The adolescent brain:
different, not deficient

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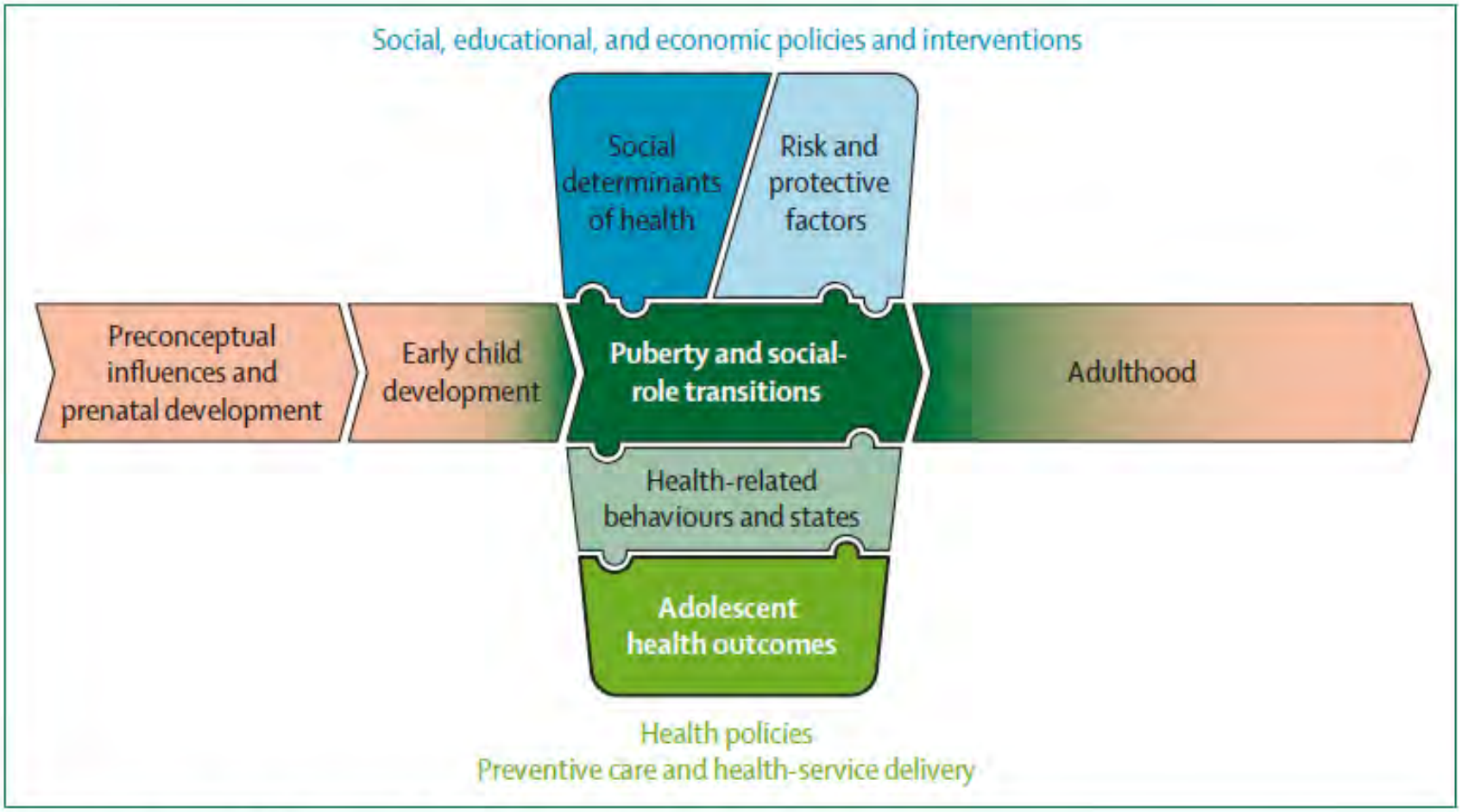
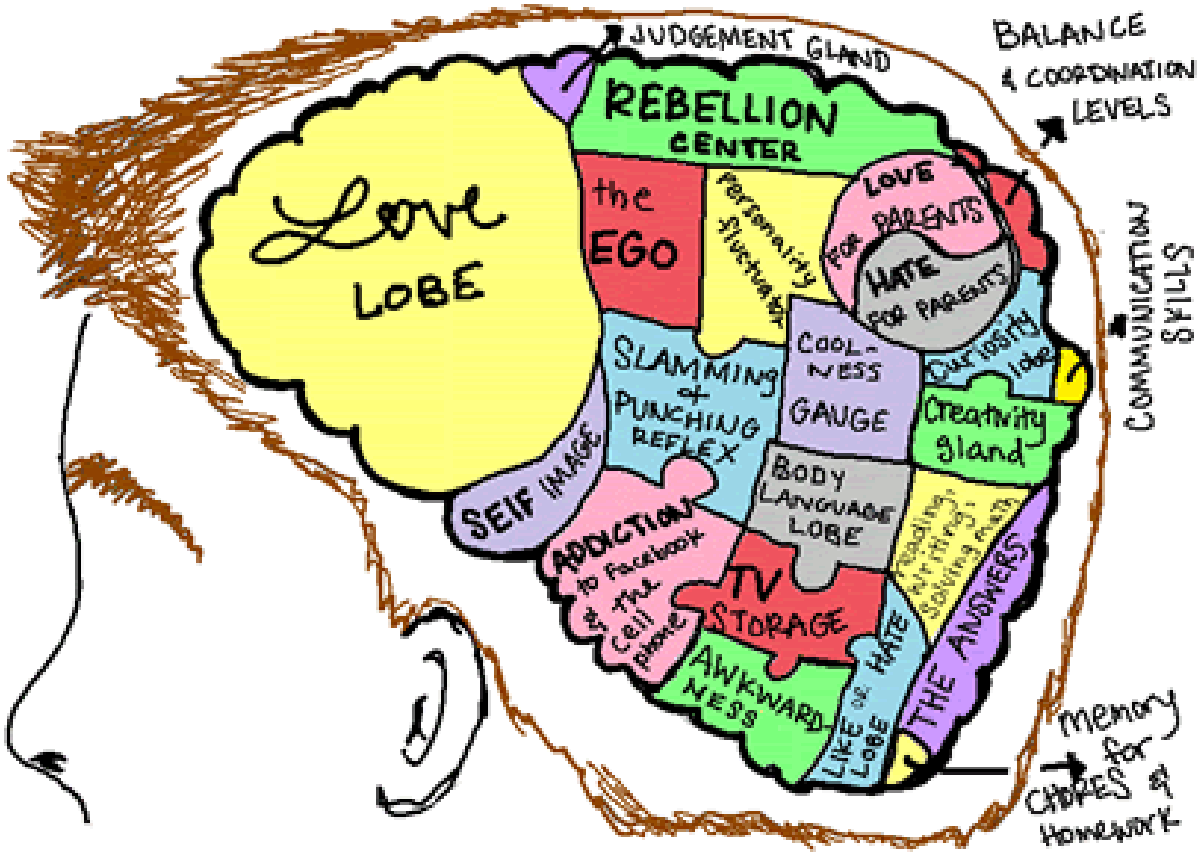
INDIANA UNIVERSITY

Conceptual framework for adolescent health



Sawyer SM, Afifi RA, Bearinger LH, Blakemore SJ, Dick B, Ezeh AC, Patton GC. Adolescence: a foundation for future health. *Lancet* 2012; 379: 1630-40.

THE AVERAGE TEENAGE BRAIN

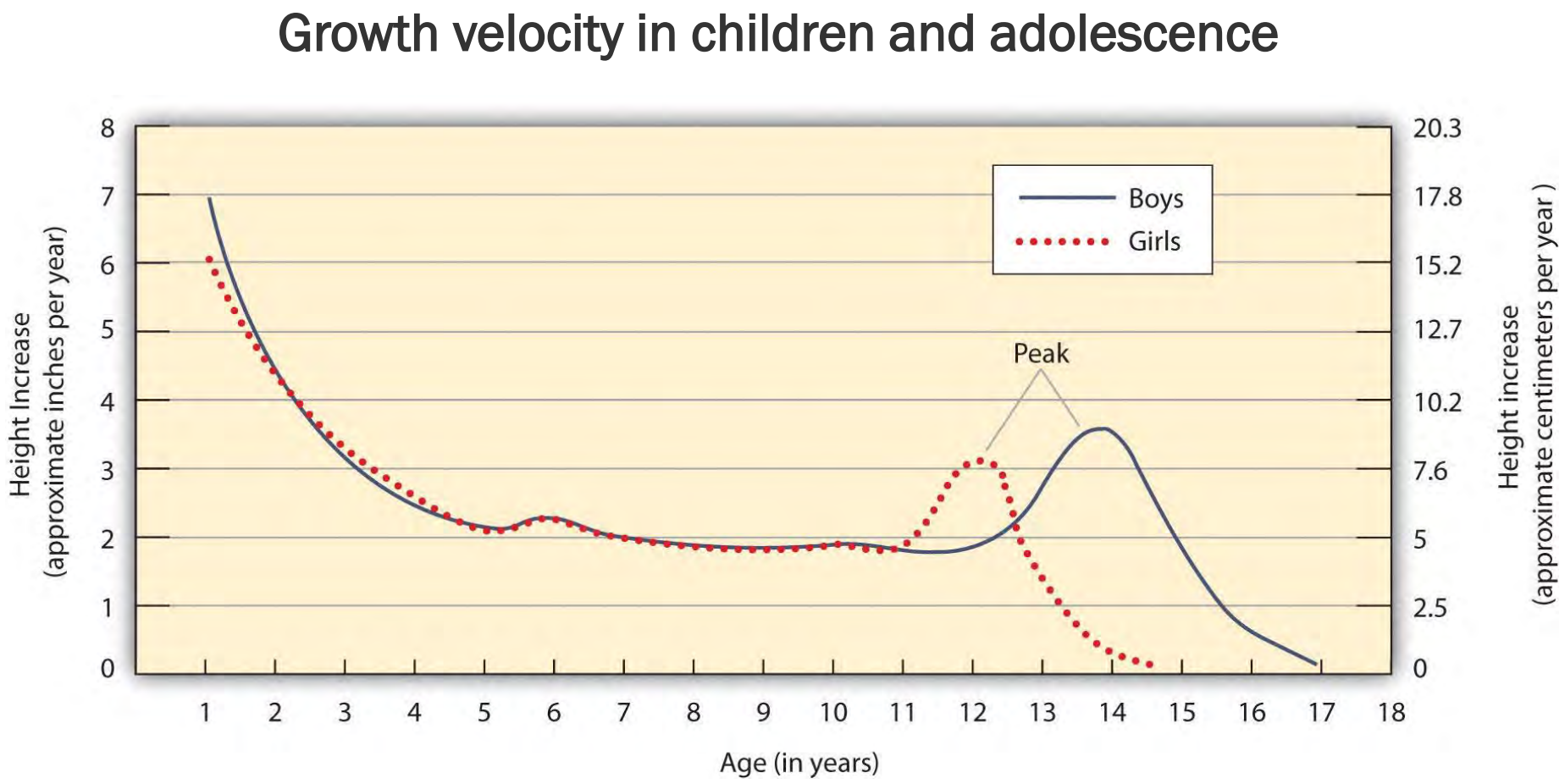


http://www.ted.com/talks/sarah_jayne_blakemore_the_mysterious_workings_of_the_adolescent_brain

Adolescence: 11-21 years

Physical changes of adolescence

Puberty occurs early in adolescence



Data from: Ulijaszek, S. J., Johnston, F. E., Preece, M. A., & Tanner, J. (1998). The Cambridge encyclopedia of human growth and development. Cambridge University Press: Cambridge, UK. Image from: catalog.flatworldknowledge.com/bookhub/reader/12013?e=tye_1.0-ch08_s02.

Social Transitions

- Less time with family; more time with peers
- High Emotional Turmoil → 5%–15%
- Friendships →closer, intimacy, disclosure, support
- Romantic relationships → normative in middle adolescence, stable & improve social functioning
- Civic involvement → ↑ compassion, interdependence
- College → 39% 18-25 year olds
- Living at home → 56% 18-24 years

Sources: (1) Smetana, Judith G., Nicole Campione-Barr, and Aaron Metzger. "Adolescent development in interpersonal and societal contexts." *Annu. Rev. Psychol.* 57 (2006): 255-284, (2) Pew Research Center, 2013

Academic demands of adolescence

Step 1: $k \div 3 = 4$

Step 2: $k \div 3 = 4$

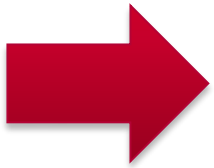
x3 x3

Step 3: ~~$k \div 3$~~ $= 4$ x3

~~x3~~

12

Step 4: $k = 12$



14. $\int u\sqrt{a+bu}\,du = \frac{2}{15b^3}(3bu-2a)(a+bu)^{\frac{3}{2}} + C$

15. $\int u^2\sqrt{a+bu}\,du = \frac{2}{105b^3}\left(15b^2u^2 - 12abu + 8a^2\right)(a+bu)^{\frac{3}{2}} + C$

16. $\int u^n\sqrt{a+bu}\,du = \frac{2u^n(a+bu)^{\frac{3}{2}}}{b(2n+3)} - \frac{2an}{b(2n+3)}\int u^{n-1}\sqrt{a+bu}\,du$

17. $\int \frac{u\,du}{\sqrt{a+bu}} = \frac{2}{3b^2}(bu-2a)\sqrt{a+bu} + C$

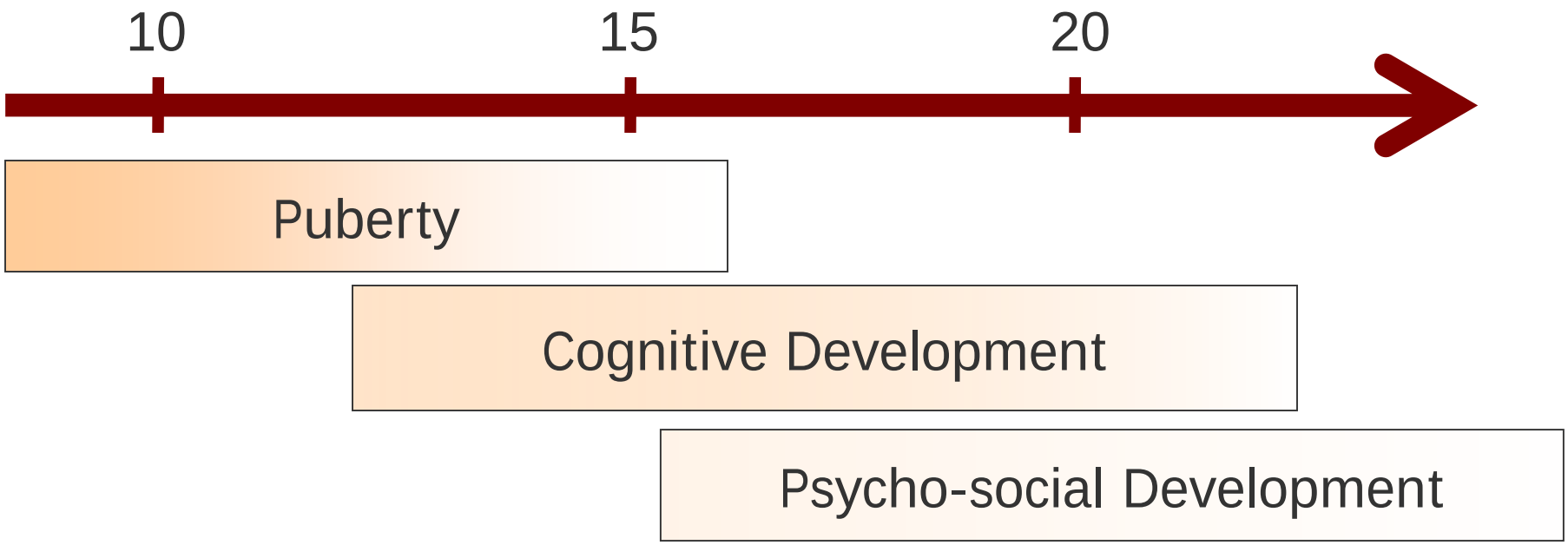
18. $\int \frac{u^2\,du}{\sqrt{a+bu}} = \frac{2}{15b^3}(3b^2u^2 - 4abu + 8a^2)\sqrt{a+bu} + C$

19. $\int \frac{u^n\,du}{\sqrt{a+bu}} = \frac{2u^n\sqrt{a+bu}}{b(2n+1)} - \frac{2an}{b(2n+1)}\int \frac{u^{n-1}\,du}{\sqrt{a+bu}}$

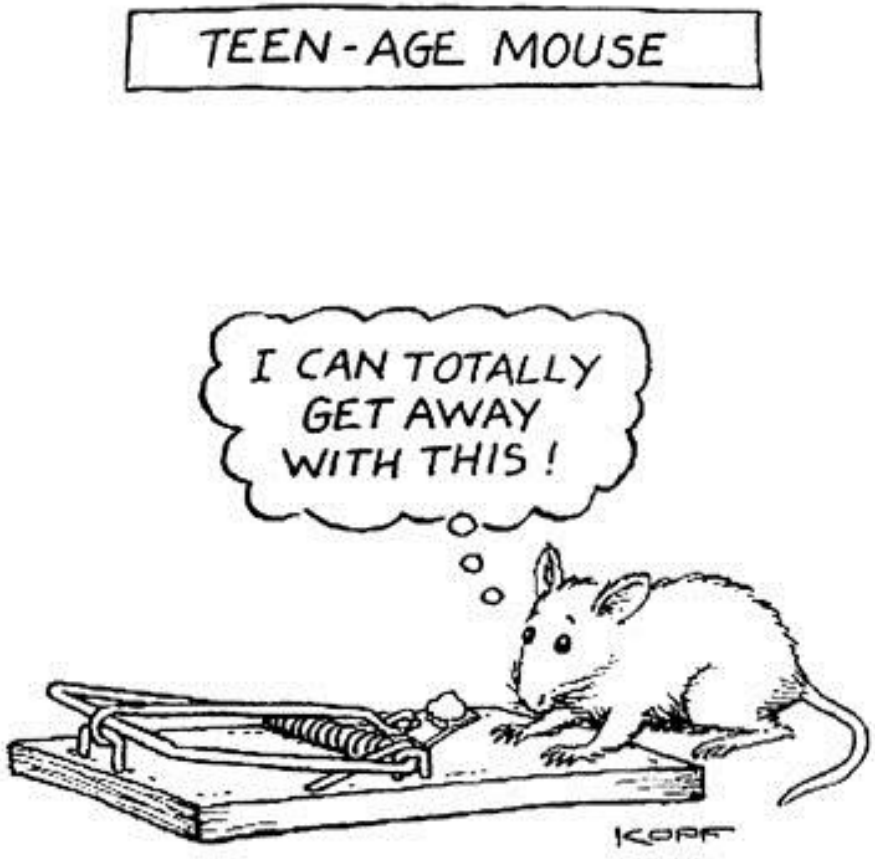
20. $\int \frac{du}{u\sqrt{a+bu}} = \begin{cases} \frac{1}{\sqrt{a}}\ln\left|\frac{\sqrt{a+bu}-\sqrt{a}}{\sqrt{a+bu}+\sqrt{a}}\right| + C & \text{if } a>0 \\ \frac{2}{\sqrt{-a}}\tan^{-1}\sqrt{\frac{a+bu}{-a}} + C & \text{if } a<0 \end{cases}$

21. $\int \frac{du}{u^n\sqrt{a+bu}} = -\frac{\sqrt{a+bu}}{a(n-1)u^{n-1}} - \frac{b(2n-3)}{2a(n-1)}\int \frac{du}{u^{n-1}\sqrt{a+bu}}$

Growth and Development



Adolescent Decision-Making



Capacity to Consent to Health Research

MacCAT-CR Subscales	Range	Our study of 12-24 yo Mean (±SD)	Studies of Healthy Adults (range)
Understanding	0 - 26	20.9 (±3.5)	20.2 - 25.8
Appreciation	0 - 6	5.5 (±0.9)	4.2 – 5.9
Reasoning	0 - 8	6.6 (±1.9)	4.4 - 7.1
Choice	0 - 2	2 (±0)	2

Ott MA, MacGregor KM. The Teenage Trialist: Adolescent Capacity to Consent, presented at Pediatric Academic Societies Annual Meeting; 1 May 2016, Baltimore, MD.

Predictors of Capacity to Consent

- Understanding:

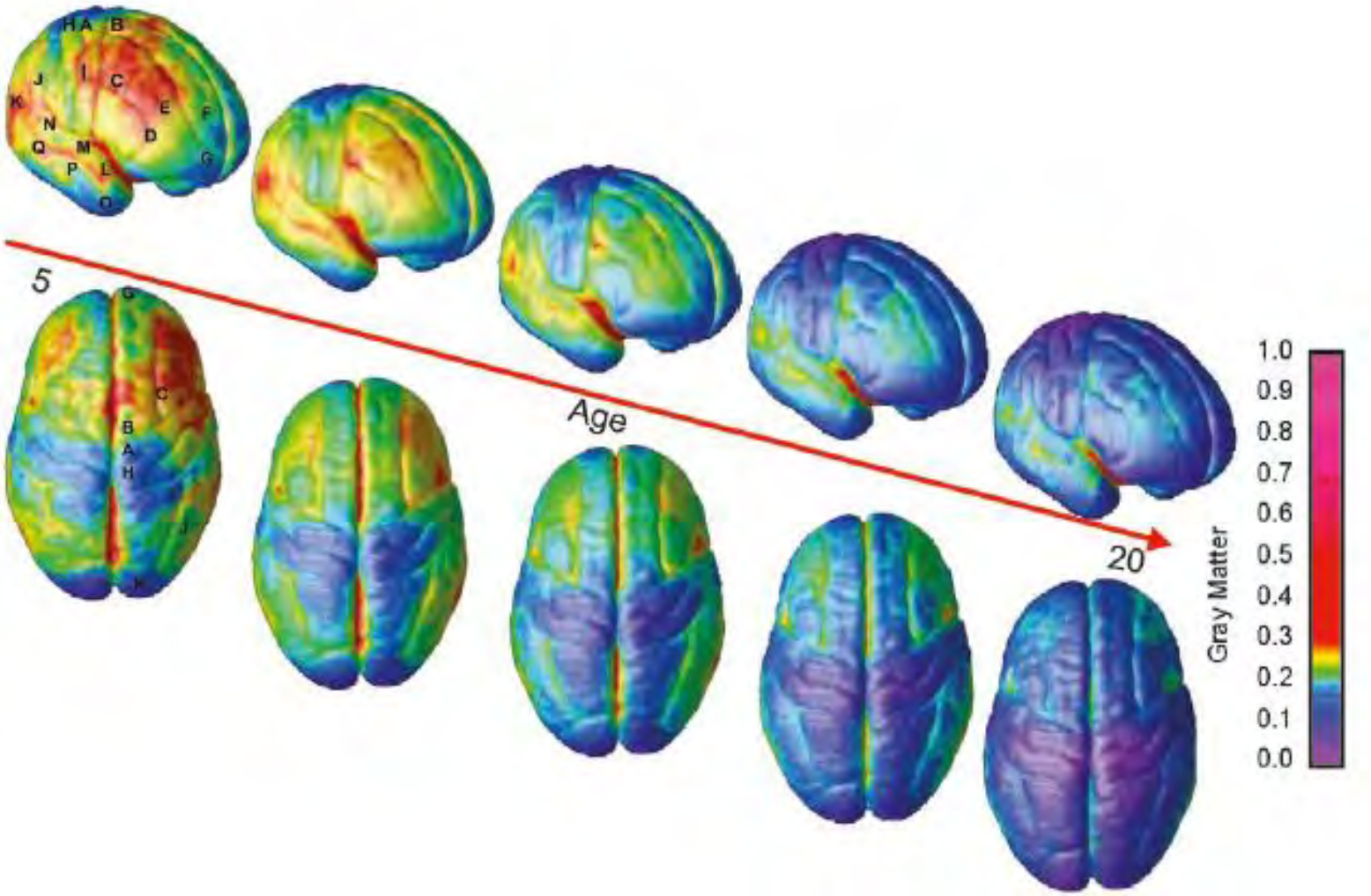
Predictor [1]	Beta (SE)	Std. Beta	t
Health Literacy (REALM)	0.317 (0.046)	0.567	6.91***
Affluence (FASII)	0.517 (0.169)	0.252	3.07**
	R2	.41***	

**p<0.01, ***p<0.001

[1] Age & chronic illness non-significant & removed

- Reasoning: similarly predicted by health literacy & affluence (R^2=0.23, p<0.001)
- Appreciation: health literacy only (R^2=0.69, p<0.001)

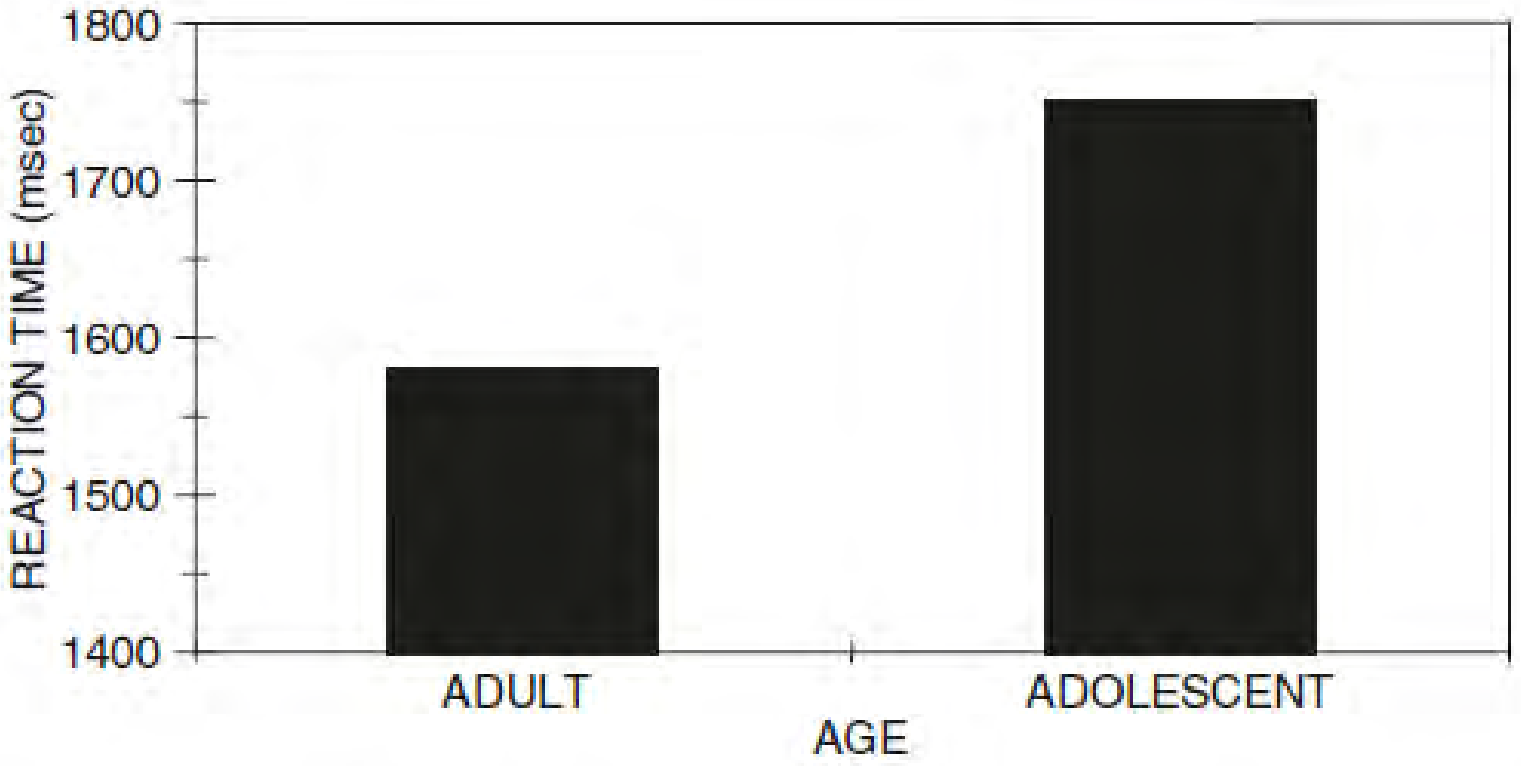
Synaptic Pruning – Evolved for Learning



Gogtay N, Giedd JN, Lusk L, Hayashi KM, Greenstein D, Vaitusiz AC, Nugent TF, Herman DH, Clasen LS, Toga AW, Rapaport JL, Thompson PM. Dynamic Mapping of Human Cortical Development During Childhood Through Early Adulthood. *PNAS* 2004;101(21):8174-9.

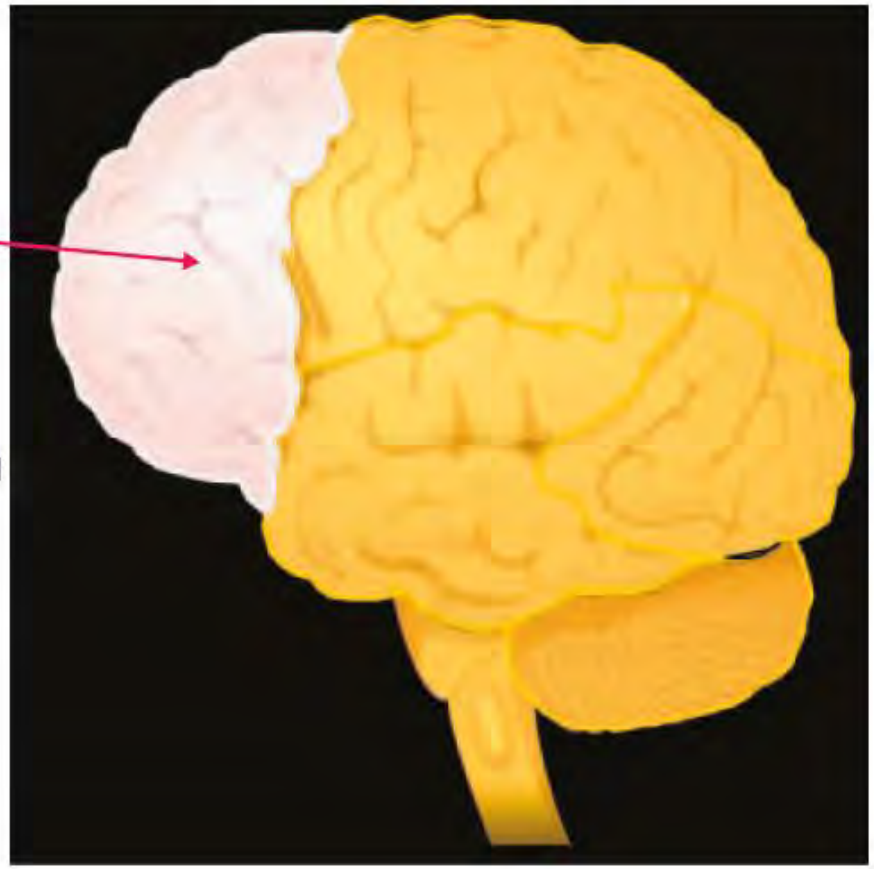
Reaction time among adolescents and adults

Participants responded to questions such as, “Is it a good idea to set your hair on fire?”, “Is it a good idea to drink a bottle of Drano?”, and “Is it a good idea to swim with sharks?”



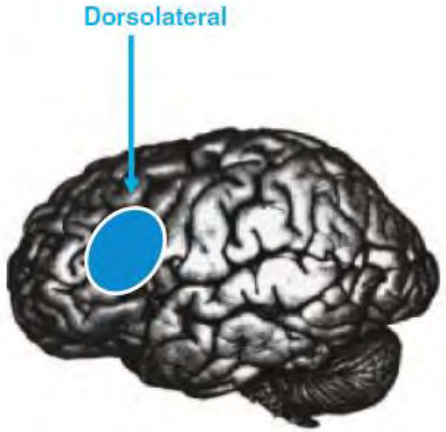
Reyna VF, Farley F. Risk and rationality in adolescent decision making: implications for theory, practice, and public policy. *Psychol Sci Public Interest* 2006;7(1):1-44.

Adolescent Brain

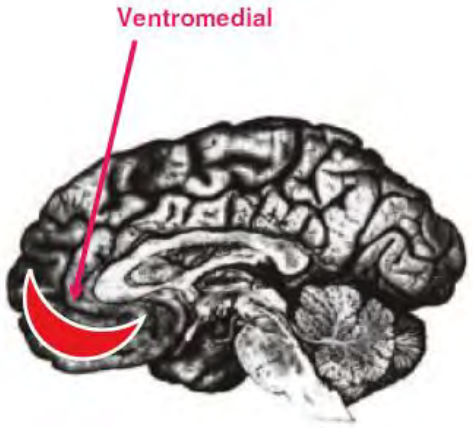


Frontal Lobe

- Executive Function
- Planning
- Reasoning
- Impulse Control



Thinking ahead and inhibition of impulsive responses



Regulation of emotions; learning from experience; weighing risks and rewards

Reyna VF, Farley F. Risk and rationality in adolescent decision making: implications for theory, practice, and public policy. *Psychol Sci Public Interest* 2006;7(1):1-44.

‘Hot’ and ‘Cold’ Decision-Making

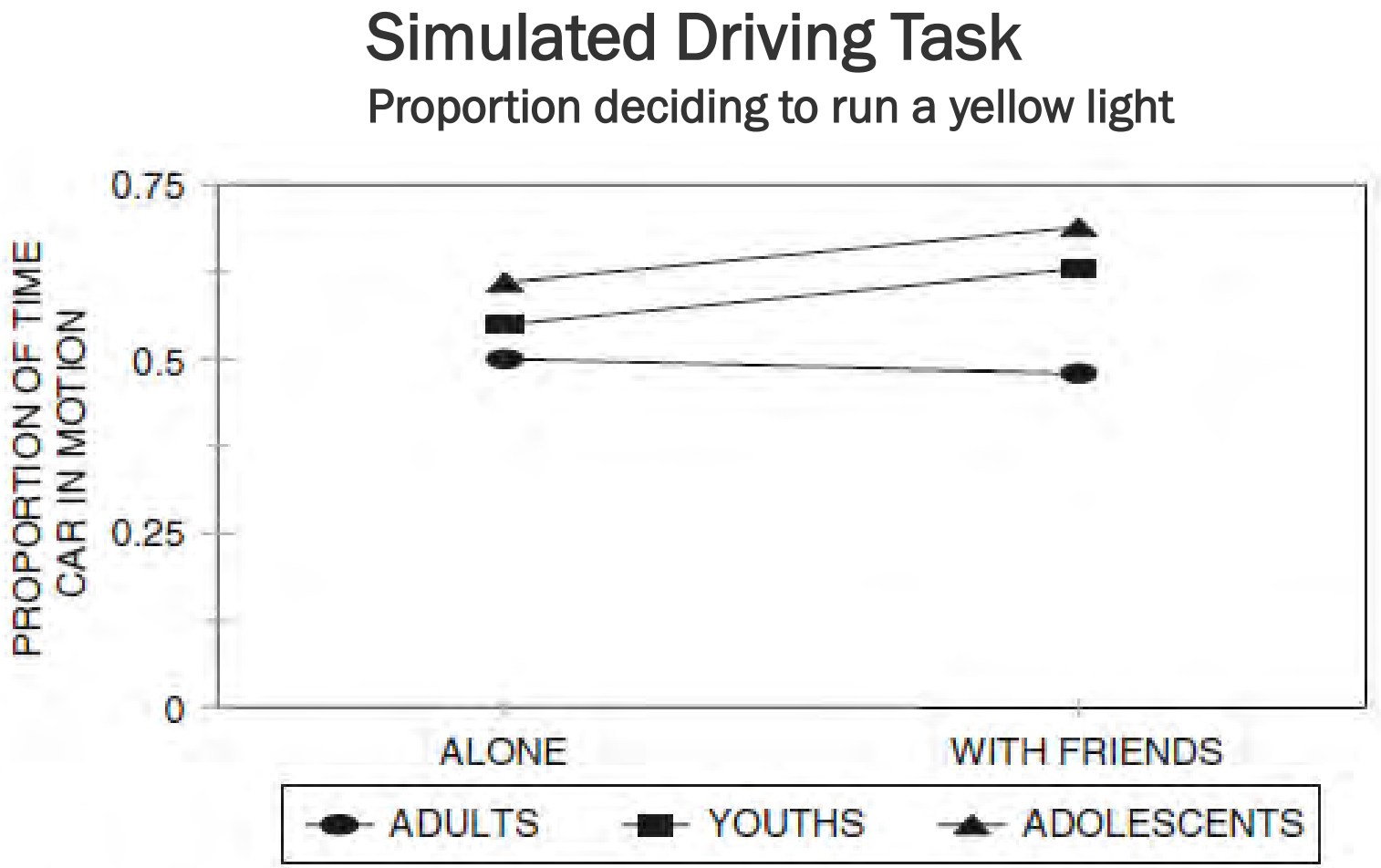
- “Cold” – controlled situation, low emotion

  → Adolescents similar to adults

- “Hot” - high emotion, distraction

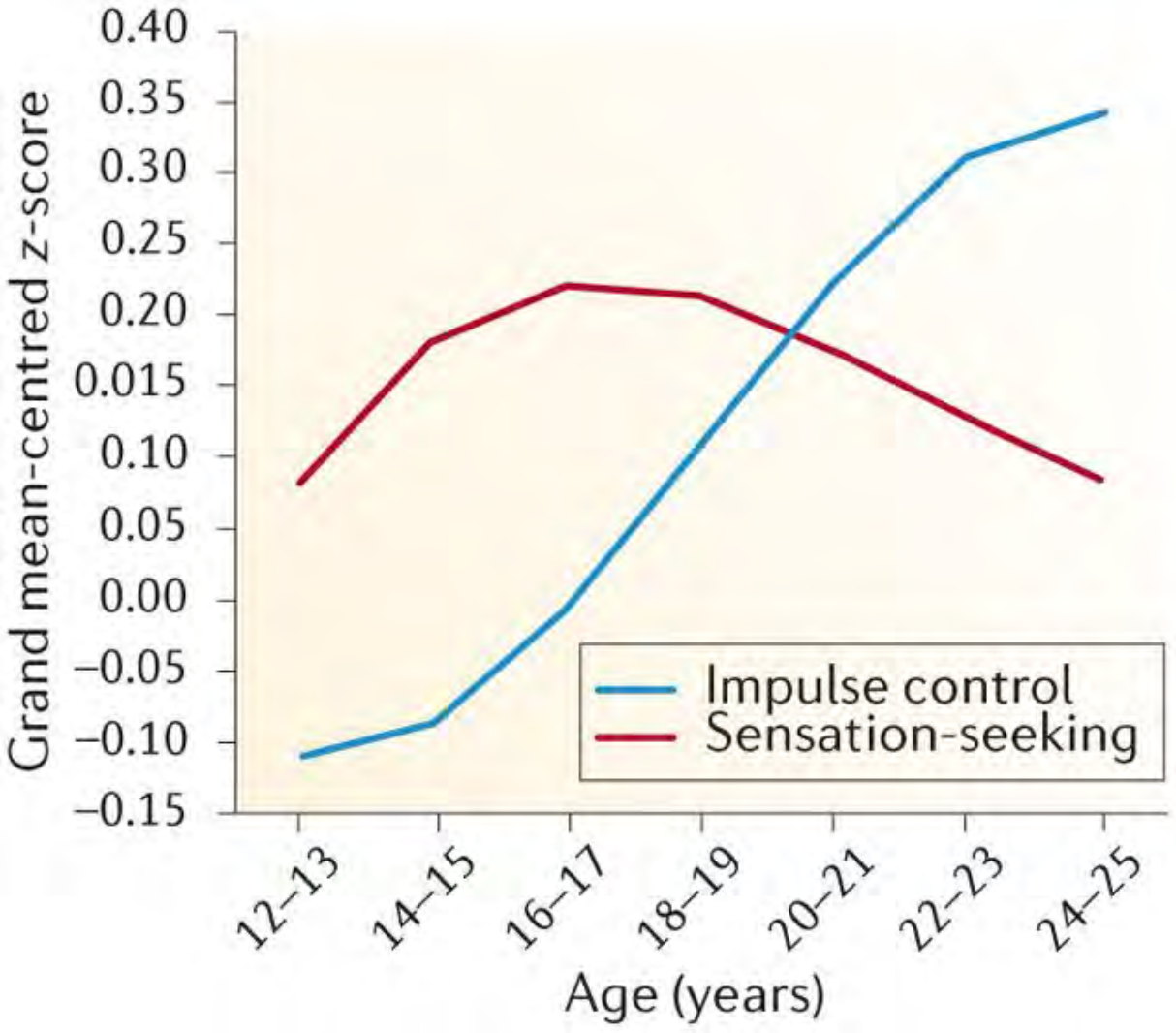
  → Adolescents different types of responses, riskier decisions

Influence of Peers



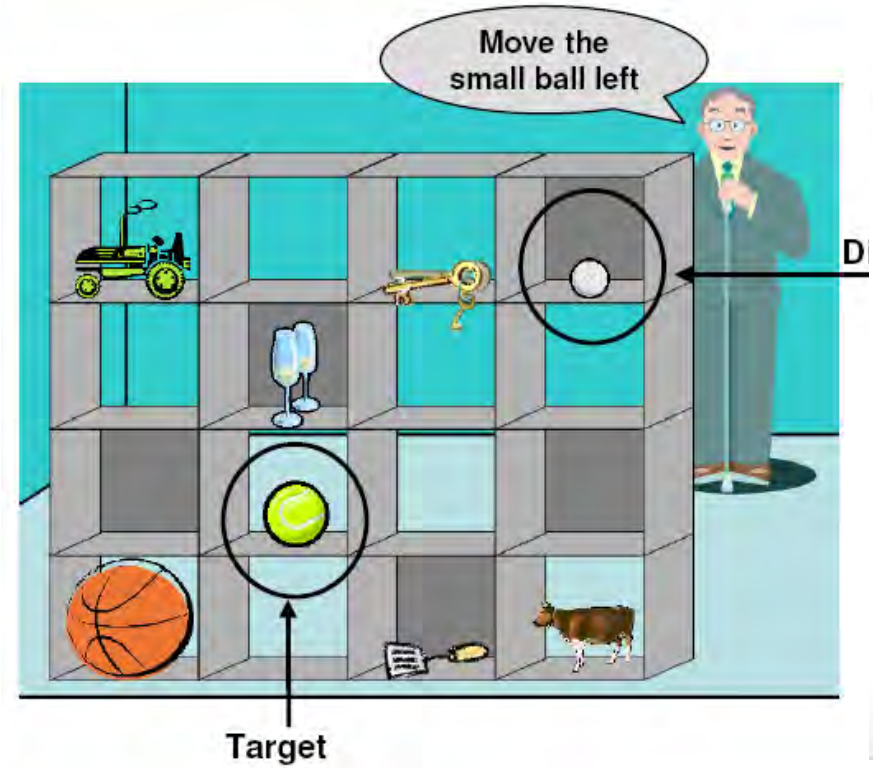
Reyna VF, Farley F. Risk and rationality in adolescent decision making: implications for theory, practice, and public policy. *Psychol Sci Public Interest* 2006;7(1):1-44.

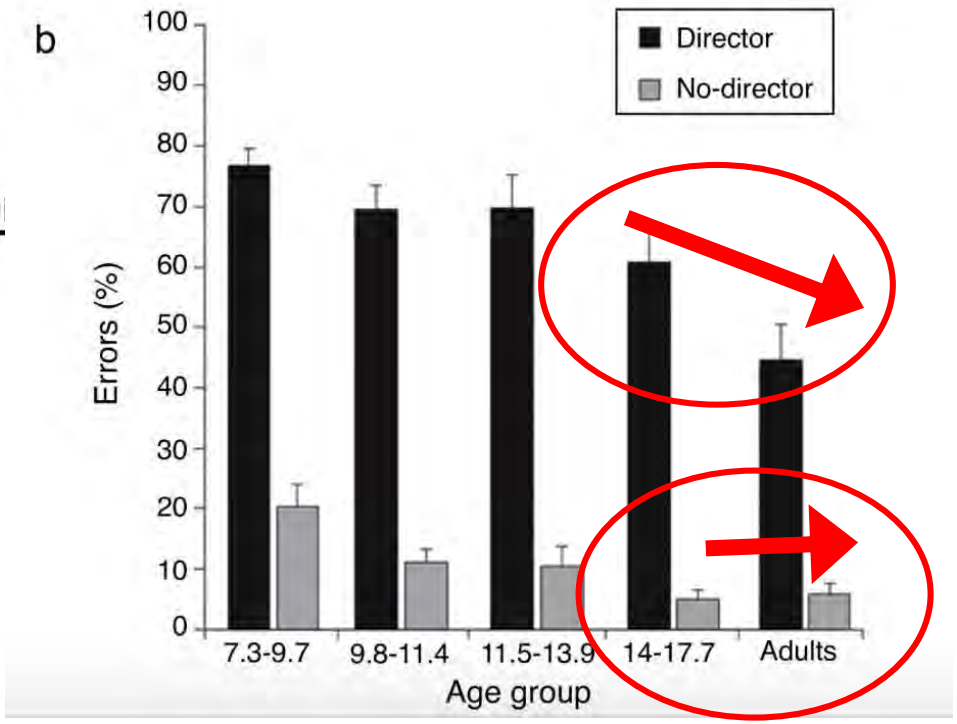
Dual Systems:
Sensation Seeking & Impulse Control



Steinberg L. The influence of neuroscience on US Supreme Court decisions about adolescents' criminal culpability. *Nat Rev Neurosci* 2013;14:513-518.

Perspective Taking

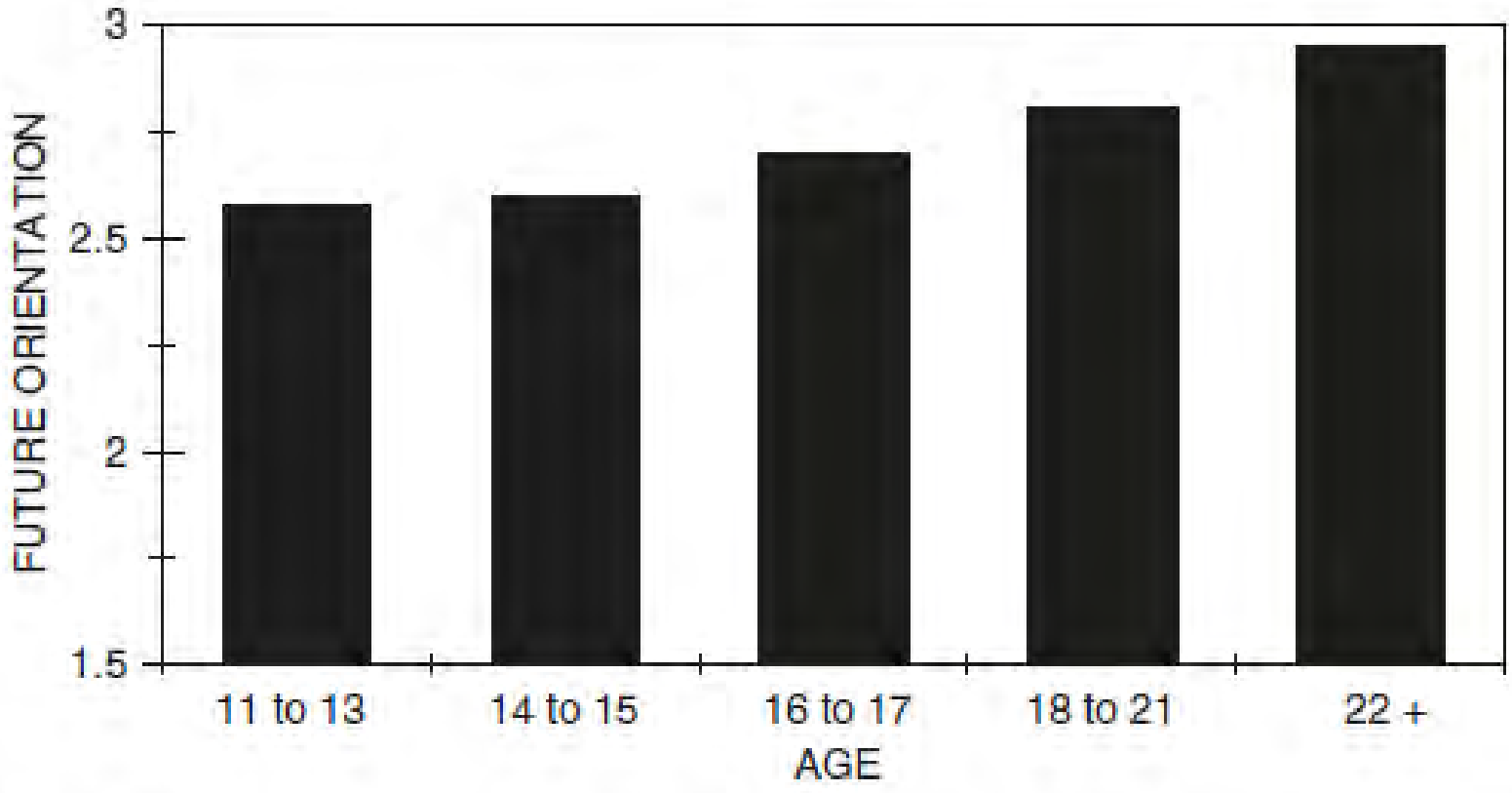




Dumontheil I, Apperly IA, Blakemore SJ. Online usage of theory of mind continues to develop in late adolescence. *Dev Sci* 2010;13:331-338.

Future orientation at different ages

Participants rated responses to the item, “I would rather save my money for a rainy day then spend it on something fun.”

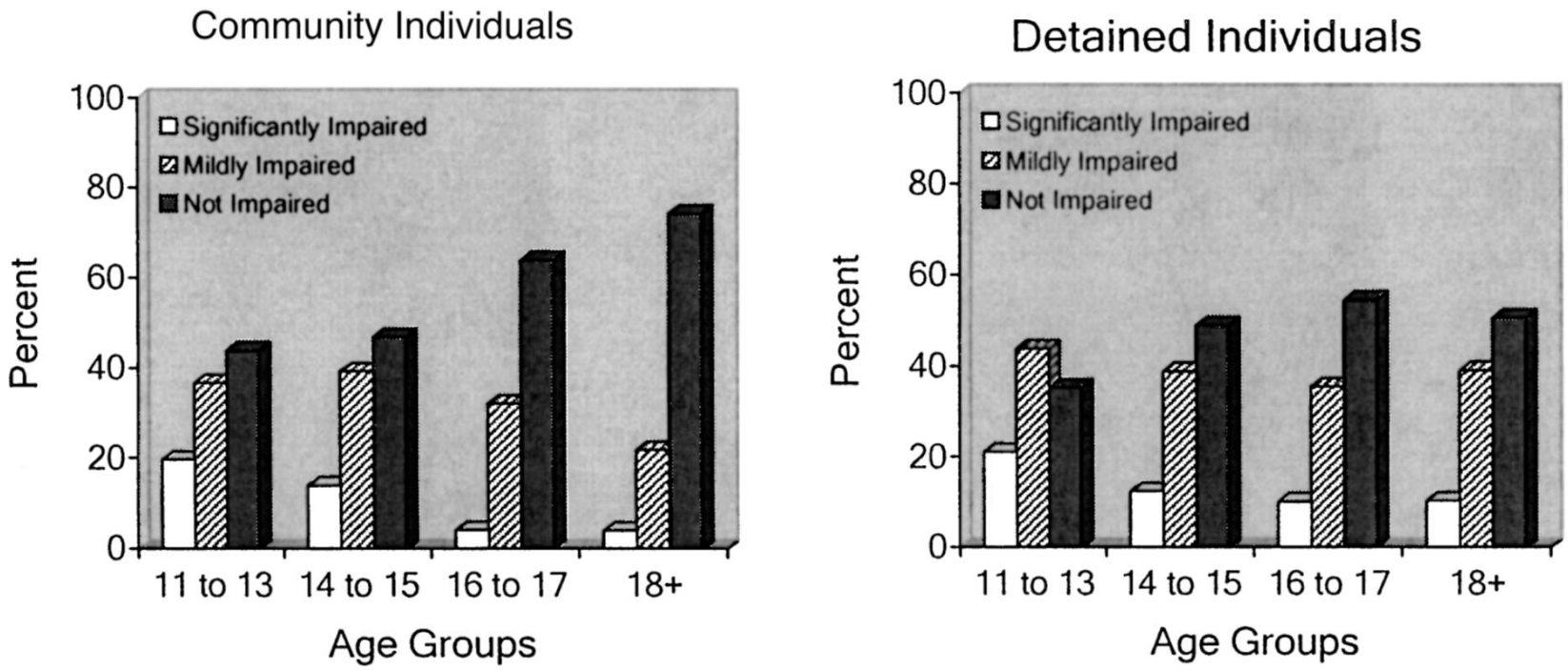


Reyna VF, Farley F. Risk and rationality in adolescent decision making: implications for theory, practice, and public policy. *Psychol Sci Public Interest* 2006;7(1):1-44.

Environmental influences on Cognition

Impairment in decision-making

community vs. system involvement



Grisso T, Steinberg L, Woolard J, et al. Juveniles' competence to stand trial: a comparison of adolescents' and adults' capacities as trial defendants. *Law Hum Behav* 2003;27:333-363.

Teaching Empathy

- "Text to connect" messages targeting cognitive/emotional empathy and prosocial behaviors sent to 555 teens 1 to 5 times a day.
- Qualitative responses
  - *I love the way that every time I got a text, no matter what it was that I was doing, I would look at my phone, and for a minute, I would be able to think about things that matter deeply to me.* [male, age 18]
- Behavioral results
  - Increased minutes helping others
  - Increased giving support in relationships
- Psychological results
  - Increased prosocial motivations
  - More emotional empathy in scenarios
  - Less aggressive beliefs

Summary – Adolescent Brain

- Logical decisions in controlled ('cold') contexts
- Specific vulnerabilities, particularly in 'hot' contexts
  - Distraction
  - Emotion
  - Perspective taking
- Specific strengths
  - "Hardwired" for learning
  - Positive risks
- Environments matter

Ideal Program

- Allows development of decision-making capacity
- Focus on learning
- Supportive environment

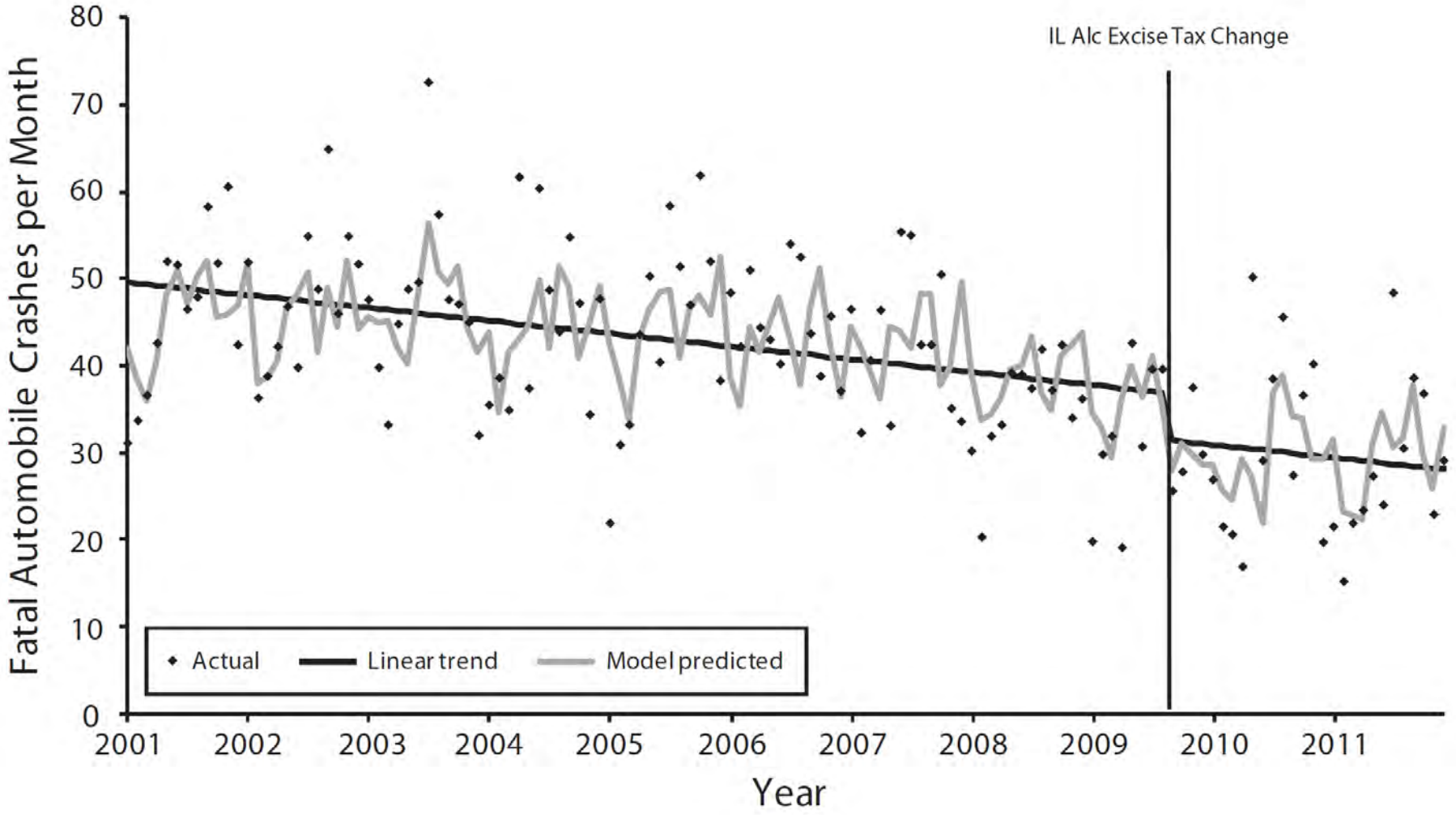
Interventions that Work

Policies addressing structural risks: graduated drivers' licensing

- Graduated driver licensing (GDL): gradually introducing higher risk driving situations to new drivers
- Systematic review of 21 GDL programs and 2 analyses of >40 US states
- ALL studies showed reductions in crash rates in ALL jurisdictions and for ALL crash types
- For 16 year old drivers: median decrease per population adjusted overall crash rates during year 1=16%
- Decrease in per population adjusted injury crash rates: median decrease=21% (range: 2-46% decrease)
- Stronger GDL programs correlated with greater fatality reduction

Russell, K.F., Vandermeer, B., Hartling, L. (2011). Graduated driver licensing for reducing motor vehicle crashes among young drivers. *Cochrane Database of Systematic Reviews 2011,* 10

Policies addressing structural risks: alcohol tax



Wagenaar AC, Livingston MD, Staras SS. Effects of a 2009 Illinois alcohol tax increase on fatal motor vehicle crashes. *Am J Public Health* 2015; 105:1880-5.

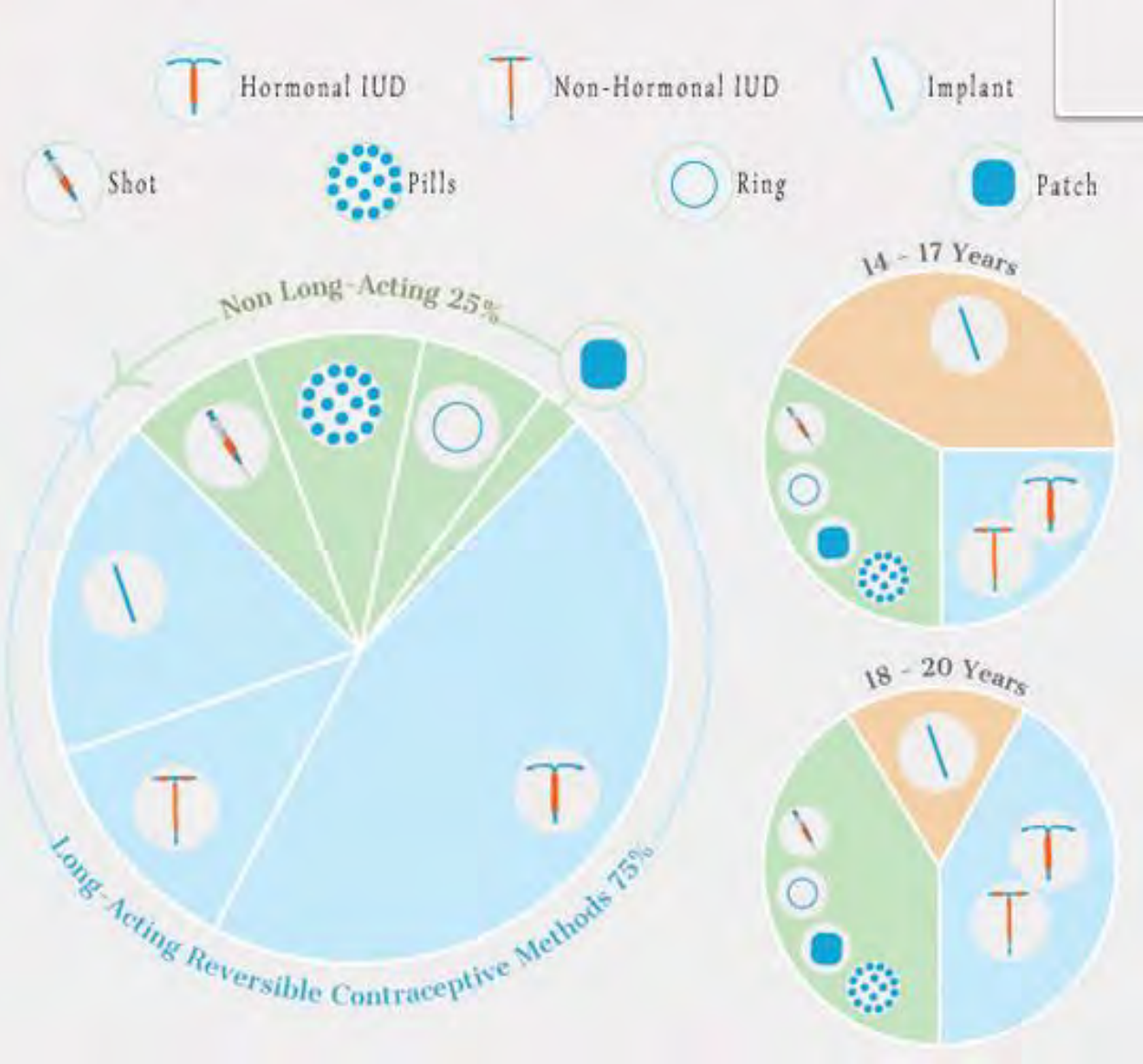
Public Costs of Teen Childbearing

Indiana (2010)

Their Choice

When our participants were counseled about all methods of birth control, 75% of the 9,256 women chose a Long-Acting Reversible Contraceptive method (LARC: IUD or Implant).

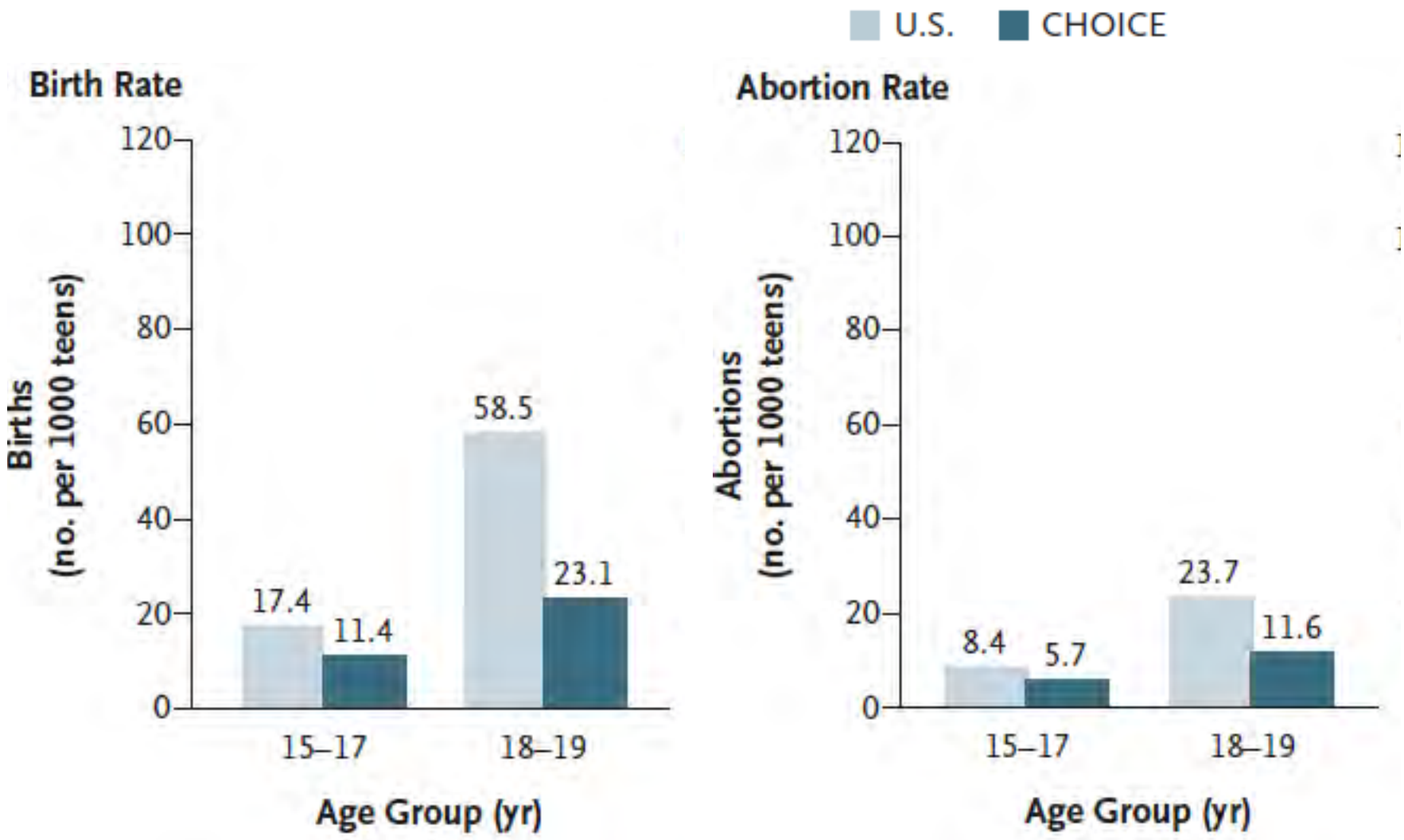
Young women under the age of 21 were also interested in the IUD and implant. Over 40% of teens of young women 14-17 years chose the implant, and over 40% of young women 18-20 years chose an IUD.



http://www.choiceproject.wustl.edu

Secura GM, Madden T, McNicholas C, Mullersman J, Buckel CM, Zhao Q, Peipert JF. Provision of no-cost, long-acting contraception and teenage pregnancy. *N Engl J Med* 2014; 371: 1316-23.

Birth and abortion rates in young women in US compared to CHOICE



Secura GM, Madden T, McNicholas C, Mullersman J, Buckel CM, Zhao Q, Peipert JF. Provision of no-cost, long-acting contraception and teenage pregnancy. *N Engl J Med* 2014; 371: 1316-23.

Colorado Family Planning Initiative

- Colorado Department of Public Health and Environment (CDPHE)
- Program (partnered with Title X)
  - Reduced cost for IUDs and contraceptive implants
  - Provider education, training
- Results– 2009-2013
  - >30,000 women chose LARCs
  - Birth rate declined 39% 15-19 year olds; 9% for 20-24 year olds.
  - Abortion declined 42% 15-19 year olds; 18% for 20-24 year olds.

Colorado Family Planning Initiative: https://www.colorado.gov/pacific/cdphe/reducing-unintended-pregnancy

Cost-Savings of LARCs

http://www.larc4co.com

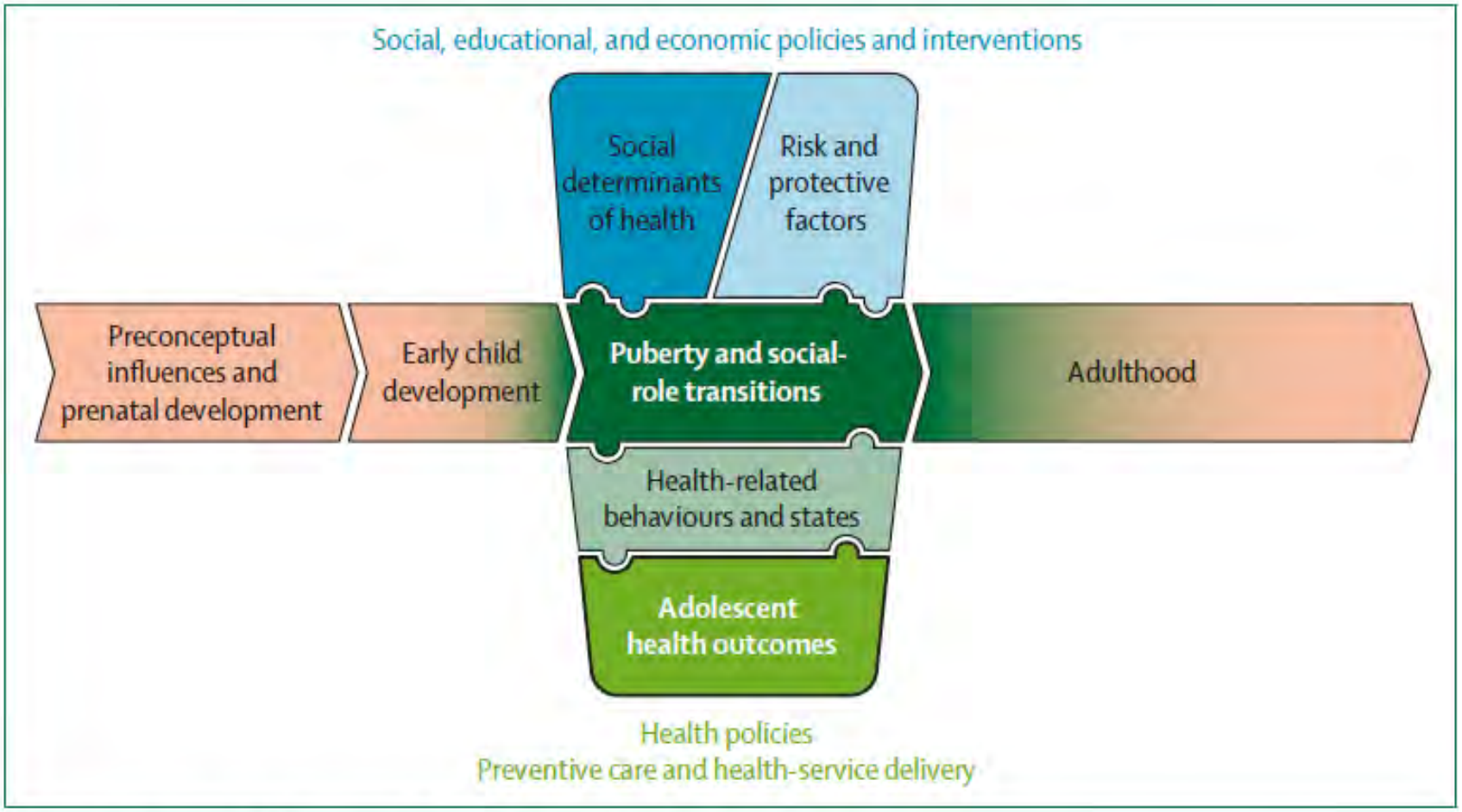
Colorado Family Planning Initiative: https://www.colorado.gov/pacific/cdphe/reducing-unintended-pregnancy;

Juvenile Detention Alternatives Initiative

- Juvenile Detention Alternatives Initiative (JDAI): diversion program where low-risk youth are diverted from detention to community-oriented options (http://www.in.gov/idoc/dys/2407.htm)
- Indiana leading the nation in JDAI efforts
  - 50+% reductions in juvenile detentions
  - DOC commitments down 37% in 2013
  - Millions of dollars saved previously used for incarceration
- Best approaches
  - Involvement of family
  - Multisystemic therapy (Tippecanoe County)

Schwalbe CS, Gearing RE, MacKenzie MJ, Brewer KB, Ibrahim R. A meta-analysis of experimental studies of diversion programs for juvenile offenders. Clinical Psychology Review 2012, 32(1), 26-33.

Conceptual framework for adolescent health



Sawyer SM, Afifi RA, Bearinger LH, Blakemore SJ, Dick B, Ezeh AC, Patton GC. Adolescence: a foundation for future health. *Lancet* 2012; 379: 1630-40.

Nurse-family partnership program effects on adolescent girls

- Study design: Randomized trial (N=310 youth from 400 families enrolled in the Elmira NFP program)
- Intervention: 9 home visits (range, 0-16) during pregnancy and 23 (range, 0-59) from birth through 2nd birthday
- Benefit to adolescent GIRLS of women in the pregnancy/ infancy nurse-visited group, compared to control group
  - FEWER arrests (10% vs. 30%)
  - FEWER convictions (4% vs 20%)
- Girls born to unmarried and low-income mothers, compared to comparison group counterparts
  - FEWER children (11% vs. 30%)
  - LESS Medicaid use (18% vs. 45%)

Eckenrode J, Campa M, Luckey DW, Henderson CR, Cole R, Kitzman H, Anson E, Sidora-Arcoleo K, Powers J, Olds D. Long-term Effects of Prenatal and Infancy Nurse Home Visitation on the Life Course of Youths19-Year Follow-up of a Randomized Trial. *Arch Pediatr Adolesc Med* 2010;164(1):9-15.

Early childhood education: Abecedarian Project

- Study design: Randomized controlled trial; N=111 young people from predominantly low-income families
- Intervention: full-day, year-round child care given 5 days a week for 5 years (from age 0–5 years with a structured curriculum)
- Results:
  - LESS teenage parenthood (26% *vs* 45%)
  - MORE years of education by age 21 years (12·2 *vs* 11·6 years)
  - MORE likely to be enrolled in a 4 year college (35·9% *vs* 13·7%)
  - MORE likely to be in school at age 21 years (42% *vs* 20%)
  - MORE likely to hold a better job (47% *vs* 27%)
  - LESS likely to report past-month marijuana (18% *vs* 39%)

Campbell FA, Ramey CT, Pungello E, Sparling J, Miller-Johnson S. Early childhood education: young adult outcomes from the Abecedarian Project. *Appl Dev Sci* 2002; 6: 42–57.

Early childhood education: Chicago Child-Parent Center program

- Study design: Quasi-experimental design; N=1539 young people
- Intervention: early childhood program including half-day preschool for children aged 3–4 years, half or full-day kindergarten, and full-day services for children aged 6–9 years
- Results at age 20:
  - MORE high school completion (50% *vs* 38%)
  - FEWER arrests (17% *vs* 25%) and violent arrests (9% *vs* 15%)
  - LOWER school dropout rates (47% *vs* 55%)

Reynolds AJ, Temple JA, Robertson DL, Mann EA. Long-term effects of an early childhood intervention on educational achievement and juvenile arrest: a 15-year follow-up of low-income children in public schools. *JAMA* 2001; 285: 2339–46.

Early childhood education: Chicago Child-Parent Center program

- Study design: Quasi-experimental design; N=1539 young people
- Intervention: early childhood program including half-day preschool for children aged 3–4 years, half or full-day kindergarten, and full-day services for children aged 6–9 years
- Results at age 24:
  - MORE school completion (71% *vs* 64%)
  - MORE attendance in 4 year colleges (15% *vs* 10%)
  - FEWER felony arrests (16% *vs* 21%), felony convictions (16% *vs* 20%), and incarceration rates (21% *vs* 26%)

Reynolds AJ, Temple JA, Ou SR, et al. Effects of a school-based, early childhood intervention on adult health and well-being: a 19-year followup of low-income families. *Arch Pediatr Adolesc Med* 2007; 161: 730–39.

Early childhood education: Chicago Child-Parent Center program

- Study design: Quasi-experimental design; N=1539 young people
- Intervention: early childhood program including half-day preschool for children aged 3–4 years, half or full-day kindergarten, and full-day services for children aged 6–9 years
- Results at age 28:
  - HIGHER income (US$11,582 *vs* $10,796), occupational prestige (28% *vs* 21%)
  - LESS substance abuse (14% *vs* 19%), drug and alcohol abuse (16% *vs* 23%), arrests (48% *vs* 54%), felony arrests (19% *vs* 25%), and incarceration rates (15% *vs* 21%)

Reynolds AJ, Temple JA, Ou SR, Arteaga IA, White BA. School-based early childhood education and age-28 well-being: effects by timing, dosage, and subgroups. *Science* 2011; 333: 360–64.

~~Big problem~~

Huge opportunity

This generation of adolescents and young adults can transform all of our futures; there is no more pressing task in global health than ensuring they have the resources to do so.

What 1 800 000 000 adolescents are facing in the world today:

Youth unemployment

Armed conflict

Promotion of unhealthy lifestyles

Less stable families

Environmental degradation

Mass migration