

Integrating developmental psychology, dynamic systems theory and evolutionary theory



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Interdisciplinary project

Disciplines:

- developmental psychology
- evolutionary developmental (evo-devo) biology

Surplus of interdisciplinary research:

It is well-known that disorders, such as schizophrenia and autism, originate from disturbances during **prenatal** development.

However, we do not know **what** exactly goes wrong, and **why** it goes wrong.

Insights from evo-devo biology contribute to the unraveling of the causes of disturbances during prenatal development.

Evo-devo biologists (e.g., Carroll, 2005) study the interaction between processes at individual and evolutionary time scales. The study of embryological development and how it constrains evolution is a major research subject.



New hypothesis

Autism is the result of disturbances during early organogenesis

Early organogenesis

- During early organogenesis, all organs and limbs start to develop.
- In humans, early organogenesis occurs from day 20 to day 40 after fertilization.
- During early organogenesis, intensive interactions among body parts occur. Other stages do not show these interactions.
- The web of intense interactions at this stage causes many **pleiotropic effects** (i.e., one mutation has several phenotypic effects) elsewhere in the embryo, thus reducing the chance of a favorable mutation.
- Because of the intense interactions, early organogenesis is characterized by **low effective modularity**.

EVIDENCE

Autism co-occurs with errors during early embryogenesis

Critical periods during early embryogenesis have been found for five teratogens and the development of autism (Arndt et al., 2005):

- ethanol
- thalidomide
- valproic acid
- misoprostol
- maternal rubella infection



Autism co-occurs with minor and major congenital anomalies

Major anomalies:

- fragile X syndrome
 - tuberous sclerosis complex
 - Down syndrome
 - neurofibromatosis type 1
- and many others (Zafeiriou et al., 2007)



Animal experiments show similar associations

Rodents prenatally infected with a virus show similar brain patterns and disturbed behavior as people diagnosed with autism (Fatemi et al., 2005)



Suggested readings

- Arndt et al. (2005). *International Journal of Developmental Neuroscience*, 23, 189-199.
- Carroll, S.B. (2005). *Endless forms most beautiful: The new science of evo devo*.
- Fatemi et al. (2005). *Synapse*, 57, 91-99.
- Galis & Metz (2001). *Journal of Experimental Zoology (Mol Dev Evol)*, 291, 195-204.
- Galis et al. (2001). *Trends in Ecology & Evolution*, 16, 637-646.
- Galis et al. (2006). *Evolution*, 60, 2643-2654.
- Ploeger et al. (2008). *Psychological Inquiry*, 19, 1-18.
- Ploeger et al. (2009). *Psychiatry Research*, 166, 85-90.
- Zafeiriou et al. (2007). *Brain & Development*, 29, 257-272.

What is autism?

Features:

- Impairment in social interactions and communication
- Restricted patterns of behavior and interests
- Onset before age 3 years

Prevalence:

1 - 6 per 1,000 children

Heritability:

90% of individual differences in autism can be attributed to genes

Is early organogenesis a vulnerable stage?

- Several teratological studies show that early organogenesis is a critical period for the induction of prenatal mortality in mice and rats (for an overview, see Galis and Metz, 2001).
- When limb and vertebral development (which are established during early organogenesis) are disturbed, many other anomalies occur (for an overview, see Galis et al., 2001; Galis et al., 2006).