Typical & Atypical Cognitive Development

Unit 1. Cognitive development from the Nature-Nurture Perspective

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SOME WORDS ON LAST ASSIGNMENTS

Next two assignments

- Reflection on today's session
- Reading article / Answering questions (Introduction to Neuroconstructivism)
  - See https://seasense.github.io
- Assignments can be done in pairs or independently
  - In case of team work, please send me only one document for each of the two assignments

SOME WORDS ON LAST ASSIGNMENTS

Reflection on Youtube video clip on Synaptic Pruning

- Some examples of your answers
  - Q1: Which metaphor is used for the notion of Synaptic Pruning?
    - A: *"A city with many smaller streets is difficult to navigate, thus there needs to be a better way to explore it. When the best route is found it becomes more highly used and needs to be widened, in the expense of other smaller routes."*
  - Q2: Briefly express this process in your own words
    - A: *"When we are born we have a lot of synapses, but it can't last forever. We have interests and we make choices, and that way, strengthen certain synapses in our brain, the others that we don't use, disappear."*

SOME WORDS ON LAST ASSIGNMENTS

Reflection on Youtube video clip on Synaptic Pruning

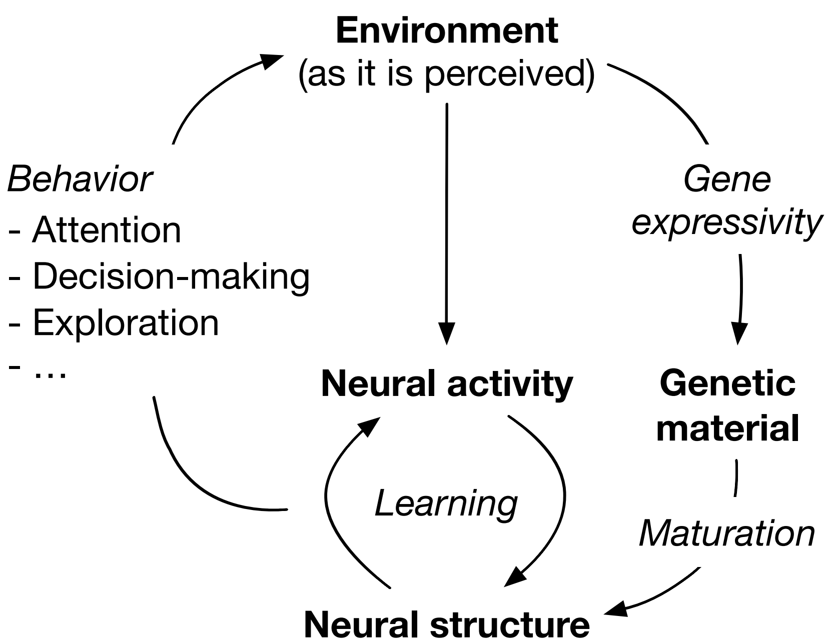
- Some examples of your answers
  - Q3: Why does synaptic pruning imply an impact of education on cognitive development ?
    - A: *Because education helps shape our thought patters and strengthening and weakening certain connections in our brain. The methods we use to learn new things is a pattern in our brain that develops in the time the child goes to school. The teachers, with their methods of teaching, can shape the way a child learns and processes new information. The more the child uses these methods to process information the stronger the connections involved will get*.

SOME WORDS ON LAST ASSIGNMENTS

Article of Tucker-Drob et al. (2013): Gene-Environment Interplay

- Some examples of your answers
  - Q1: Describe in your own words the transactional model
    - A: "…so this idea says that cognitive development is like a circular process, where genes make people choose the best environments for themselves and this affects their experiences and development and helps to develop their genetic aptitudes better."
  - Q2: Which group of children exhibits the largest estimates of heritability
    - A: *"The largest estimates of heritability obtained for older children and adolescents from economically advantaged homes – that is, among children who have the autonomy to select environmental experiences according to their own interests"*.
  - Q3: Educational implications
    - A: "*The possible implications of low SES should be explained to teachers so that they can make an educated effort to counteract it by creating high quality environments for all children so they have the opportunity to fulfil their potential.*"

NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL



Two main developmental processes:

1. Maturation: Change in behavioral potential based on growth processes precoded in our genes
2. Learning: Change in behavioral potential based on experience

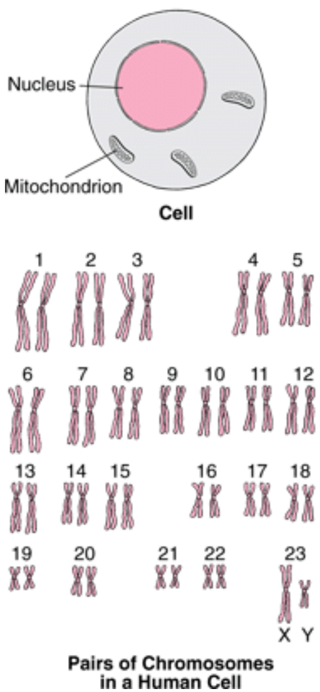
Age-old Empiricist-Nativist Debate

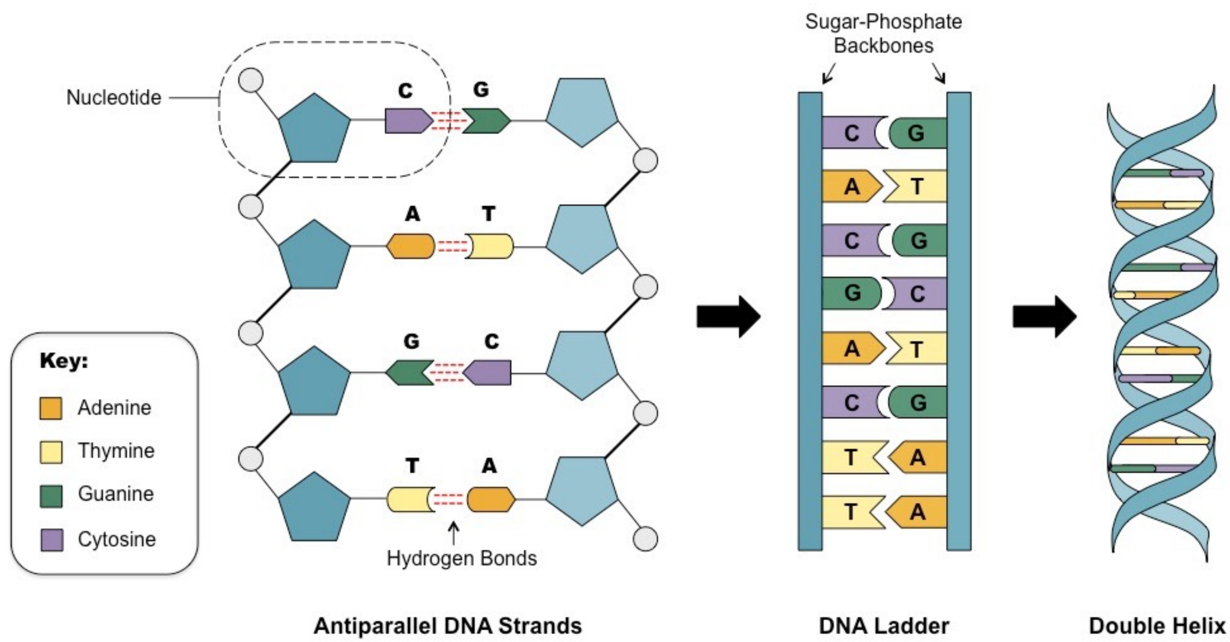
- Empiricists: All knowledge comes from experience (learning)
- Nativists: Important aspects of knowledge and knowing are innate (result of maturation)

NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

Two main developmental processes: Maturation & Learning

1. Maturation: Growth process precoded in our genes
   - Gene → Protein → Organic structure
     - Gene: DNA-based instruction inside the nucleus of how to combine amino acids to build proteins





NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

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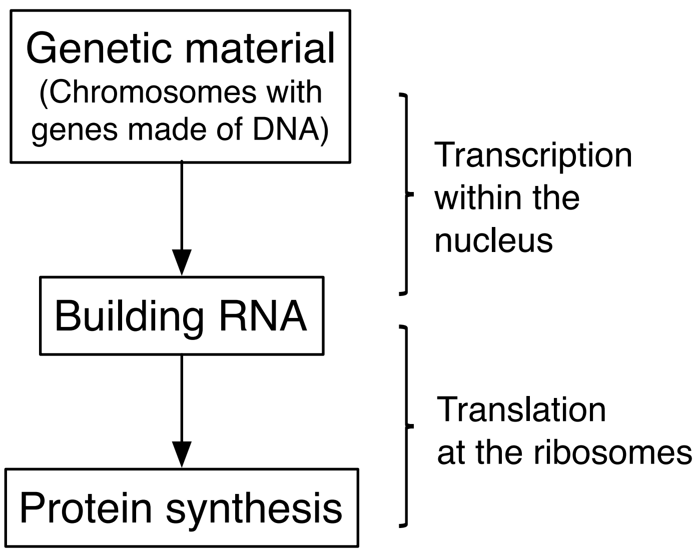
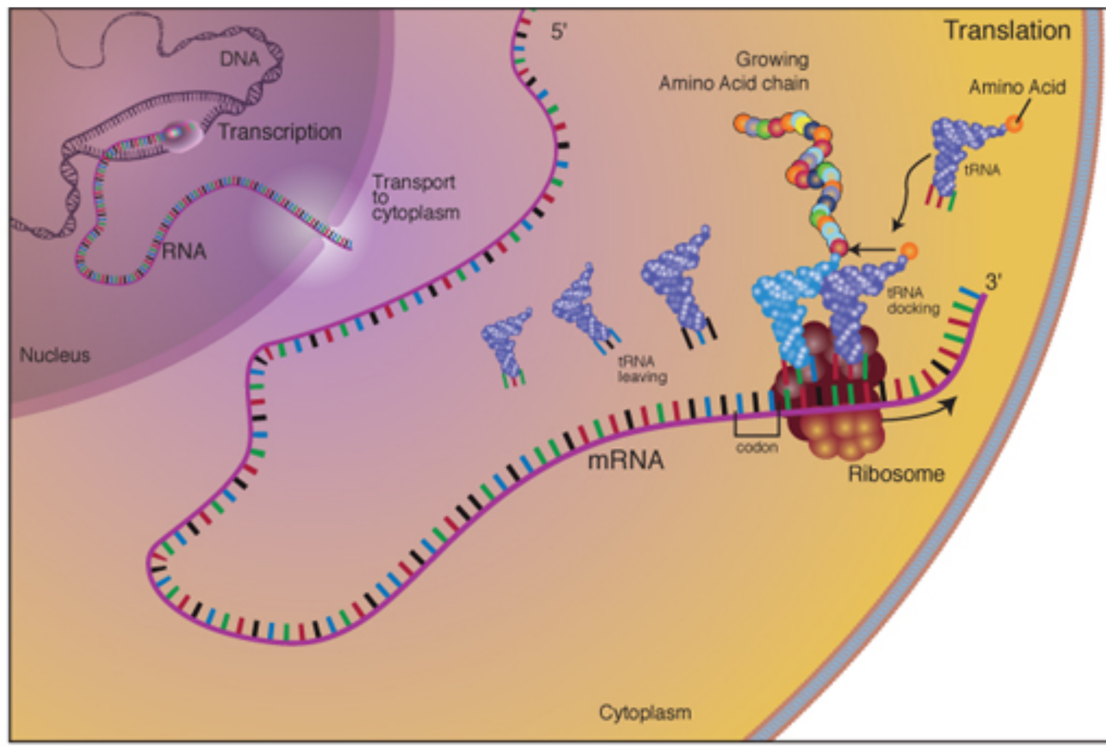


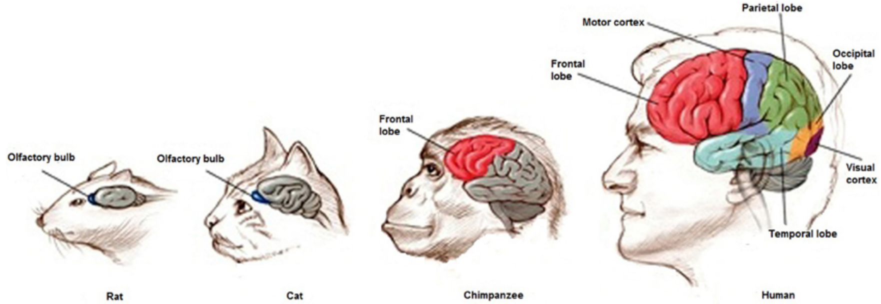


NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

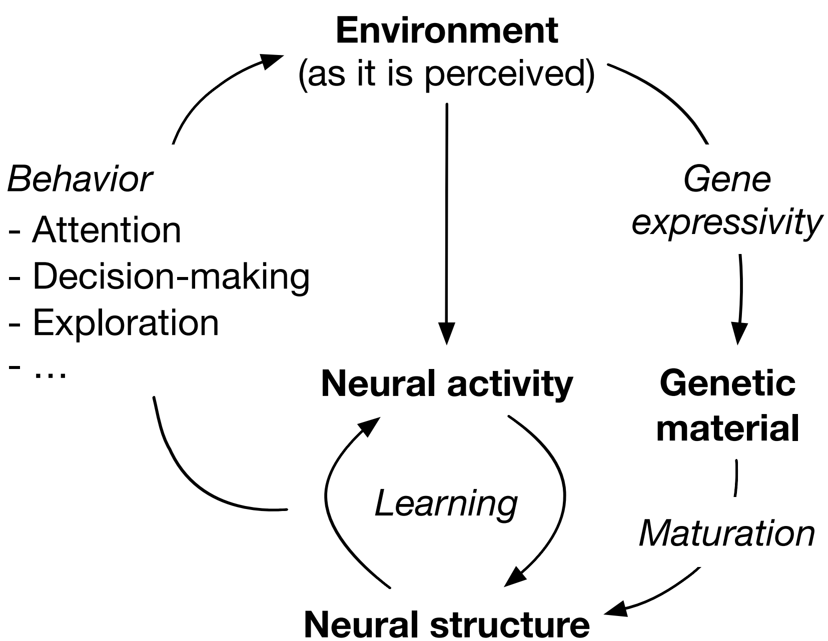
Two main developmental processes

1. Maturation: DNA-coded "time schedule", according to which proteins are synthesized
   - E.g., structural changes in prefrontal cortex from birth to early adulthood (e.g., Luna et al., 2004)
     - Human-specific growth process precoded in our genes
     - Structural changes (e.g., synaptic organization) go hand in hand with improvements in [working memory functions]and inhibitory control (e.g., Luna et al., 2004; Rajan & Bell, 2013)
       - E.g., effectively shielding attention against distraction

→ Behavioral change (e.g., improvements in attention control) due to maturation



NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL



Gene penetrance and gene expressivity

- Extent and likelihood that the gene becomes active
- Depends on environmental influences
  - E.g., study of Wiebe et al. (2009)
    - Interaction between genotype and prenatal exposure to smoking in preschoolers on tasks requiring executive control
    - Children with a particular genotype performed poorly in these tasks, but only if they had been exposed prenatally to tobacco.

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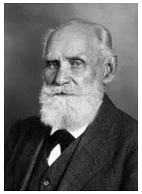
NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

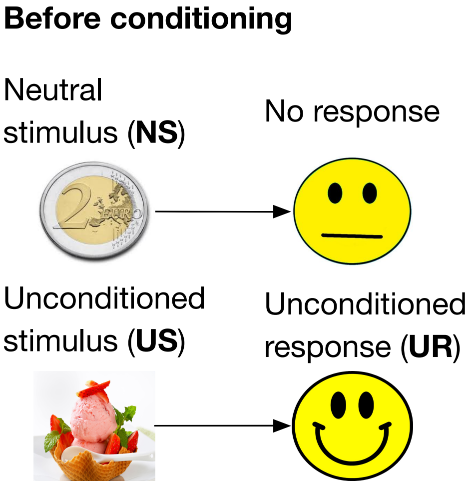
Two main developmental processes: Maturation & Learning

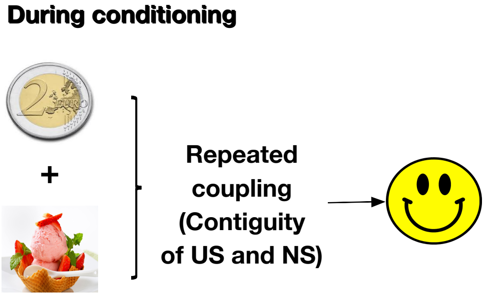
1. Maturation: Change in behavioral potential based on genetically precode growth processes
2. **Learning: Change in behavioral potential based on experience**
   - Example of *Classical Conditioning*: based on probably most universal learning principles

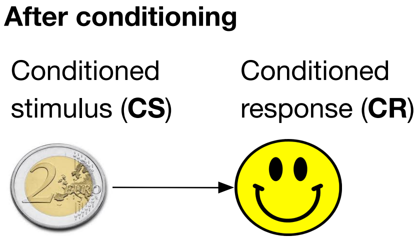


Iwan Petrowitsch Pawlow (1849-1936)

- Nobel prize for physiology
- Fundamental principles of behaviorist learning theory







Evaluative conditioning

- Type of classical conditioning
- How during **socialization**, materials/products take on affective values

NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

Two main developmental processes: Maturation & Learning

1. Maturation: Change in behavioral potential based on genetically precode growth processes
2. **Learning: Change in behavioral potential based on experience**
   - Example of *Classical Conditioning*: based on probably most universal learning principles
     - Physiological basis of classical conditioning: **Synaptic plasticity**

Eric Kandel (born 1929)

- Nobel prize for studying synaptic plasticity in **Aplysia Californica**
  - Only 20.000 neurons (human: 16 billion)
  - Cell bodies up to 1mm
  - Ideal research objects to study biological basis of reflexes and how they change through classical conditioning

Gill Withdrawal Reflex (GWR)

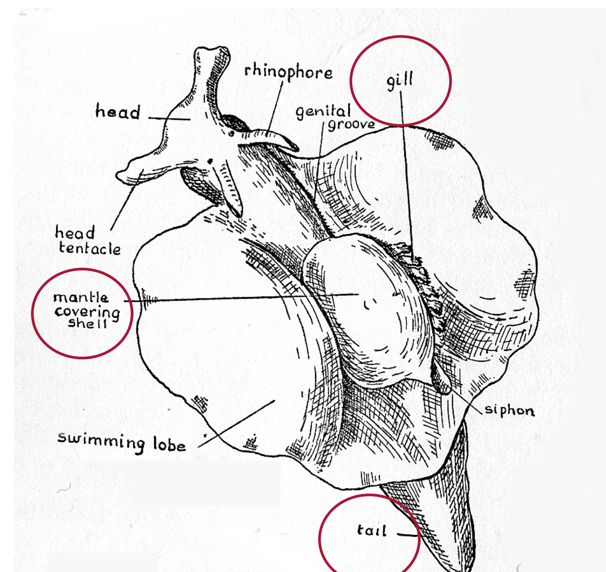


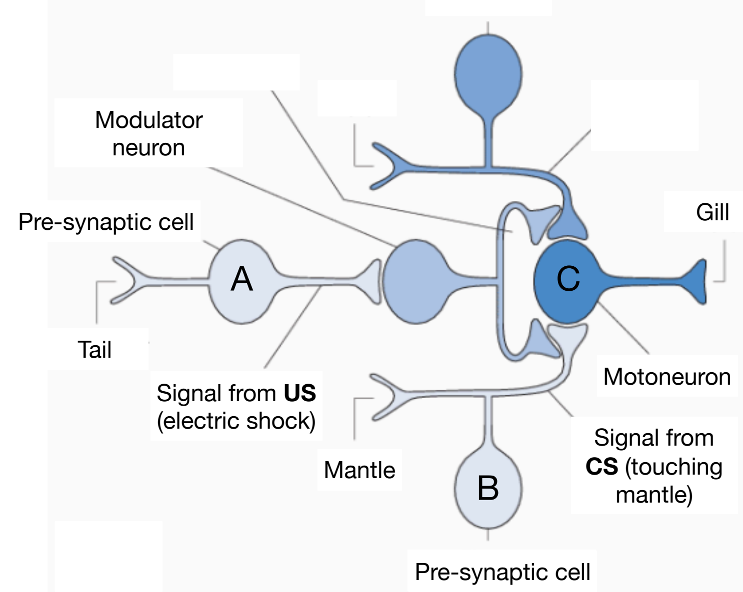
Fig. 1 External characters of *Aplysia*

NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

Synaptic plasticity directly observed in Aplysia

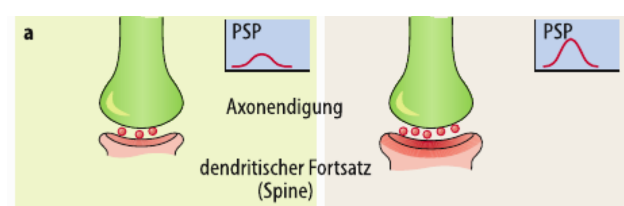
- **Gill Withdrawal Reflex** (**GWR**; genetically encoded, based on **maturation**): triggered by touching the mantle shelf
- If touching the mantle is coupled repeatedly with an electric shock provided at the tail, GWR increases in strength (= **Classical Conditioning**).

Neural system underlying GWR and classical conditioning



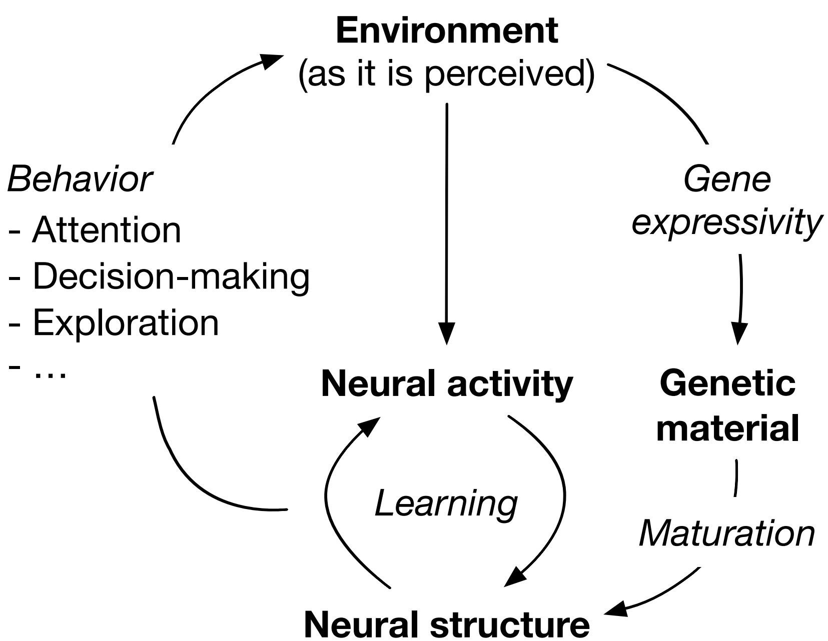
- Learning rule of Hebb: "**What fires together, wires together**"
  - Typically, 3 neurons involved: 2 pre- and 1 post-synaptic neuron
  - The act of firing of the post-synaptic cell (**C**), increases the strength of connection to all other cells involved (i.e., **A** and **B**) → Increased GWR even without the electro shock

Synaptic plasticity



Before After

NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL



- Classical conditioning as a fundamental and universal learning process
  - Change in neural structure (synapses) through environmental influences on neural activity (cells firing together)
  - Similar across different species (from snails to humans)
  - Central to the understanding of more complex and higher level cognitive processes in neural networks (see next unit)

NEUROCONSTRUCTIVIST INTERPRETATION OF THE TRANSACTIONAL MODEL

- Developmental processes of maturation and learning cannot be theorized and investigated separately
  - Maturation is affected by new learning experiences (e.g., through new gene activation or altered gene expressivity)
  - Learning operates on already evolved (matured) neural structures

    → Dynamic coupling

    → *An answer to the Empiricist-Nativist Debate?*

- Estimating the effect of genes relative to environmental influences (and vice versa)
  - At different points of an individual's life time
  - Under different contexts (e.g., socio-economical)

→ Methods and concepts of **Behavior Genetics**

BEHAVIOR GENETICS: SELECTED CONCEPTS, TOPICS & RESULTS

Concepts of (quantitative) Behavior Genetics (e.g., Dick & Rose, 2001)

- Heritability $h^2 = Var(G) / Var(X)$
  - $Var(G)$ = Proportion of variance in a certain variable (e.g., executive control function) that can be attributed to **genetic variation**
  - $Var(X)$ = Total variance
    - $Var(X) = h^2 + c^2 + e^2$
      - c^2 = proportion of variance due to **environmental influences shared** by siblings
      - e^2 = proportion of variance arising in **unshared (unique) environmental experiences** that makes siblings differ from one another

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

Concepts of (quantitative) Behavior Genetics (e.g., Dick & Rose, 2001)

- Estimating the different sources of variance by comparing identical twins (IT) and fraternal twins (FT)

  h^2, c^2

  - Comparing Similarity(FT) to Similarity(IT)

  c^2

  - Determining similarity among adopted siblings raised together

  e^2

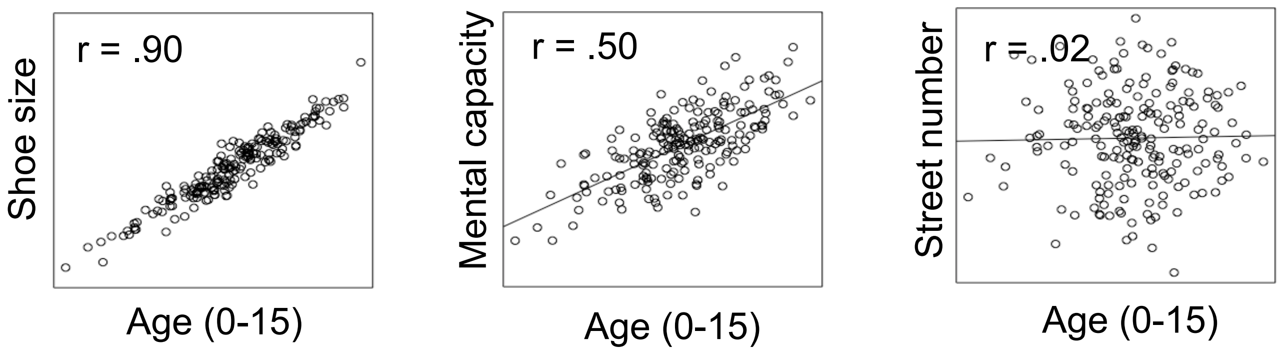
  - Dissimilarity among IT raised together

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

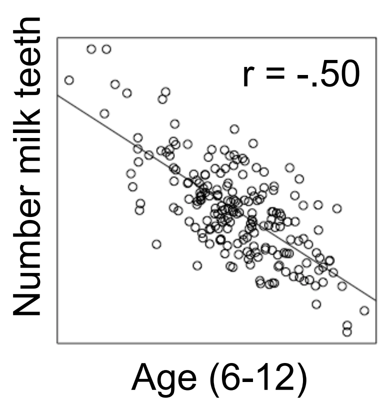
Concepts of (quantitative) Behavior Genetics (e.g., Dick & Rose, 2001)

- Basic statistical concept to quantify similarities: **Correlation coefficient *r***
    - Extent to which a linear relationship between two variables exists

Examples of positive linear relationships



Example of a negative linear relationship



$$r_{xy} := \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 \cdot \sum_{i=1}^{n}(y_i - \overline{y})^2}}$$

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

IQ correlations adapted from Plomin (1988)

	r	*N* (pairs)
Genetically identical		
The same person (retest)	.87	1 456
IT, raised together	.86	1 300
IT, raised separately	.74	169
Genetically related in the first degree		
FT, raised together	.62	1 864
Siblings raised together	.49	1 358
Siblings, raised separately	.40	1 125
Parents-child, living together	.35	3 973
Parents-child, adopted away	.31	1 345
Genetically unrelated		
Unrelated children, raised together	.25	1 601
Adoptive parents-adoptive child	.15	1 594
Unrelated, living separately	-.01	15 086

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

- Such results appear to provide much evidence of a nativist position

> "*Intelligence is mostly a matter of heredity, as we know from studies of identical twins reared apart.*
> *… Social programs that seek to raise I.Q. are bound to be futile.*"

-- Jim Holt, New York Times Sunday Book Review, March 27, 2009

- From a transactional process-viewpoint, however, a more differentiated view would be advocated

> "*We do not think that development is precoded in the genes and merely emerges with maturation. Rather we stress the role of the genotype in determining which environments are actually experienced and what effects they have on the* ***developing person*** *… The ‚end state' of this transactional process – high levels of heritability of cognitive abilities – is therefore expected to differ depending on* ***the quality and availability of environmental experiences****.*" (p.350)

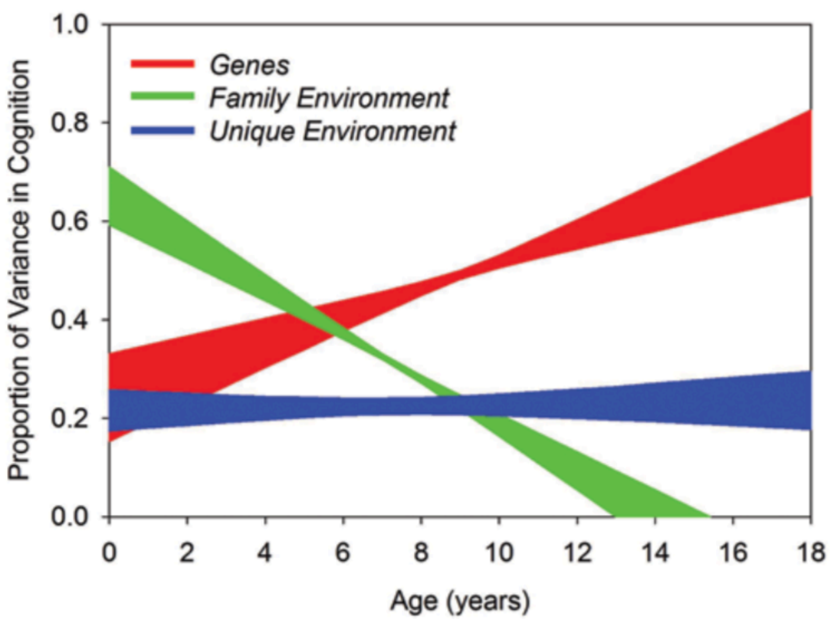
-- Tucker-Drob et al. (2013)

→ How do estimates of heritability change, if developmental stages (i.e., age) and quality / availability of environmental experiences (i.e., SES) are taken into account?

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

Study of Tucker-Drob et al. (2013)

– Estimates of h^2, c^2 and e^2 as a function of **Age**

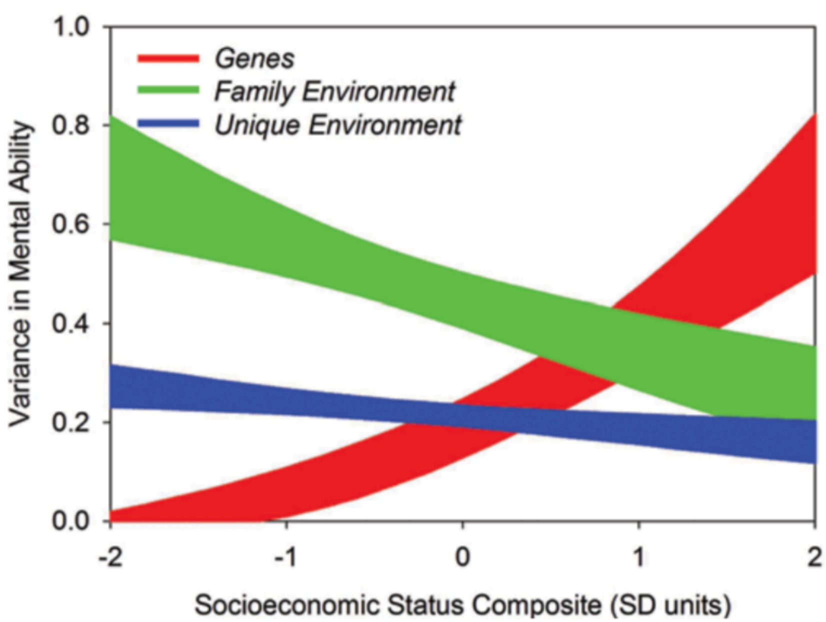


- c^2 decreases throughout development
  - In infancy: 60% and more
  - By adolescence: explaining virtually no variance
- The decrease of c^2 is contrasted by an increase of h^2
  - In infancy: less than 25% explained by genes
  - By adolescence: approximately 70%

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

Study of Tucker-Drob et al. (2013)

– Estimates of h^2, c^2 and e^2 as a function of **Socioeconomic status**



- h^2
  - Low SES: Heritability estimates approach zero
  - High SES: Genes account for as much as 80
- c^2
  - Almost inverse pattern of results

SELECTED TOPICS & RESULTS OF BEHAVIOR GENETICS

Study of Tucker-Drob et al. (2013)

- **Conclusions**
  - Meaningful interpretations of h^2, c^2 and e^2 only when considering interactions between Age and SES
  - The higher a person's autonomy, which increases with age and SES, the more likely the person is to fulfill her or his potential

LITERATURE OF TODAY'S SESSION

Dick, D., & Rose, R. (2002). Behavior genetics: What's new? What's next? *Current Directions in Psychological Science, 11*(2), 70-74. DOI: https://doi.org/10.1111%2F1467-8721.00171

Luna, B., Garver, K., Urban, T., Lazar, N., & Sweeney, J. (2004). Maturation of cognitive processes from late childhood to adult childhood. *Child Development, 75*(5), 1357-1372. DOI: https://doi.org/10.1111/j.1467-8624.2004.00745.x

Tucker-Drob, E., Briley, D., & Harden, K. (2013). Genetic and environmental influences on cognition across development and context. *Current Directions in Psychological Science, 22*(5), 349-355. DOI: https://dx.doi.org/10.1177%2F0963721413485087

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