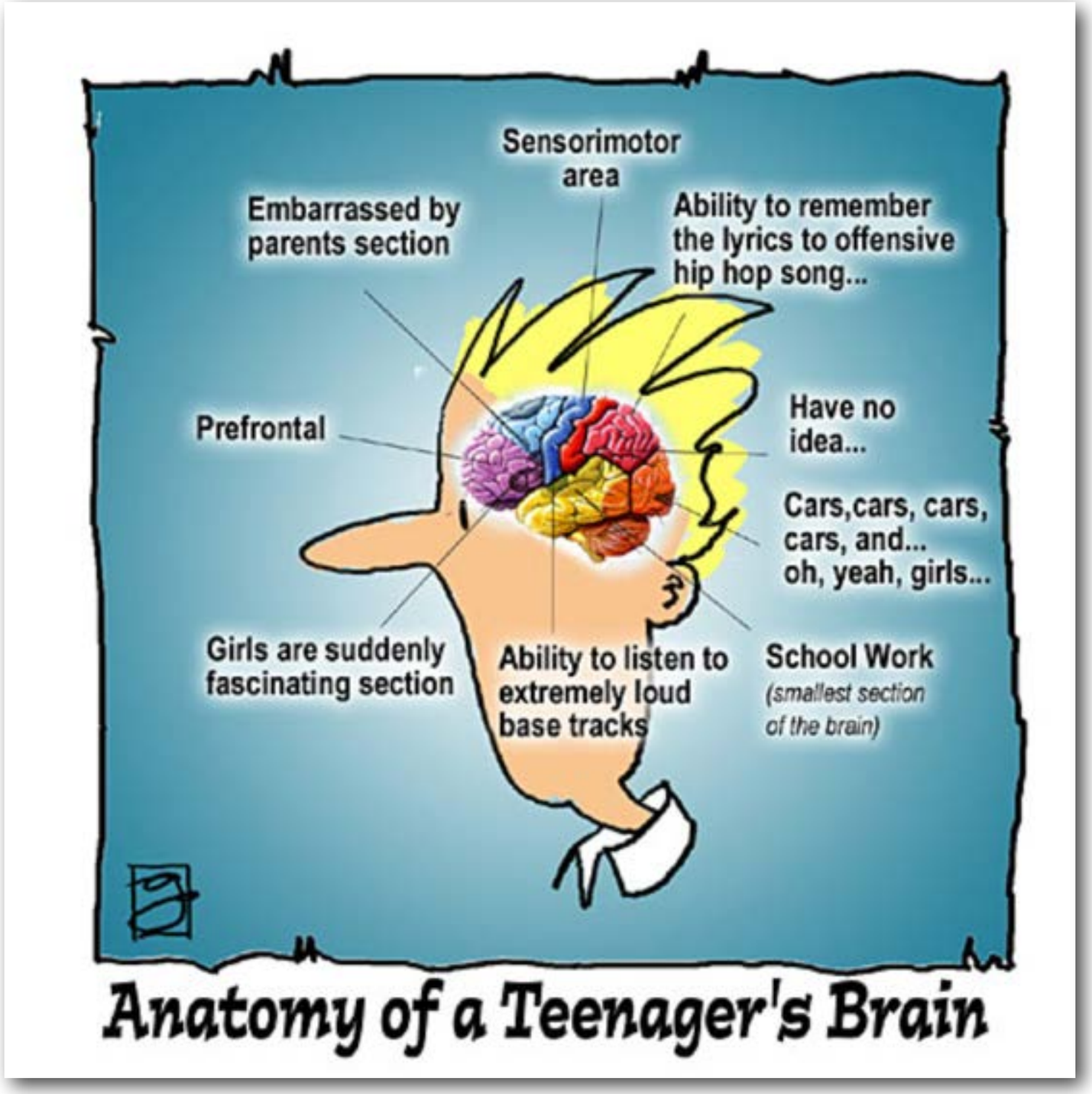
Reward Response



Football - Implications

- Focus on the EARNING of rewards for early teens, and
- Focus on the RECEIVING of rewards for late teens
- Rewards to individuals that are MEANINGFUL to **peers** are important

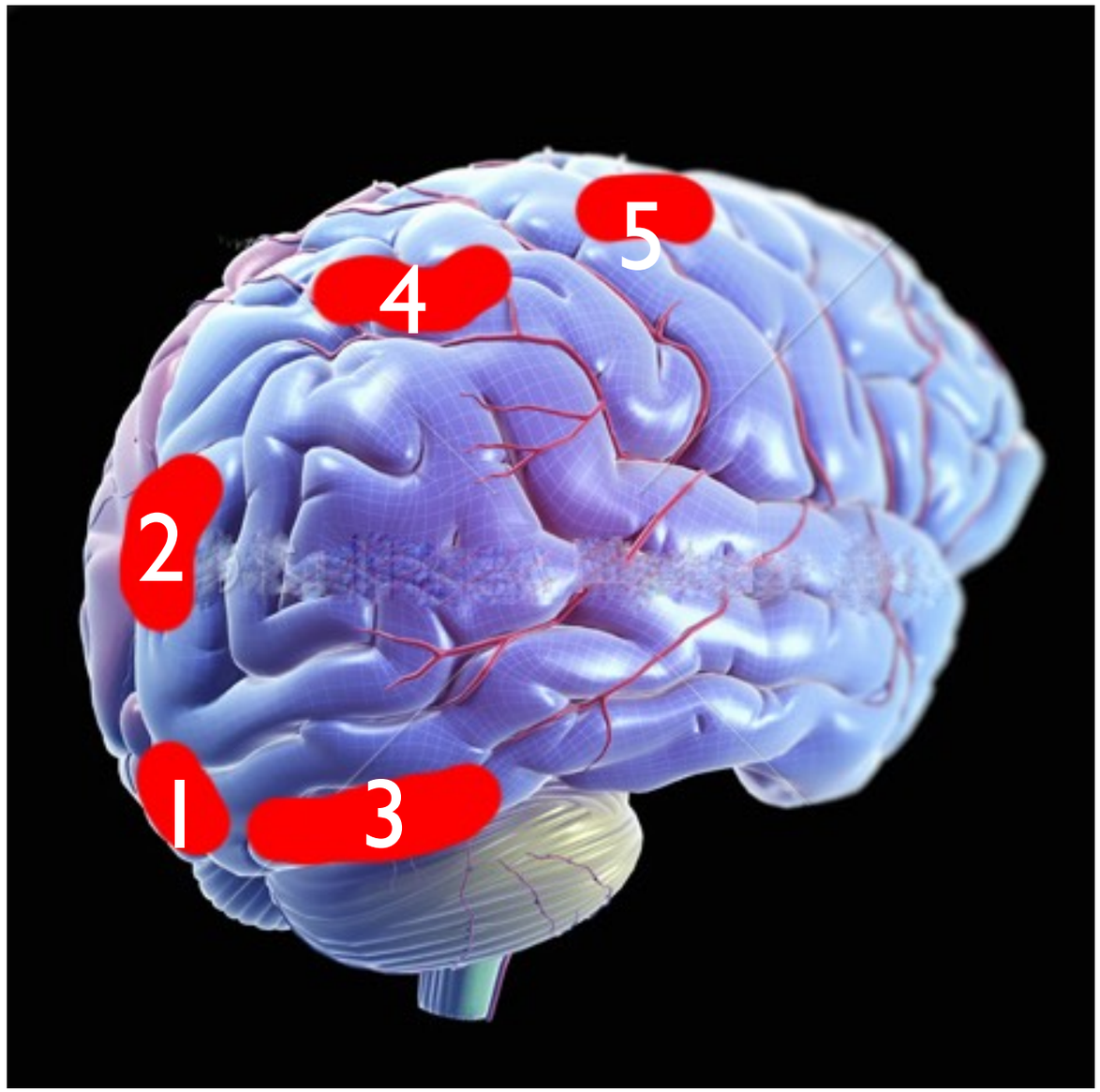
Gender differences



Brain areas: fMRI activity during math

Active brain area: Males

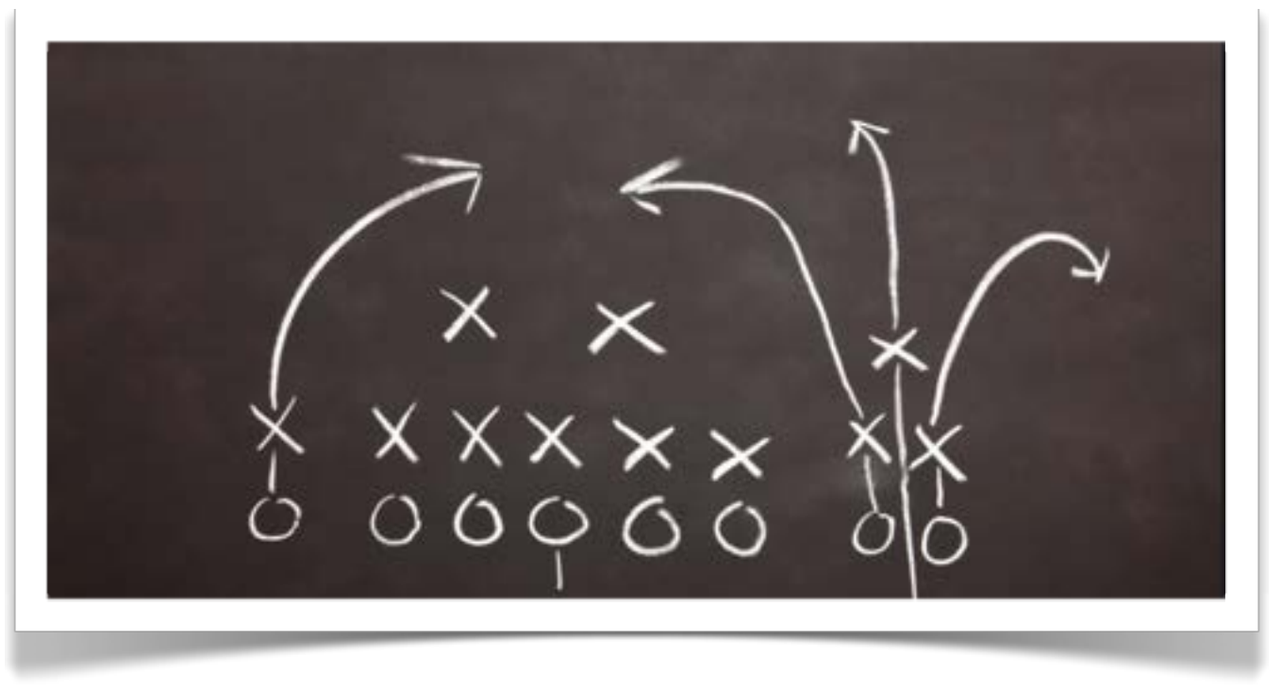
Active brain area: Females



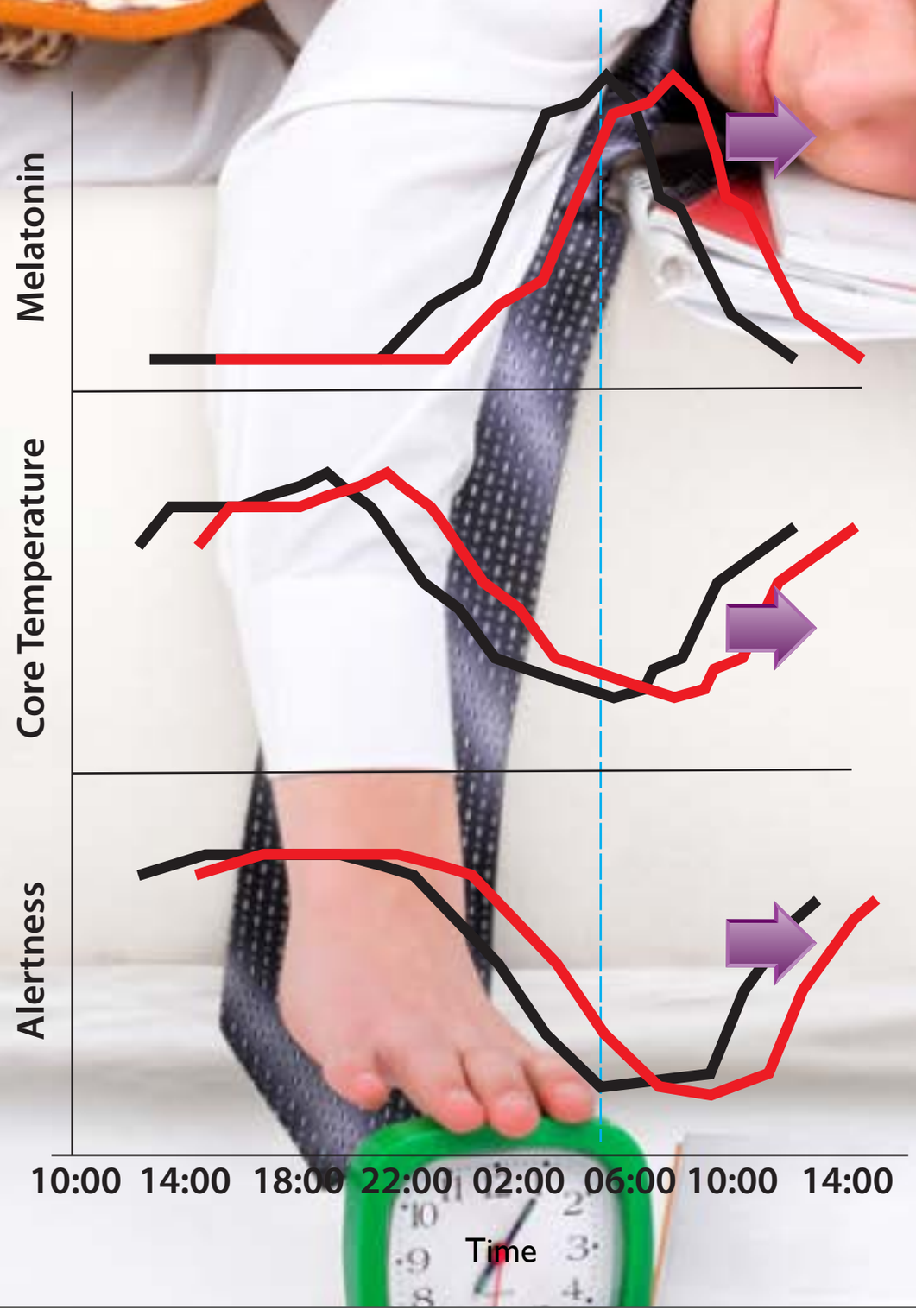
Different - not better or worse

Football Implications

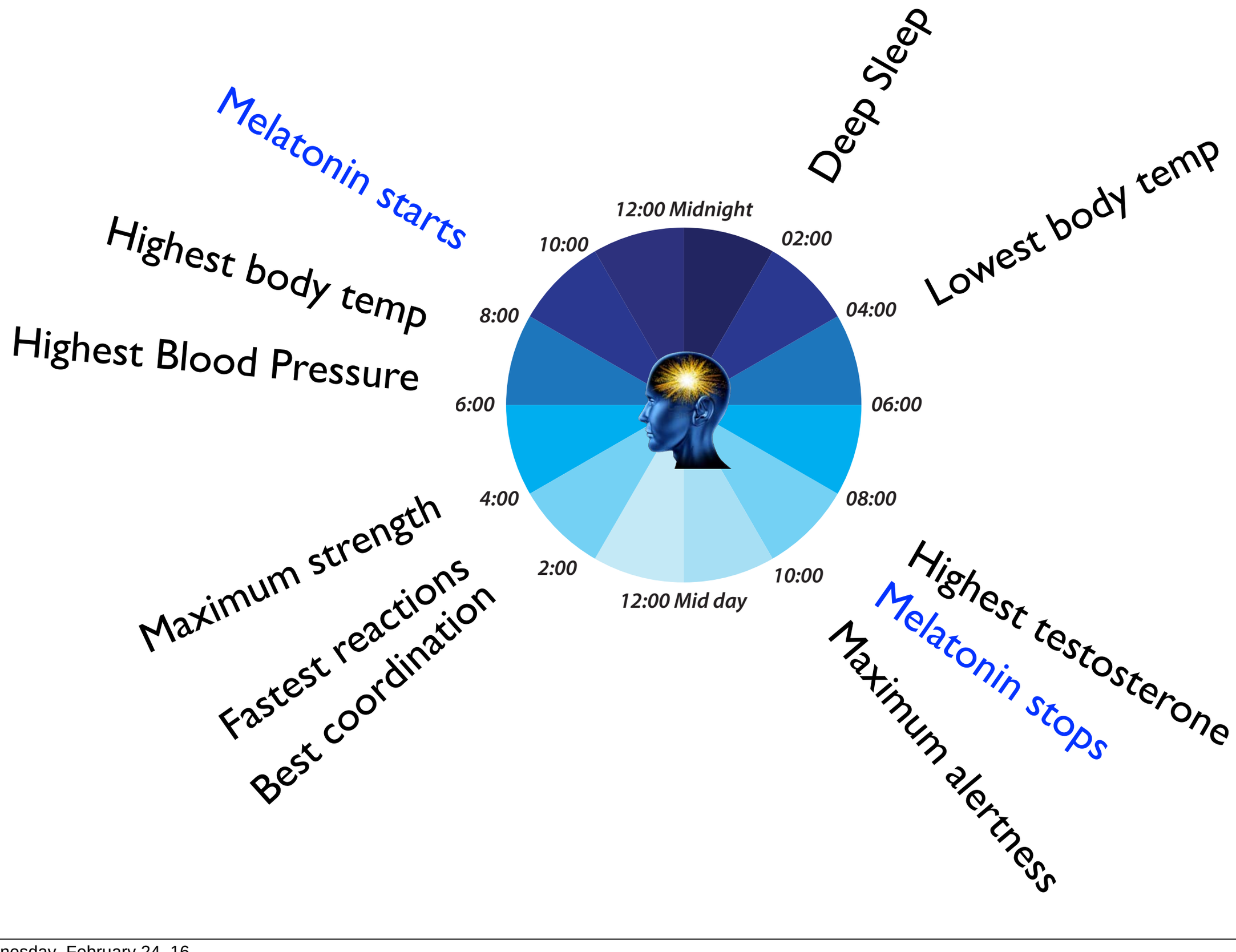
- DON'T KNOW - but we do know this is likely to mean gender-different processing of spatial information
- May impact how we **should** teach tactics and strategy.



Teens and sleep



In adults


Melatonin starts
Deep Sleep
Lowest body temp
Highest body temp
Highest Blood Pressure
12:00 Midnight
02:00
04:00
06:00
08:00
10:00
12:00 Mid day
2:00
4:00
6:00
8:00
Maximum strength
Fastest reactions
Best coordination
Highest testosterone
Melatonin stops
Maximum alertness

Pushed back by two hours

Deep Sleep

Lowest body temp

Highest testosterone

Melatonin stops

Maximum alertness

Highest body temp

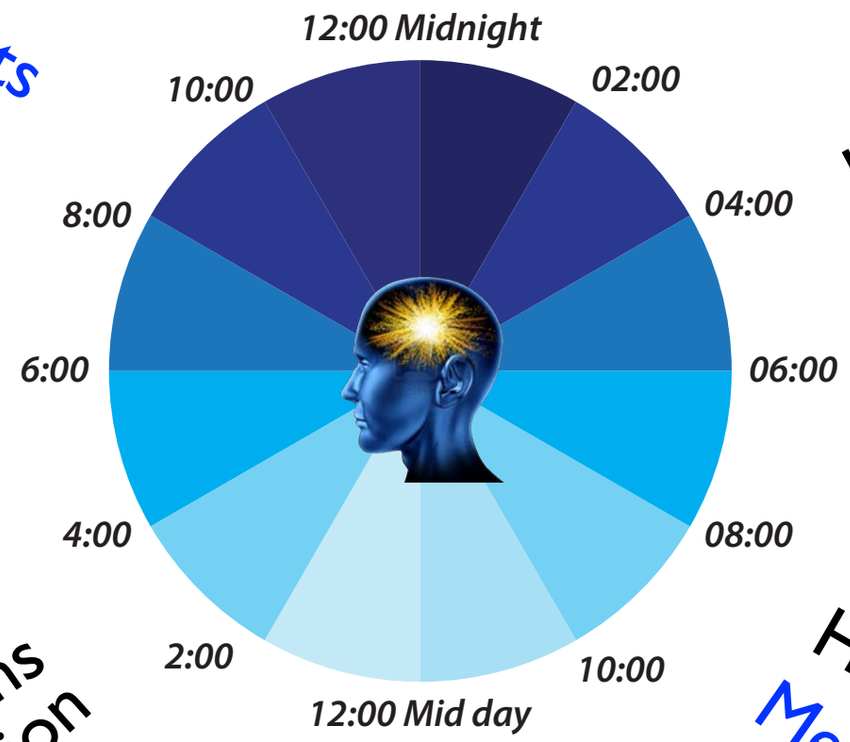
Highest Blood Pressure

Melatonin starts

Maximum strength

Fastest reactions

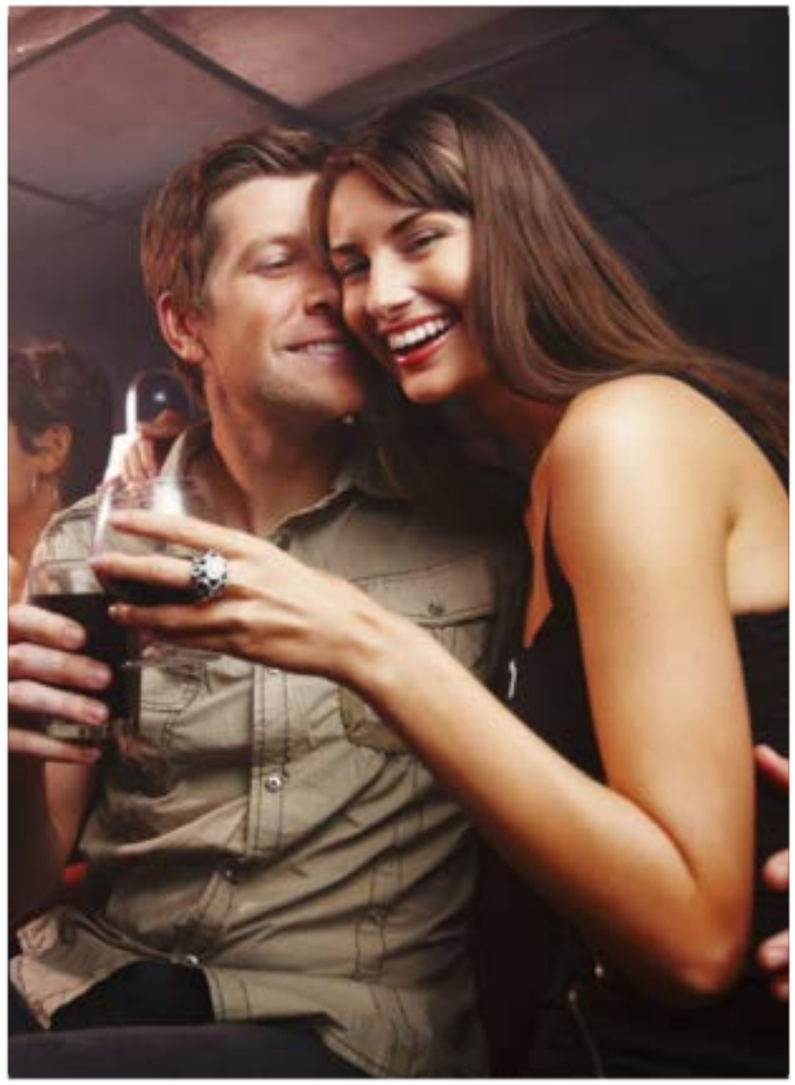
Best coordination



In adolescents

Circadian shift

- No clear reason why.
- Possible explanations
  - Unintended consequence of other hormonal changes of adolescence.
  - Evolutionary change to extend time for sexual activity.
  - Phase shift from children.

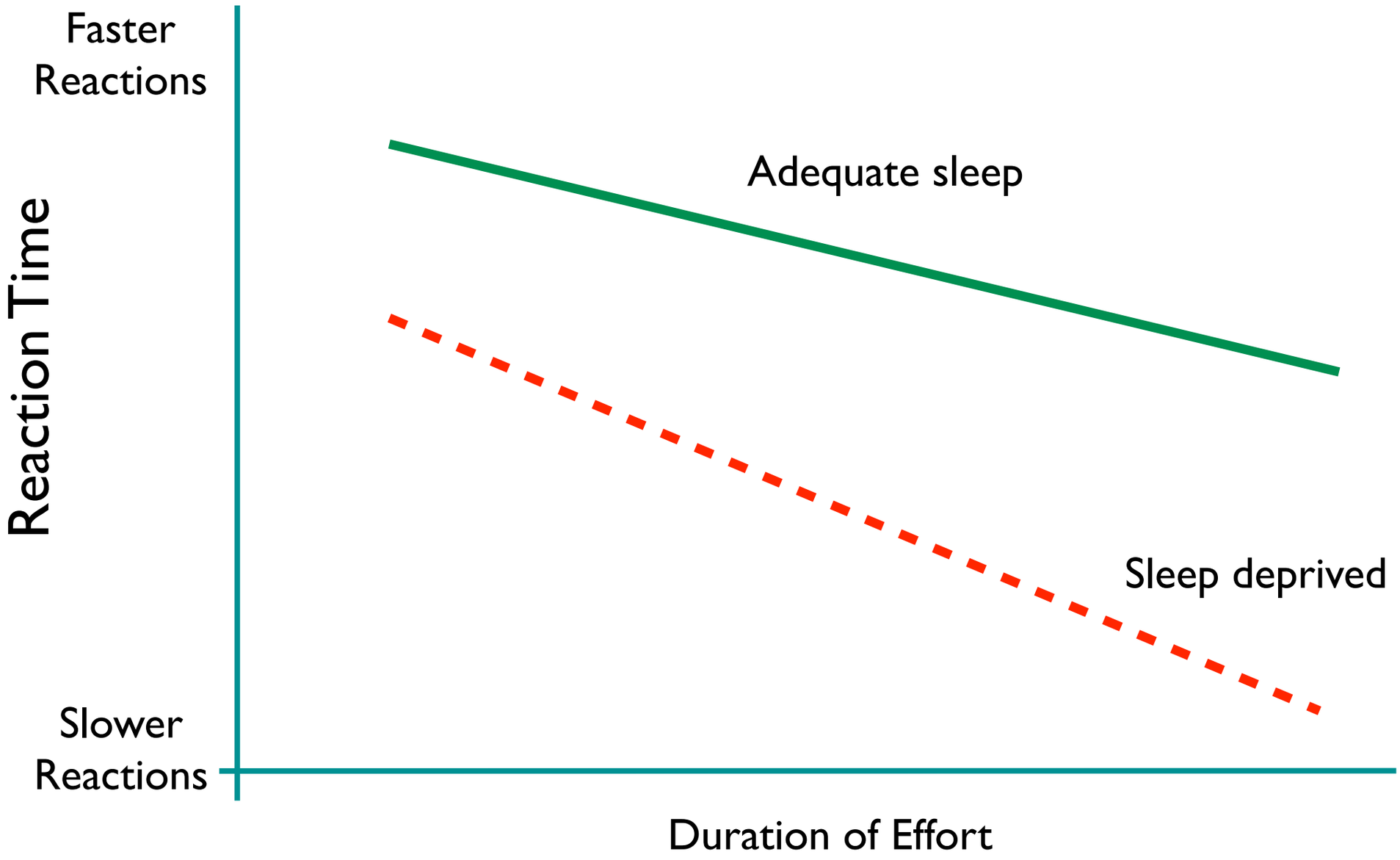


Why this picture?

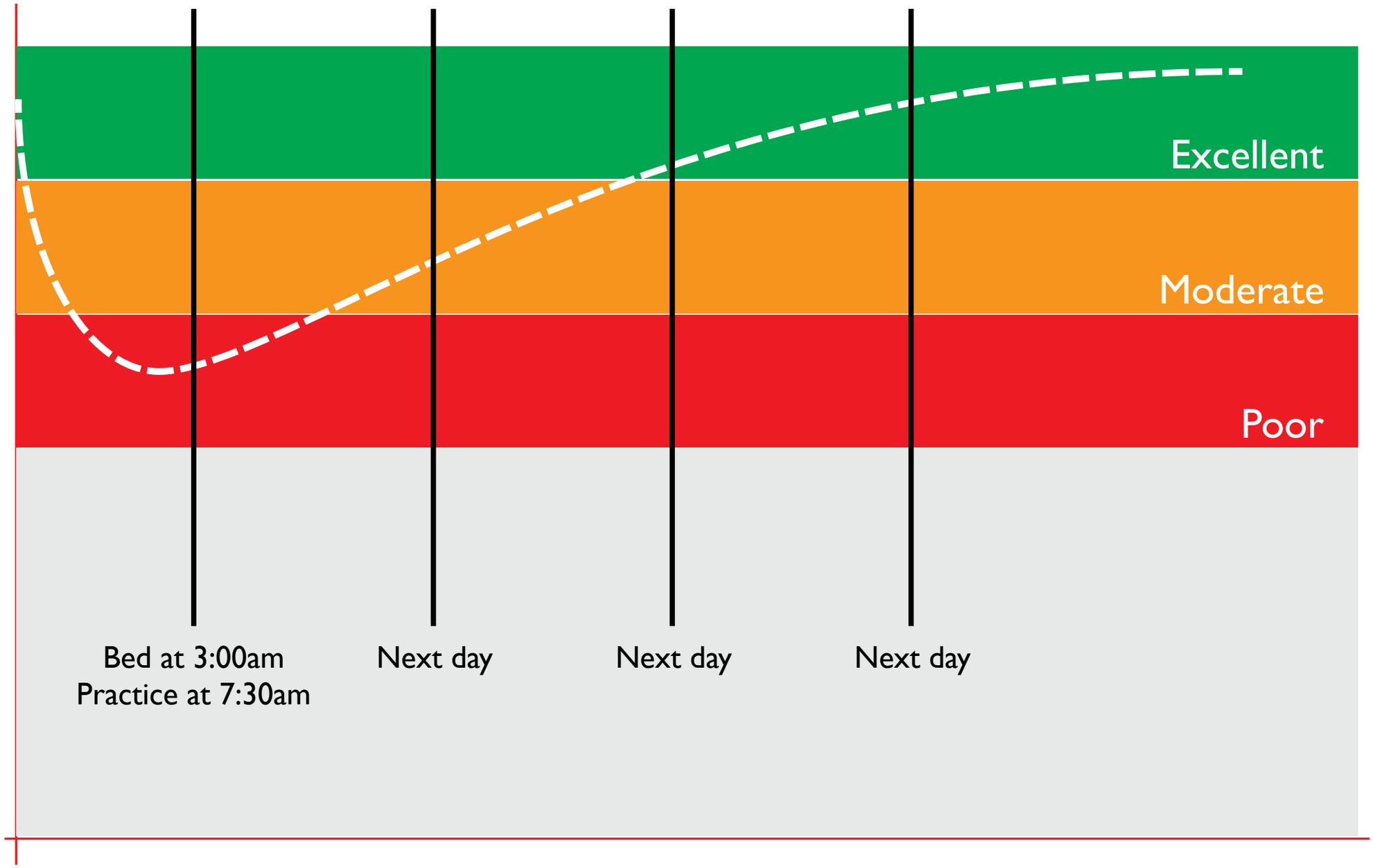
Circadian phase-shift increased

- When teens are exposed to blue-spectrum light.
  - TV
  - Computer screens
- With dark mornings

....Leading to sleep deprivation



One short night!



Football Training Implications

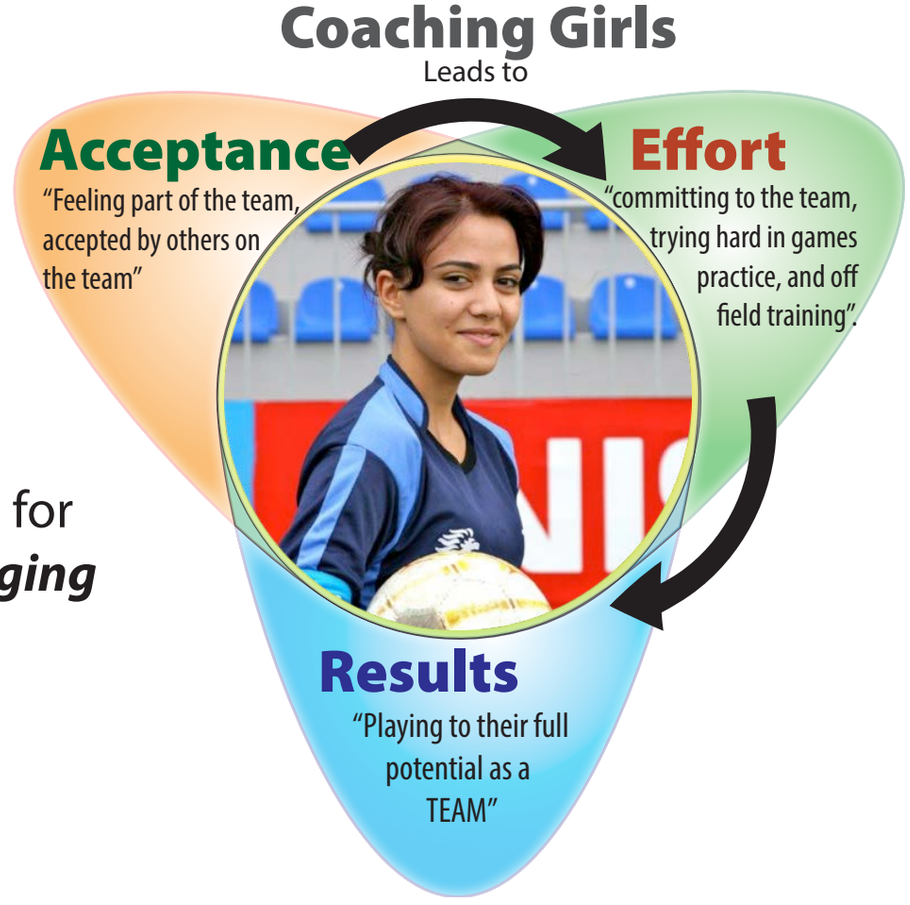
- Early morning practices!
  - Avoid if possible
  - Physical, not strategy/tactics
- Scheduling of facilities
- Parental control of electronics
- Sleep now known to be a **key performance factor**

Football Tournament Sleep

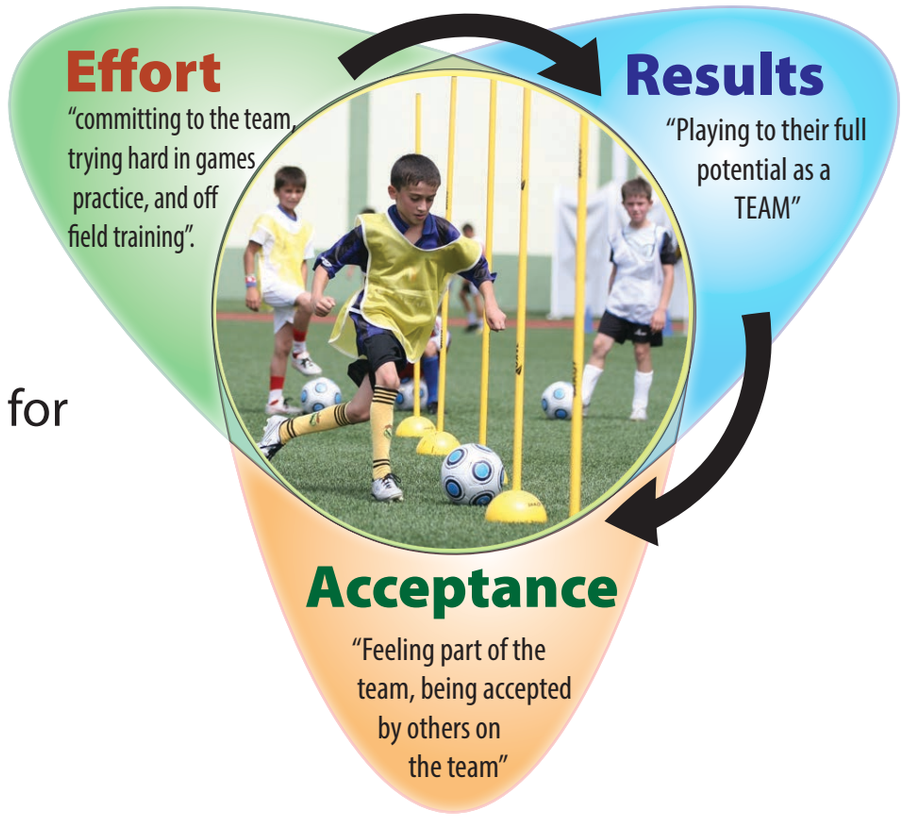
- One of the most important contributors to team success.
- Good luck!
- Normalize the process

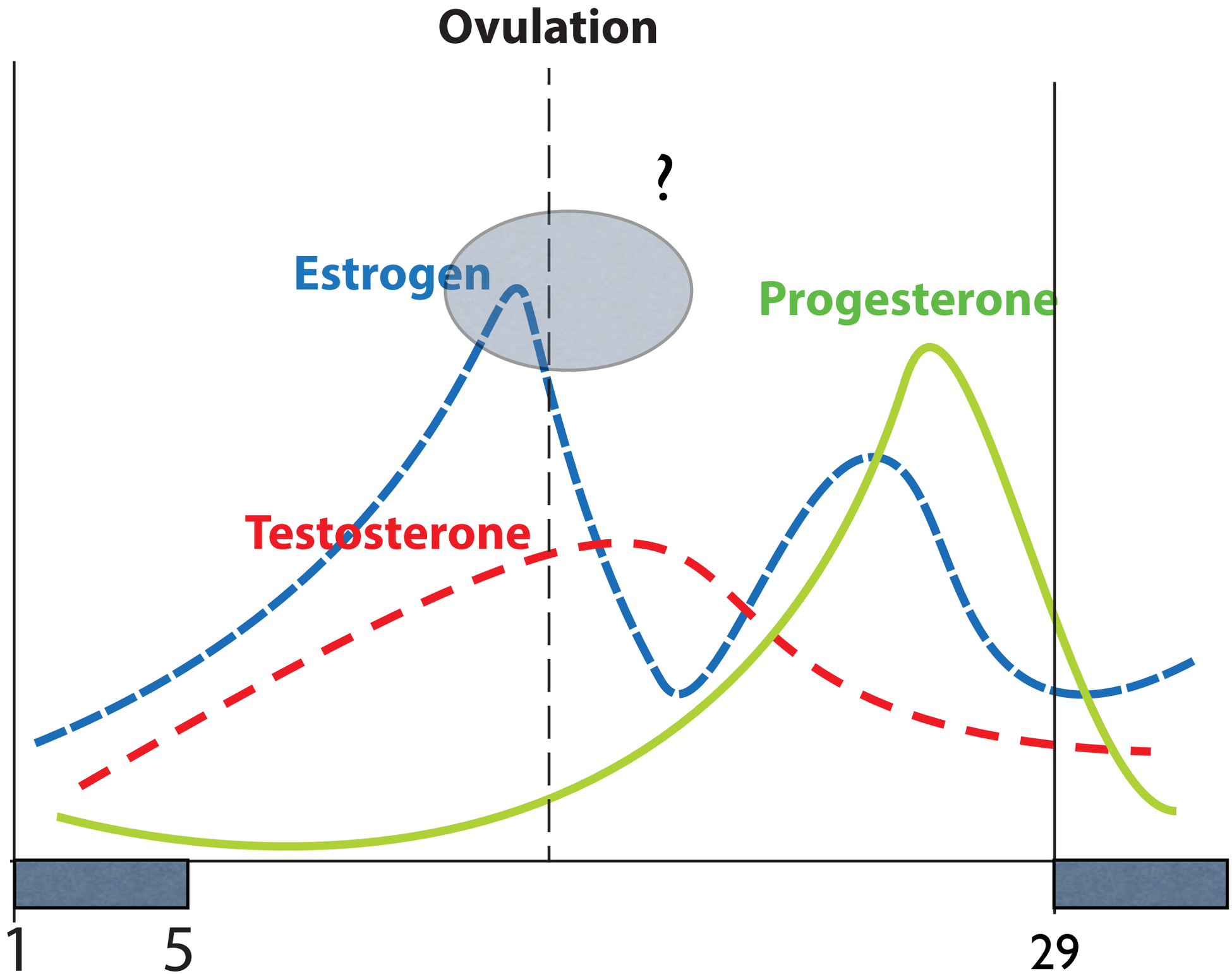
Gender specific?

Coach for
Belonging



Coach for
Effort

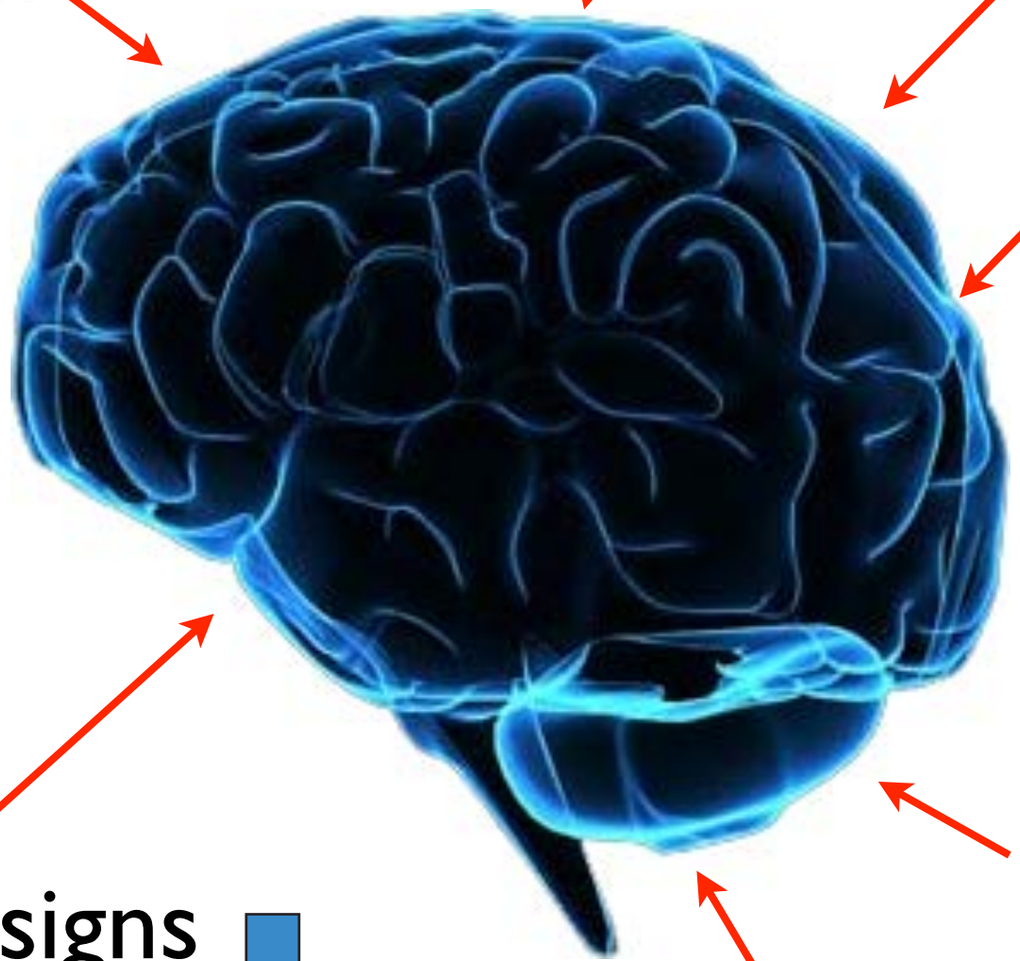



Ovulation
?
Estrogen
Progesterone
Testosterone
1
5
29

Teens and Alcohol

- Train to Train is peak time for alcohol initiation
- Greater pressure in team sports - and some team sports in particular (Rugby in UK, Hockey in Canada)
  - Canadian Soccer?
- Short-term and long-term effects

Teen brains and alcohol



Socialization

Hangover

Intoxication

Reward

Damage

Skills

Danger signs

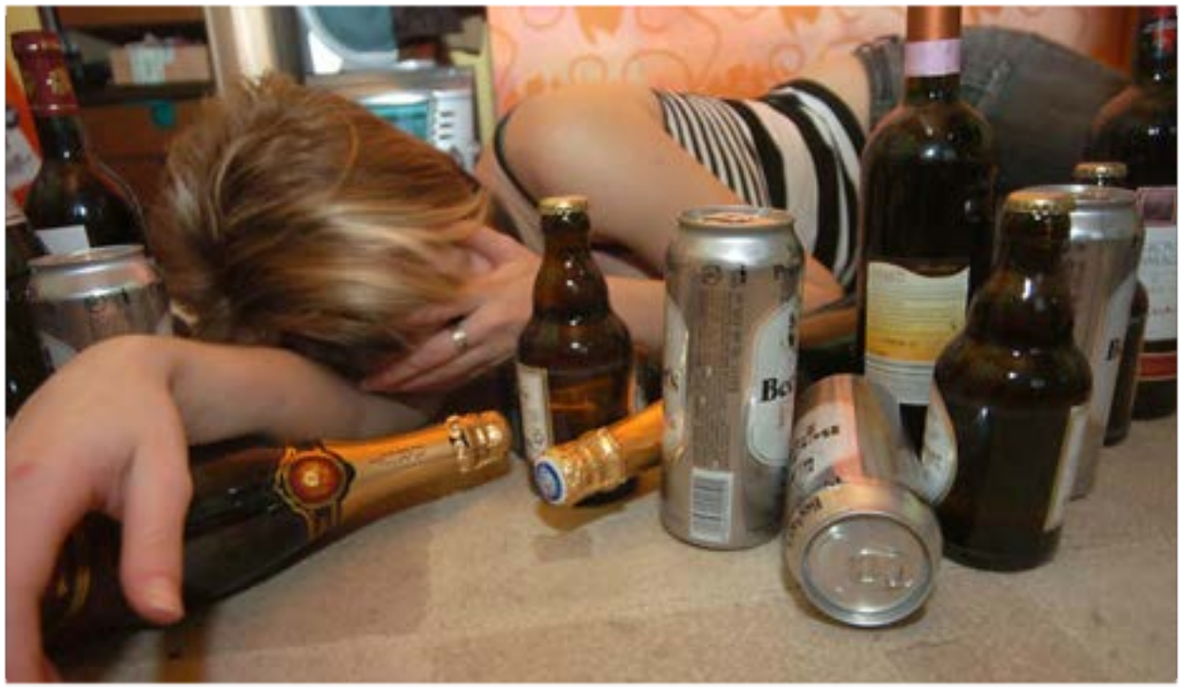
Decision making

Novelty and risk

Teens and alcohol

*"We were impressed by how **little** gross behaviour change occurred in children....after a dose of alcohol which had been intoxicating in an adult population"*

Behar et al. 1983, p 407



Football Implications

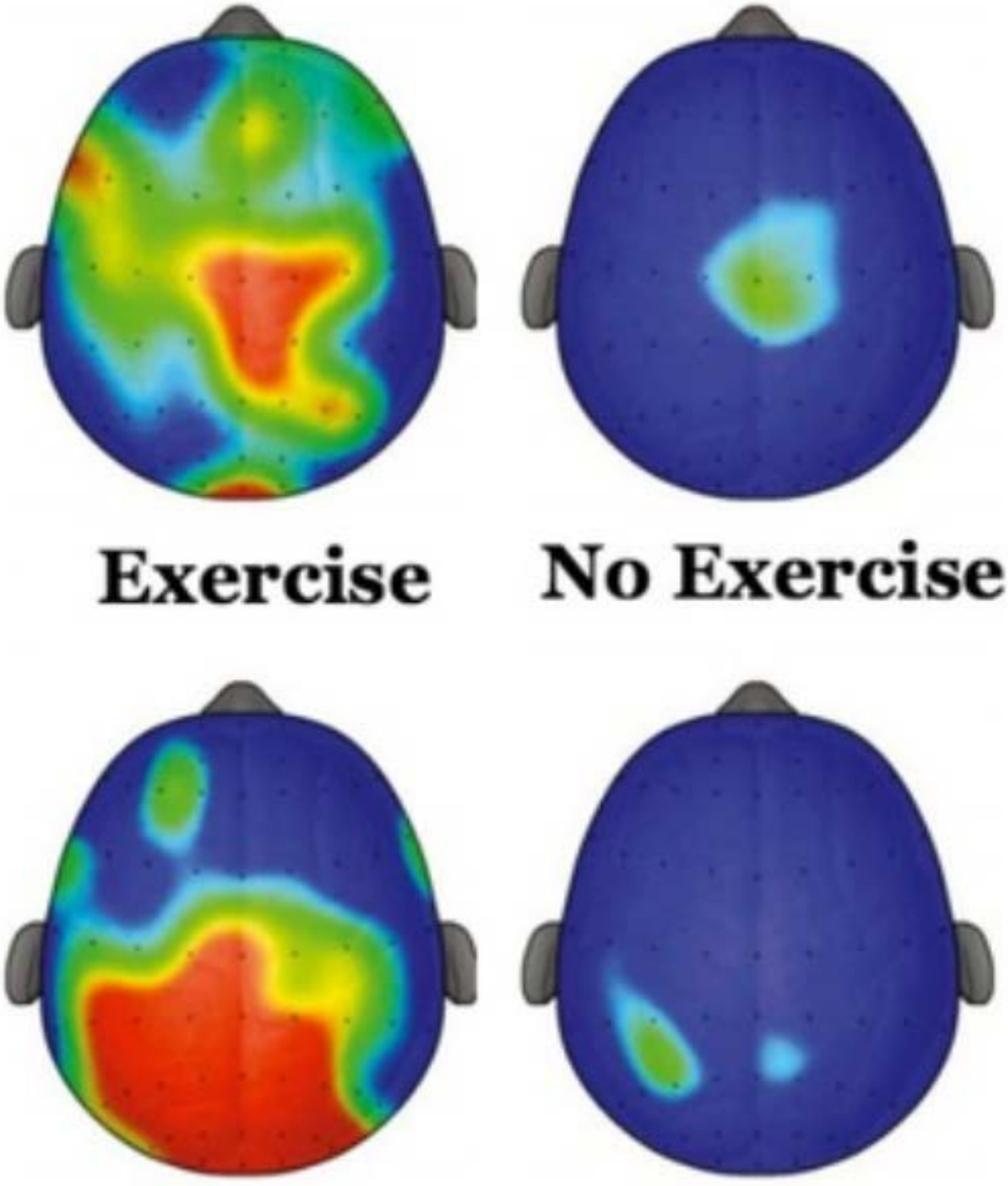
- When mid-to-late teen athletes show signs of intoxication - they have a LOT of alcohol in their blood.
- Narrow range of alcohol consumption between intoxicated and toxic.
- Brain's reward structure (+peers) encourages drinking and risk taking
- Probably the same for drug use - but few studies.

What does this all mean

- The (strange to adult) behaviours we see in adolescent footballers are (mostly) NORMAL
- They can be constrained but not eliminated
- They are necessary to help adolescents move "out of the nest" and live in the wider world.
- But the evolutionary consequence is that some teens will not survive.

What does it all mean?

- There is strong evidence that DESPITE their behaviours and their distain for adults; adults with whom they have a good ongoing relationship DO have a very positive influence on their actions.
- Just don't expect to be thanked for the intervention!


Exercise
No Exercise

Summary

- I don't know what all of this means for working with adolescent footballers.
- Together we have to keep up with the emerging science and work it out!

Thank You