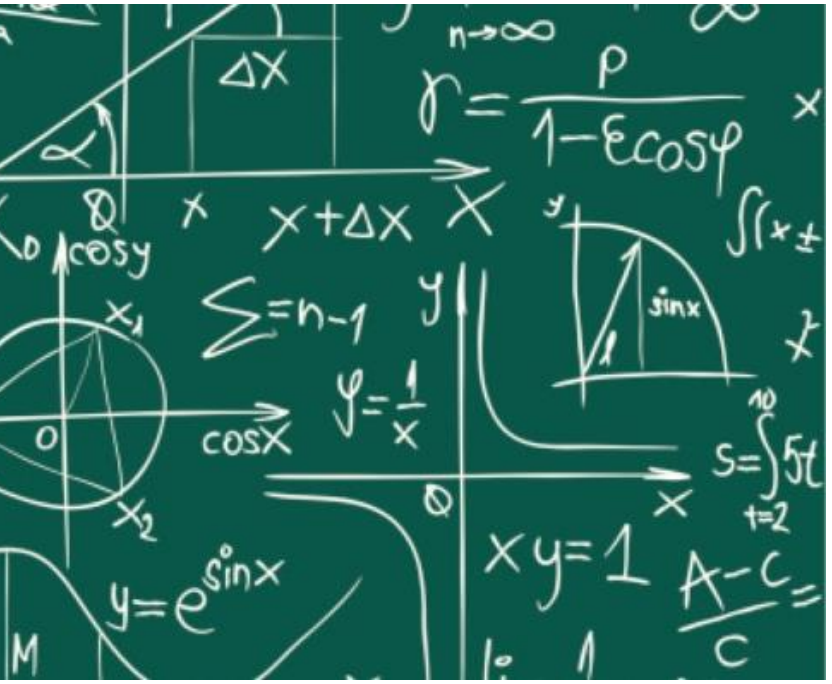
Mathematical abilities and life success



Tina Bregant, MD, PhD

University Rehabilitation Institute of Republic Slovenia

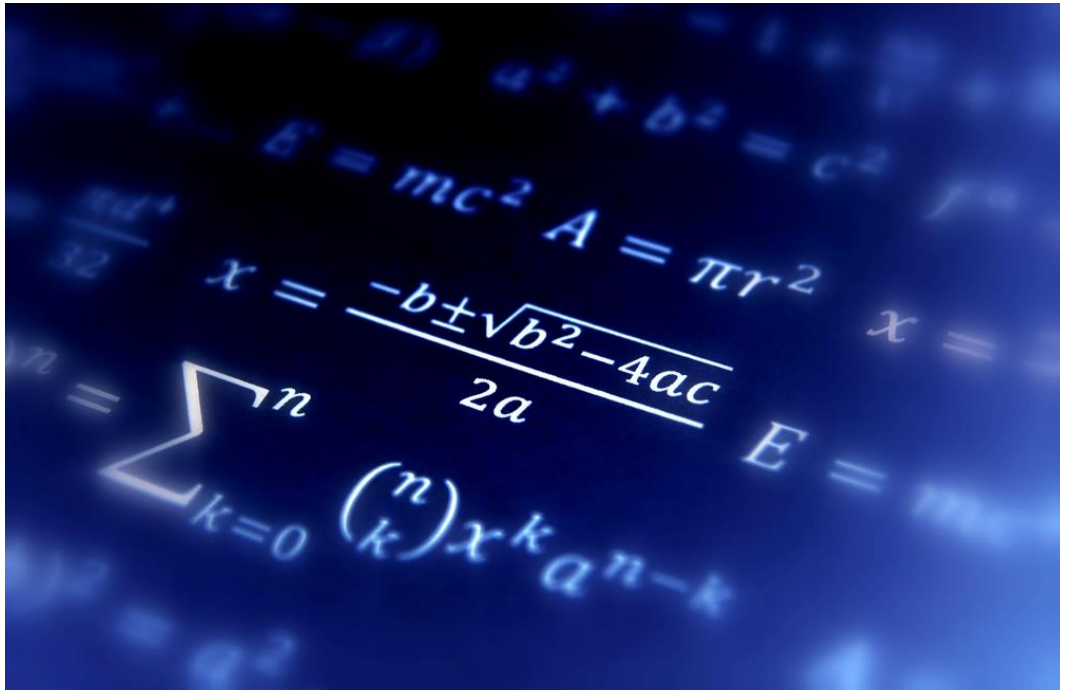
KUPM 2016, Brdo pri Kranju, 16th-17th November 2016

Conference on Learning and Teaching Mathematics 2016

- Eleanor Roosvelt in 1930: “What is the purpose of education? This question agitates scholars, teachers, statesmen, every group, in fact, of thoughtful men and women."

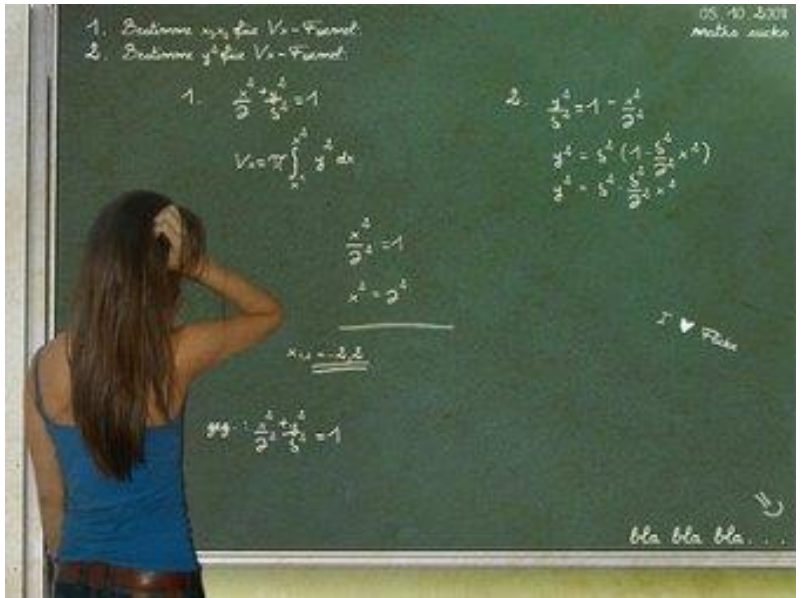
Goals

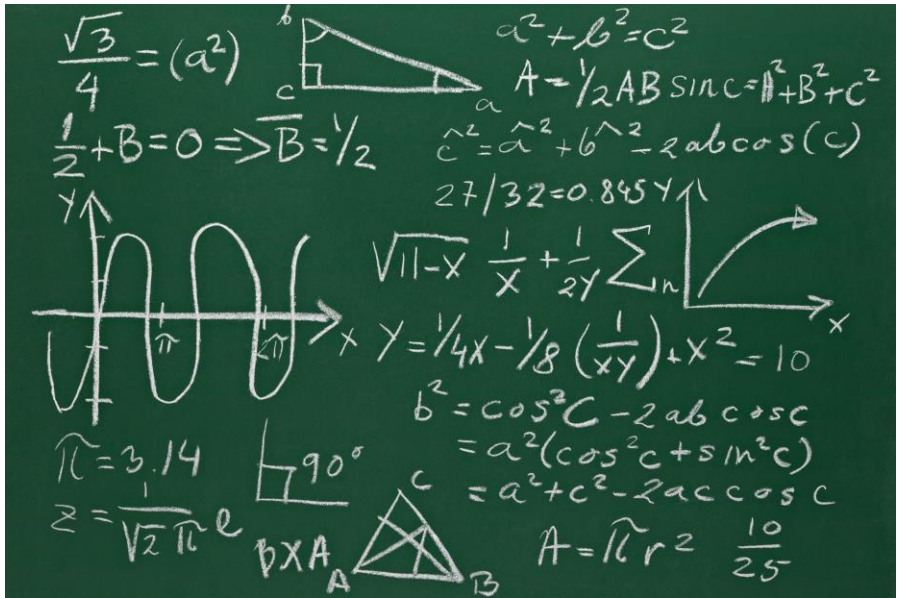
- Provide an overview of research studying mathemathical abilities through a developmental perspective
- Find the key to life success?
- Study the link between mathemathical abilities and academic success; high-rated employement (bigger salaries); socio-economic influence



Objectives

- Define mathemathical abilities
- Understand the difficulty in defining life-success
- Measuring unmeasurable - „soft“ outcomes
- Understand mathemathical abilities as a brain function
- Give an overview of how to nurture mathemathical abilities





Mathemathical abilities

Learnt or inborn capabilities to process numerical data and conclude a mathematical calculation based on that data

Mathematics is empowering –

discovering the wonderful feeling of knowing thing

for certain, the proverbial “mathematical certainty

Like music:

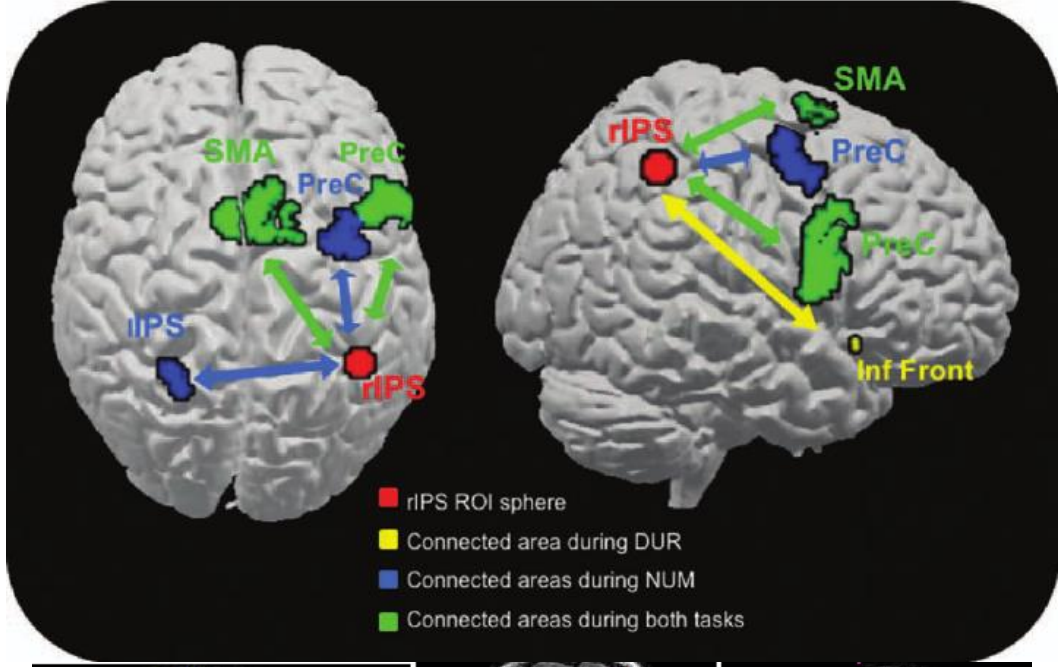
- a personality-building activity
- shapes the way the learner thinks and sees the world
- has a profound educational impact
- Depends on systematic, cumulative learning, and each new skill needs to be built on a solid foundation laid at earlier stages

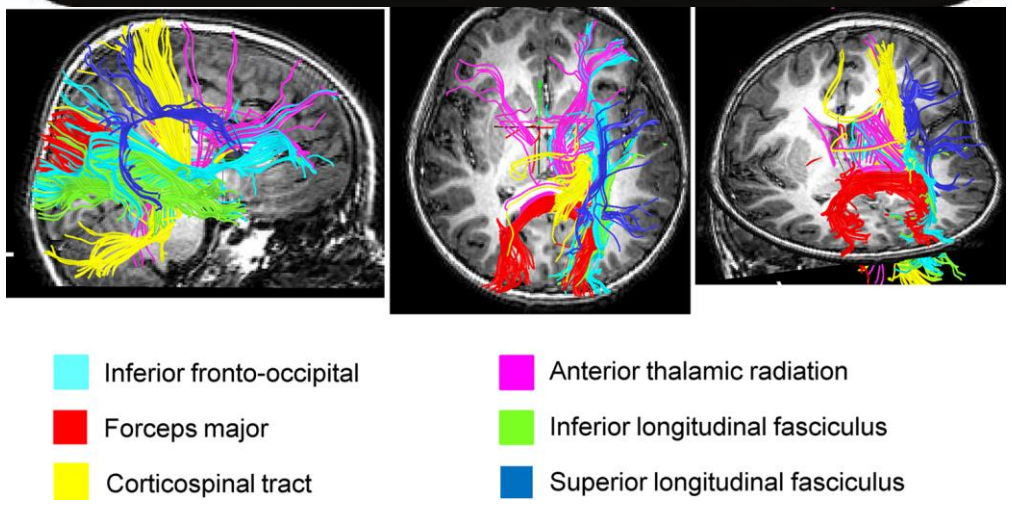
Innate (inborn) ability

- Innate to teritorrial animals - ability to recognize quantity
- Widely spread in the population at large (social, ethnic)
- Different mathematical traits appear at different ages

Mathematics in brain - IPS

- All domains of mathematics (algebra, analysis, geometry, and topology) recruit a bilateral network, of prefrontal, parietal, and inferior temporal regions = region which is activated when numbers are mentally recognized and manipulated.
- High-level mathematical thinking makes minimal use of language areas and instead recruits circuits initially involved in space and number.
- Amalrica M, Dehaenea S. Origins of the brain networks for advanced mathematics in expert mathematicians. PNAS; 113 (18): 4909–4917. doi: 10.1073/pnas.1603205113





Human Brain Mapping 33(6):1490-501 · June 2012
DOI: 10.1002/hbm.21300. A common right fronto-parietal network for numerosity a processing: An fMRI study
Front. Hum. Neurosci., 24 November 2009 | doi: 10.3389/neuro.09.051.2009
Neuroanatomical correlates of developmental dyscalculia: combined evidence from morphometry and tractography

Predictor of success in preschool years

- Mathematical abilities = a manifestation of brain function.
- An indepth high-level mathematical thinking requires minimal use of language areas - it recruits circuits initially involved in space and number processing instead. Since these are the circuits which are active during early years of development, thi could be the reason, why knowledge of number and space, already during early childhood, predicts later mathematical achievement.

Mathemathical abilities  life success

A continuous spectrum:

- **the top 20% in the school:**

end up in: engineering, information technology, the financial sector, etc.

sufficiently large group to warrant the allocation of resources to be supported and nurtured within every school

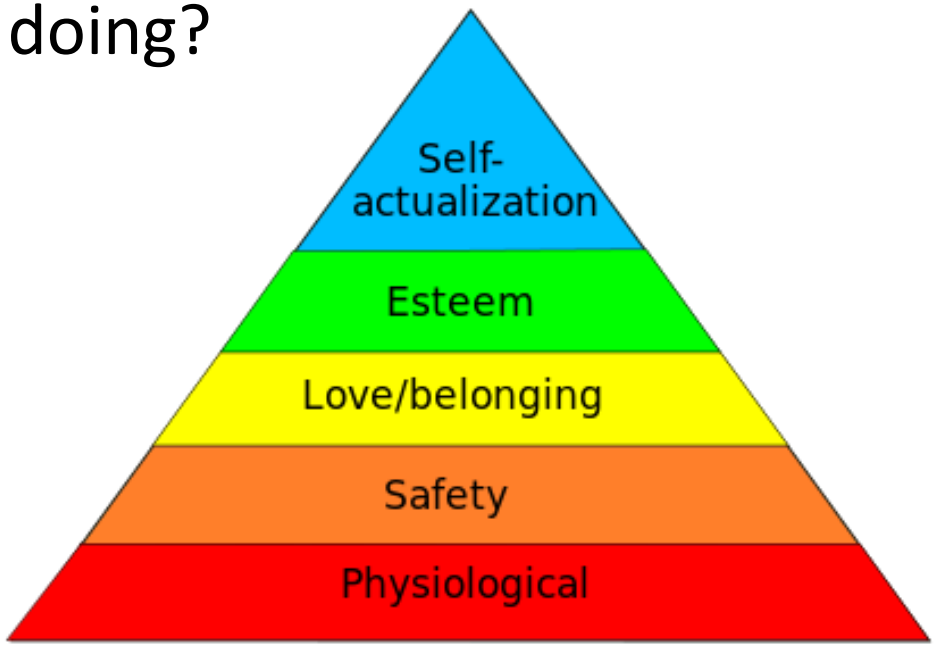
we need some of the top 20% (and the best of them) to return to school as teachers of mathematics.

- **top 1% in the school:**

professional academic community, mathematicians and computer scientists, users of advanced “hardcore” mathematics in science, engineering, biotechnology and the financial sector

Life success

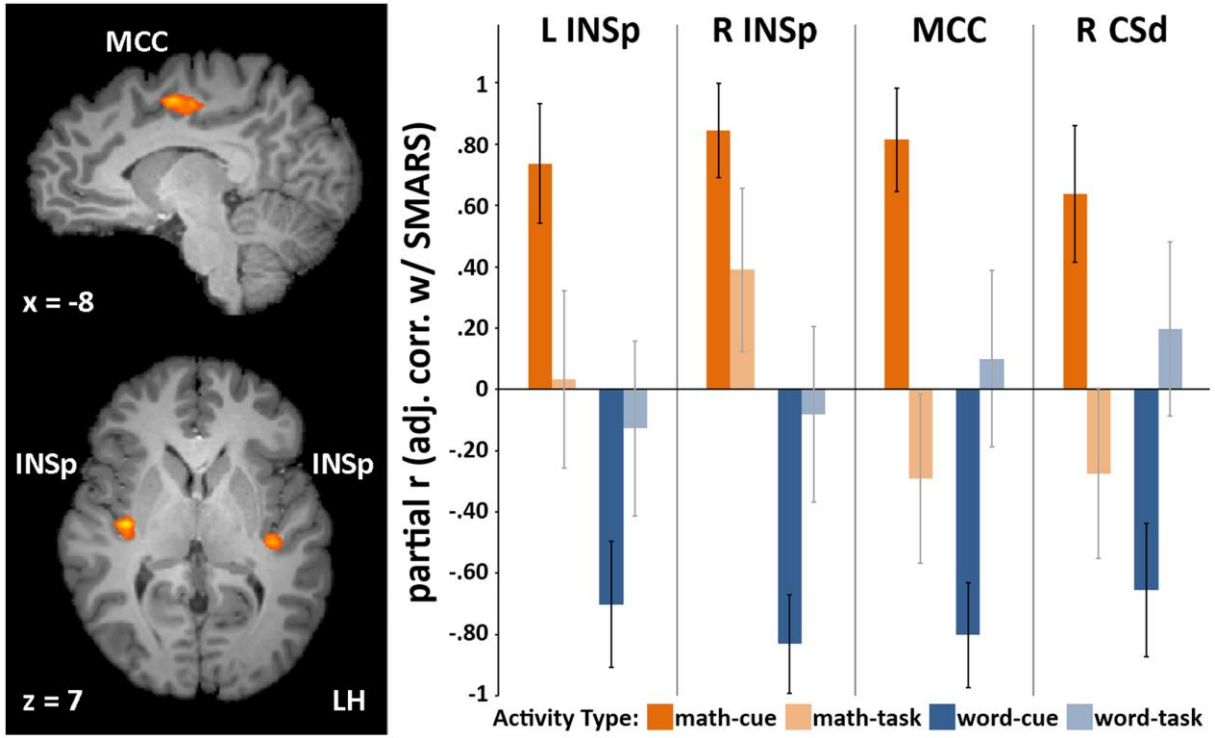
- Subjective notion
- SES, payment, educational level, happiness, drug consumption, number of children...
- What about if the higher you are on Maslow's hierarchy of needs, the better you are doing?



Literacy and numeracy problems have a robust structure of life course associations

- Prolonged education has significant long-term health benefits for all children, such as reduced risk of dying between the ages of 40 and 70 years of age, particularly from cancer, ischaemic heart disease, and accidents.
- Higher literacy and numeracy mean better health in general.
- Knowing that numeracy and literacy at school completion predict employability and wages in adulthood (basic quantitative and preliteracy skills at school entry presage numeracy and literacy at school completion) ->
- Mathematical skills for academic achievements, general health, and socioeconomic status on individual level.

Mathemathics anxiety - pain network activation



Feelings of dread, fear of mathematics:

- psychological epiphenomena OR
- visceral sensation – such as pain

When anticipating an upcoming math-task, the higher one's math anxiety, the more one increases activity in regions associated with visceral threat detection, and often the experience of pain itself (bilateral dorso-posterior insula).

Not during math performance but rather, the anticipation of math is painful

Lyons IM, Bellock SL. When Math Hurts: Math Anxiety Predicts Pain Network Activation in Anticipation of Doing Math. PLOS

•Published: October 31, 2012; http://dx.doi.org/10.1371/journal.pone.0048076

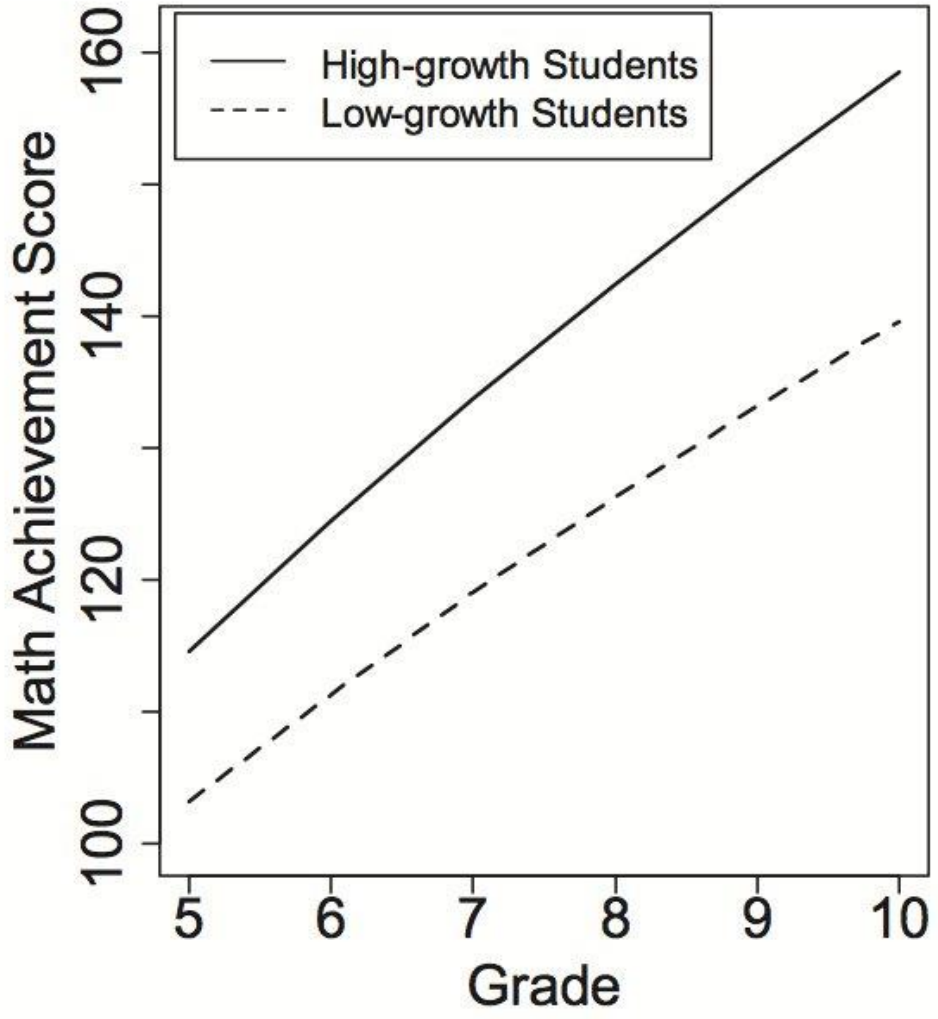
Women are not for mathemathics

- Women who believed their math skills were fixed and unchangeable showed less math identification and less interest in math tasks than women who believed their math skills were malleable.
- Women with fixed-trait beliefs are more likely to fall prey to the gender gap that exists in mathematics fields.



Burkley M, Parker J, Stermer PS, Burkley E. Trait beliefs that make women vulnerable to math disengagement. Personality and Individual Differences 2010; 48 (2): 234–238.

IQ + believing in malleable talent for math



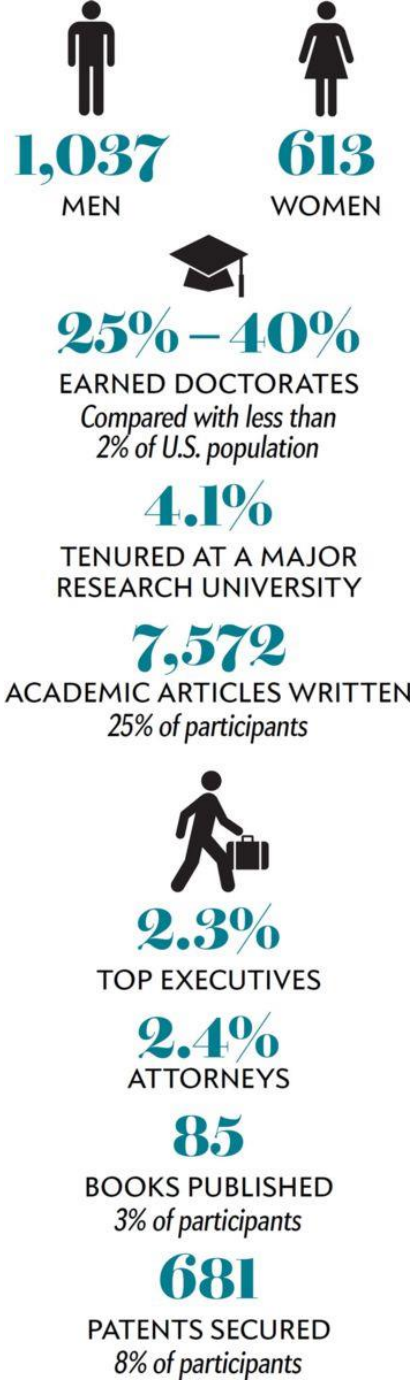
- 3,520 students for five years — from 5th grade till 10th grade
- Performance measure on the PALMA Mathematics Achievement Test (basic arithmetic, algebra, and geometry).
- Self-assessment: study habits and interest in math.
- High-growth students believed they could get better at math the more they practiced and used in-depth study techniques.
- Students listed as low-growth were more likely to believe that math ability is something you're born with and it can't be improved, and they relied more on memorization when studying.

- BUT
- a high IQ generally meant a high math score!
- Intelligence is strongly linked to students' math achievement, but only in the initial development of competence in the subject

Mathemathics prodigy

1970s USA researchers identified 13-year-olds who were exceptionally talented in math (the top 1 percent of mathematical reasoning scores on SAT tests) -> 40 years: wunderkinder are now midcareer:

“For both males and females, mathematical precocity early in life predicts later creative contributions and leadership in critical occupational roles.”

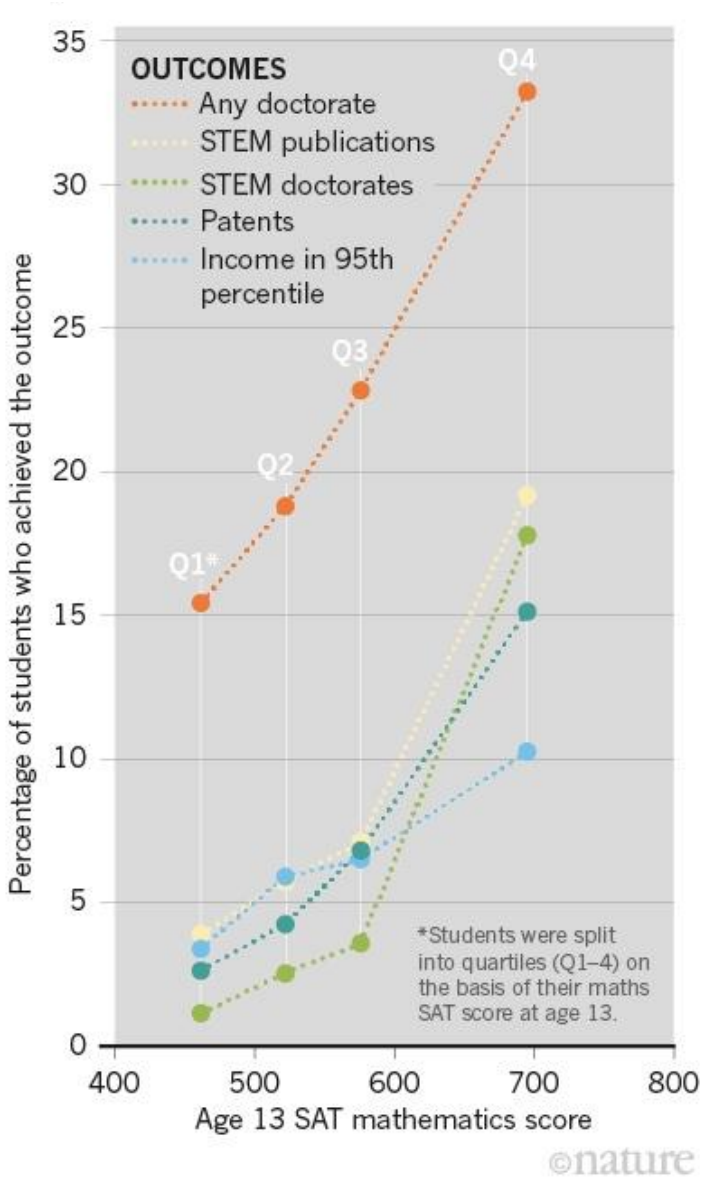


Lubinski D, Benbow CP, Kell HJ. Life paths and accomplishements of mathemathically precocious males and females four decades later. Psychological Science 2014; 25 (12).

How to raise a genius: lessons from a 45-year study of super-smart children

Clynes T. A long-running investigation of exceptional children reveals what it takes to produce the scientists who will lead the twenty-first century. Nature 2016; *537:* 152-155.

The Study of Mathematically Precocious Youth (SMPY) founded by Julian C. Stanley, on 1 September 1971, at Johns Hopkins University. Camilla P. Benbow and David Lubinski co-direct SMPY at Peabody College of Vanderbilt University. https://my.vanderbilt.edu/smpy/



How to nurture mathemathical abilities?

- Sweden (large group experiment):
- the government proposed new school system from 1949 to 1962
- all 1.2 million children were set on one of two paths:
- compulsory for 9 years or mandatory schooling for 8 years, with the most academically gifted children remaining in school for up to 10 years
- -> new, prolonged education for all children in 1962.
- Because

1) long-term health benefits - reduced risk of dying between the ages of 40 and 70, particularly from cancer, ischaemic heart disease and accidents. The two groups had an identical risk of dying before the age of 40
2) longer schooling – higher literacy
3) higher literacy – better health

Marcus Richards, a cognitive epidemiologist at University College London, followed two cohorts of British children, born in 1946 and 1958: the younger group, which had received an extra year of schooling owing to UK educational reform, had consistently higher literacy. (Other confounding factors?)

How to nurture mathemathical abilities?

- The Munich Longitudinal Study of Giftedness
- 26,000 gifted students in the mid-1980s
- Cognitive factors were the most predictive, but that some personal traits — such as motivation, curiosity and ability to cope with stress — had a limited influence on performance. Environmental factors, such as family, school and peers, also had an impact.
- Smart mum: inteligence inherited by mum?

Chocolate consumption and Nobel Prizes: A bizarre juxtaposition if there ever was one

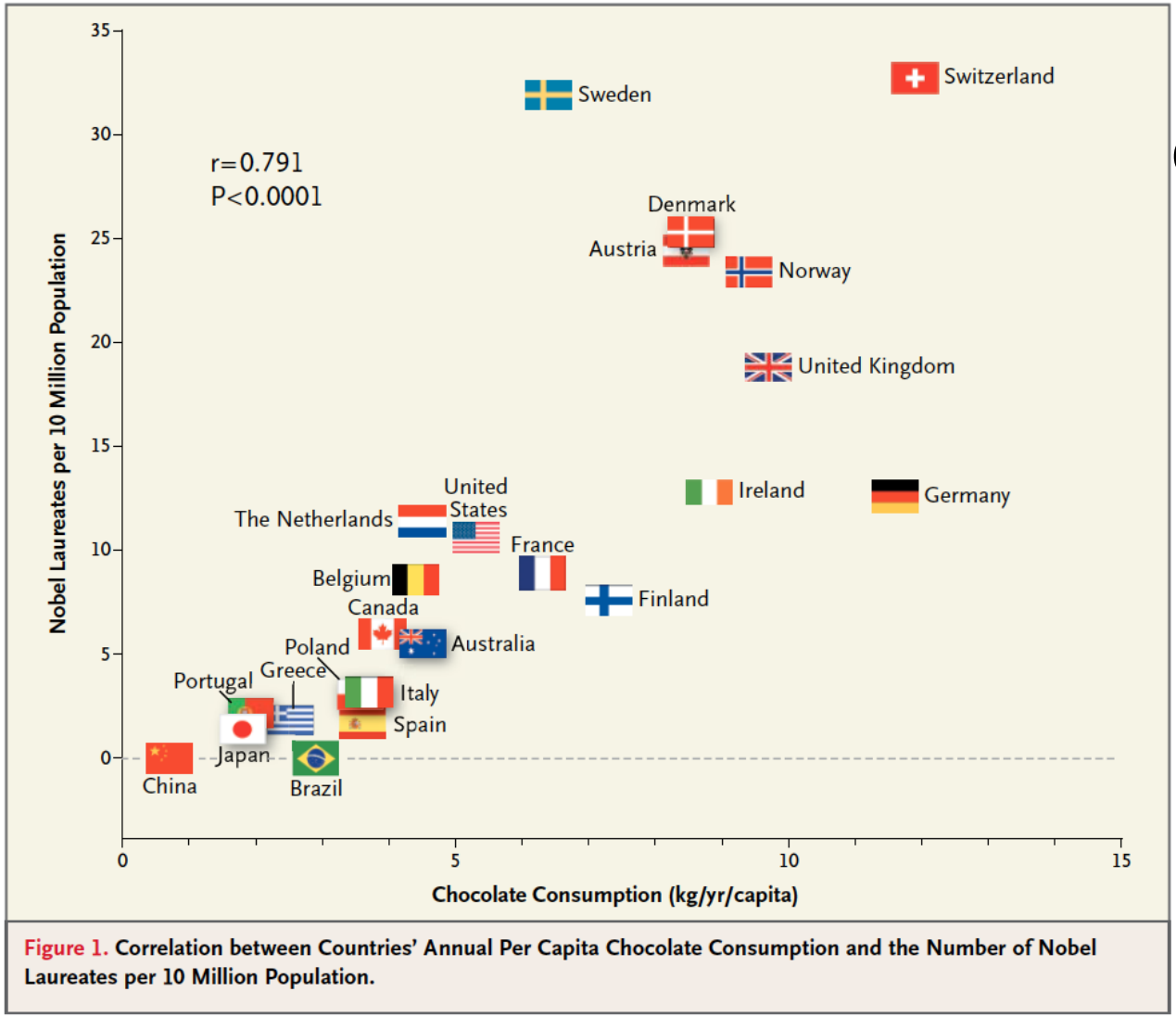


Figure 1. **Correlation between Countries' Annual Per Capita Chocolate Consumption and the Number of Nobel Laureates per 10 Million Population.**

Messerli FH. Chocolate Consumption, Cognitive Function, and Nobel Laureates. N Engl J Med 2012; 367:1562-1564
DOI: 10.1056/NEJMon1211064

Mathematical abilities and life success

- Have a smart, high expectant, working and wealthy mum
- Have a healthy brain (no developmental delays)
- Have high IQ
- Eat chocolate – a lot of it
- Believe in malleable abilities
- Believe in Yourself
- Do chores
- ?

Just enjoy...