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Generative Entrenchments in Cognitive Development and Cultural Evolution: Stepping Stones as well as Obstacles?

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INSTITUTE FOR LOGIC, LANGUAGE AND COMPUTATION

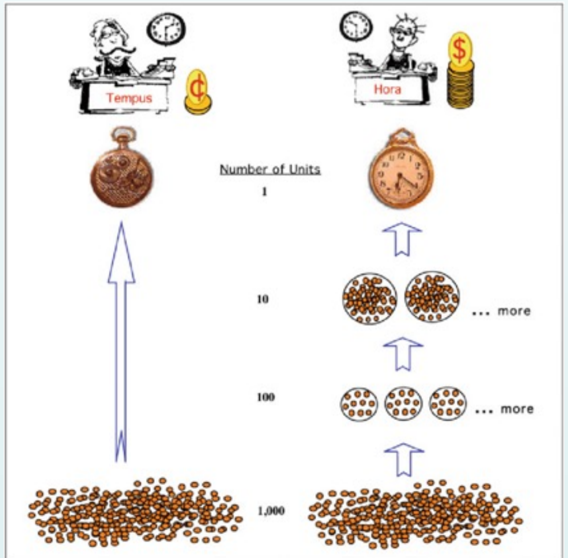
abc amsterdam brain & cognition

Emergence of ‘intermediate stable forms’ in *all* ‘nearly decomposable’ dynamical systems

Dynamical systems will develop an architecture with:

- ‘Intermediate stable forms’: high-level, low-frequency subsystems (*modules)*
- multiple hierarchical layers
- increasingly complexity as a consequence

(Herbert Simon, 1962: The Architecture of Complexity; cf. Wimsatt, 2007)



- **Two fine watchmakers**: Hora and Tempus, who were making equally fine watches, each consisting of 1000 parts. Their popularity attracted many phone calls from customers, interrupting their work and making the partly assembled watch at hand fall apart.
- **The math**: Assuming that the probability of an interrupton occurring while a part is being added to an assembly is 0.01, Hora made 111 times as many complete assemblies per watch as Tempus; Tempus had to make 20,000 as many attempts per completed assembly as Hora.
- **The outcome**: Hora became a rich man, but Tempus went bankrupt.

Intermediate stable forms function as 'generative entrenchments' in evolution

The 'intermediate stable forms' function as 'generative entrenchments' (GE) in evolving systems:

- increasing number of 'down-stream' features that depend upon GE
- GE are more structural, less species-specific features (cf. hox-genes for body-plans)
- impact on processes of change:
  - faster changes when building upon GEs
  - increasing stability of such 'entrenched' features
  - increasing disruptive effect of changes in GE

    (Wimsatt 2007; Lorenz e.a. 2011 'Emergence of modularity in biological systems')

150 R. J. Richards

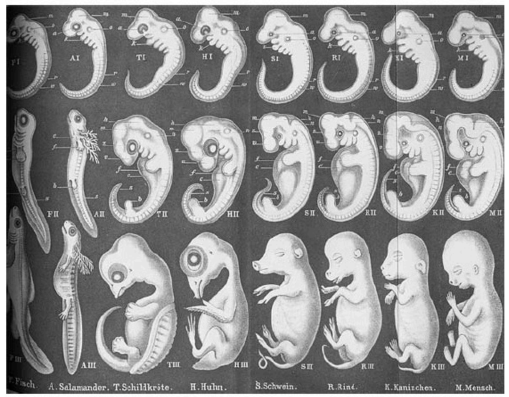


Fig. 2 Illustration from Ernst Haeckel, *Anthropogenie* (1874)

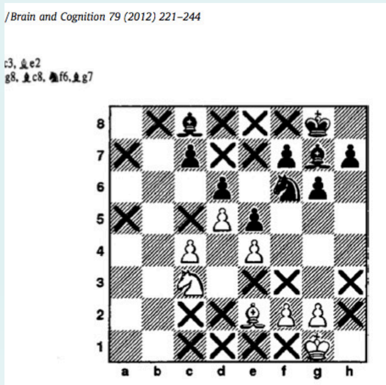
‘Sculpted space of action options’ with complex representations in expert cognition

Learning and development entails a ‘Representational Redescription’ process, implying that experts typically have a <u>‘sculpted space of action options’</u> with:

- more cognitive representations, that are
- more hierarchically-structured and complex
- enabling faster recognition & recall,
- better understanding & response facilitation

than beginners .

(Keestra 2014, 2017 ‘Drawing on a sculpted space of actions’, fig; Karmiloff-Smith & Clark 1998; fig. Guida & Gobet on chess masters 2012)



82 *M. Keestra*

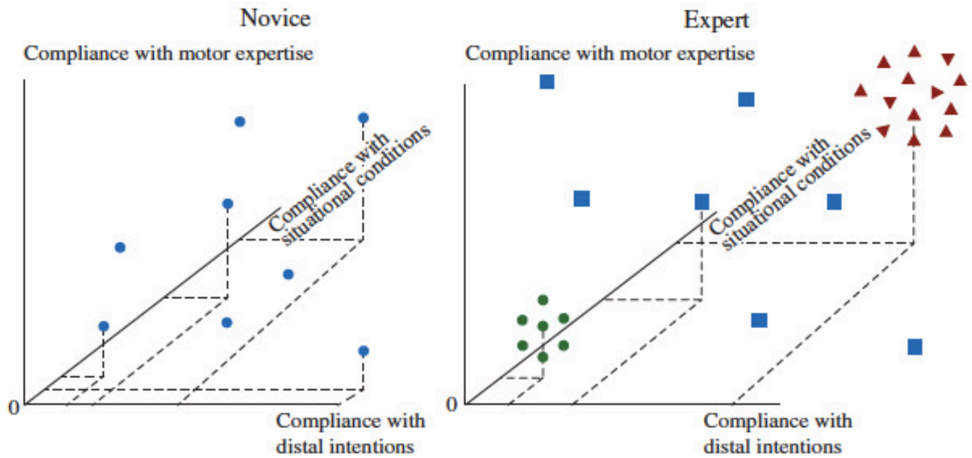


Figure 1: Spaces of Actions of a Novice and an Expert.
[Color figure can be viewed at wileyonlinelibrary.com]
The expert’s space of options for action is sculpted along (at least) three dimensions which represent the compliance of these action options with situational conditions (z-axis), with motor expertise (y-axis), and with distal intentions (x-axis) respectively. This sculpting process entails that an expert’s action options are no longer randomly distributed across the space—as is the case in the novice’s space that is filled by action options that are neither preferred nor suppressed. Instead, the expert’s sculpted space of actions is filled with more action options, some of which occupy sub-spaces as a function of having become strongly preferred (red triangles in Expert panel), or strongly suppressed (green dots in Expert panel), depending upon their degree of compliance with three important action characteristics, with some indifferent (blue squares) options scattered through the space. (Figure adapted from Keestra, 2014, p. 375 with permission.)

Culture as ‘niche construction’ with a mixture of innovation and stasis

Cultural evolution with ‘generative entrenchments’ in the form of

- artifacts
- infrastructure and institutions
- education and transmission

and the interaction between these.

(Wimsatt 2007, 2014 fig.)

84 William C. Wimsatt

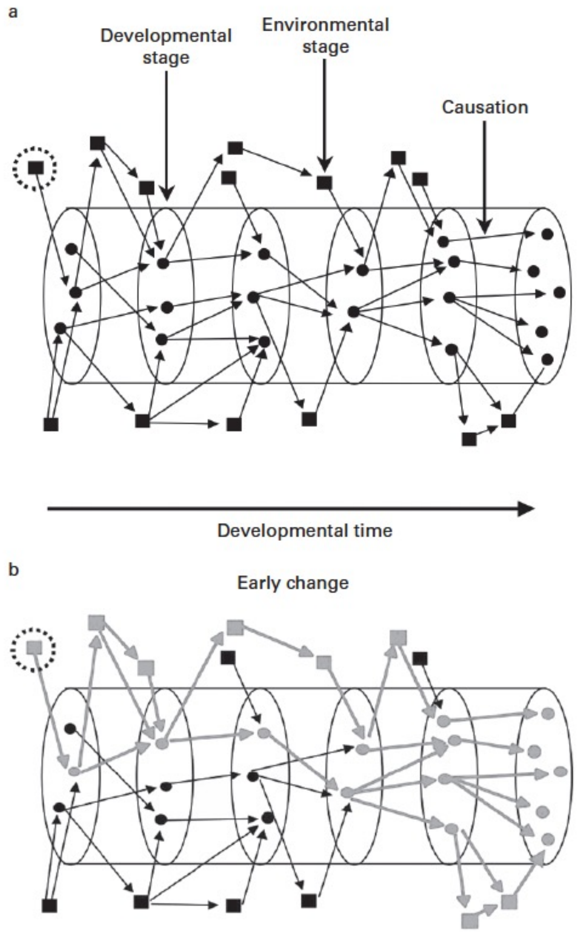


Figure 3.1
Generative entrenchment in a developmental structure (courtesy of Jeffrey Schank). (a) Causal dependency network in an ontogeny. (b) Early change in an ontogeny, with induced downstream changes. From Wimsatt and Schank 2004.

Canonicity and conservatism of scientific traditions due to generative entrenchments

Scientific traditions characterized by GE, e.g.:

- notation systems
- instruments, tools,
- education, training
- examples and models (paradeigmata, cf. Kuhn)
- applications
- institutions

which support (scaffold) progress and adaptation.

Challenge of of de-anchoring, raising the anchor: cf. decolonization, and ethno-mathematics

Given ‘anchored innovation’ or generatively entrenched nature of a scientific tradition, challenge of:

- recognition of early contributions from other traditions
- connections to contemporary other traditions
- recognition of limitations, *brittleness*, of any form of expertise
- evaluating other traditions on their own merits
- recognizing mathematics’ emergences from local human needs, interests
- (cf. Perkins, 1994, ‘Klondike-spaces’ in creative evolution fig.)

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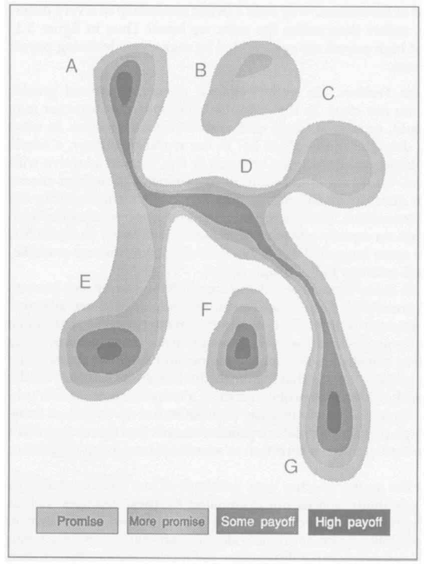

Figure 5.1
A sample “Klondike space.”

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