Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

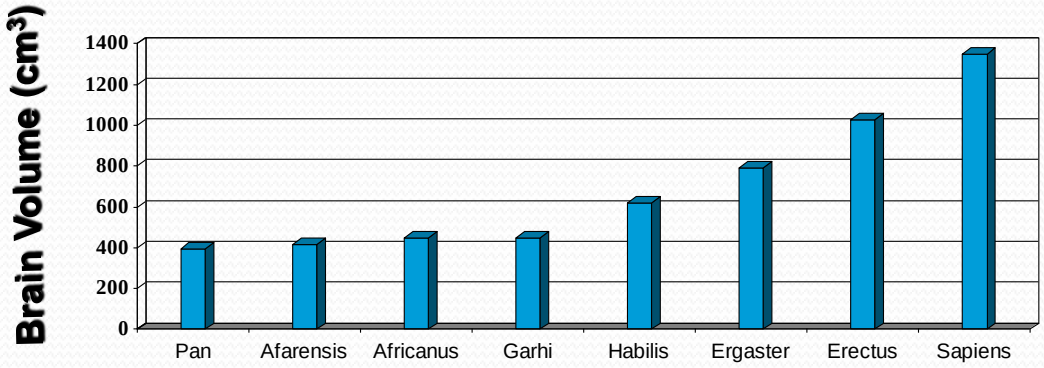
David C. Geary

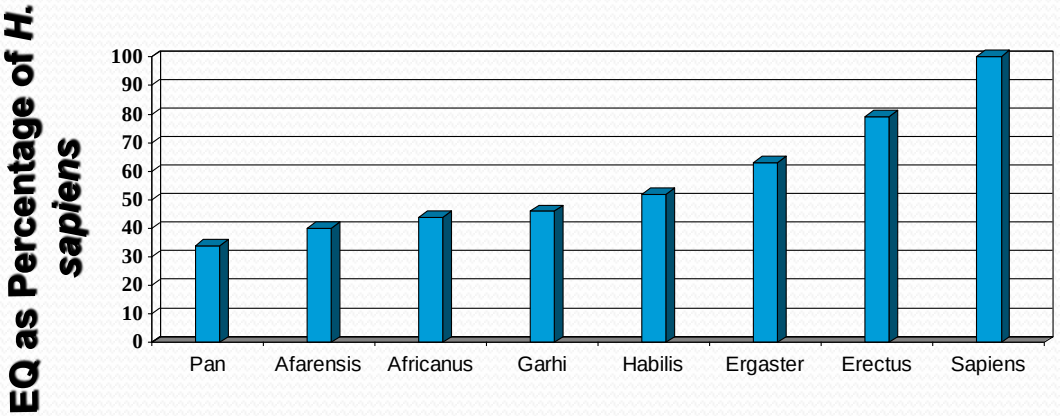
University of Missouri

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- Very Brief Tour of Brain and Cognitive Evolution
- Evolution and function of human development
- Mechanisms for learning during development
- Cultural evolution and the emergence of evolutionarily novel knowledge and abilities
- Illustrate with Darwin's discovery of natural selection
- Evolutionary educational psychology
- Implications for talent development

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture





Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Understanding what drove brain evolution tells us what people are biased to think about:**

- **Climatic Pressures:**

  A. Selection for ability to predict change in climate

- **Ecological Pressures:**

  A. Selection related to ability to secure resources from ecology

  B. Ecological Dominance: Ability to control biological and physical resources in ways that reduced mortality risks

- **Social Pressures:**

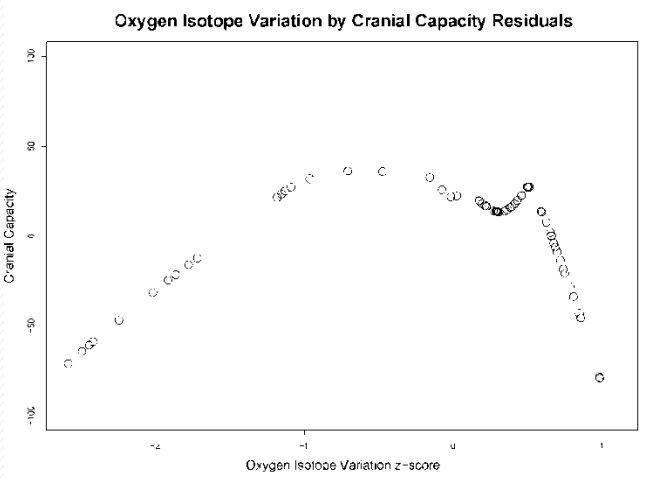
  A. With Ecological Dominance: Selection remains a "struggle for existence" but becomes primarily a struggle with other people for CONTROL of the resources that support life and allow one to reproduce

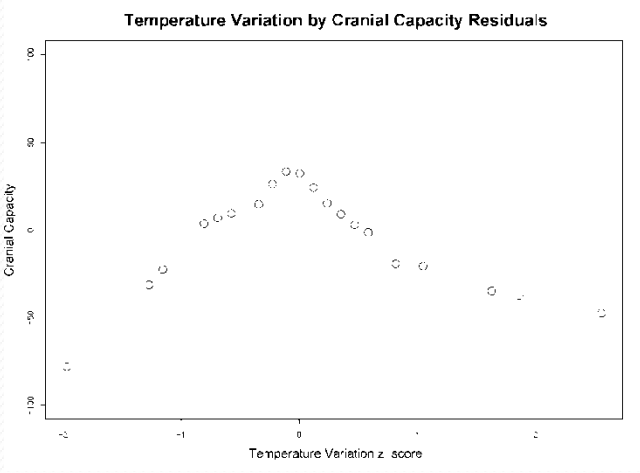
Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

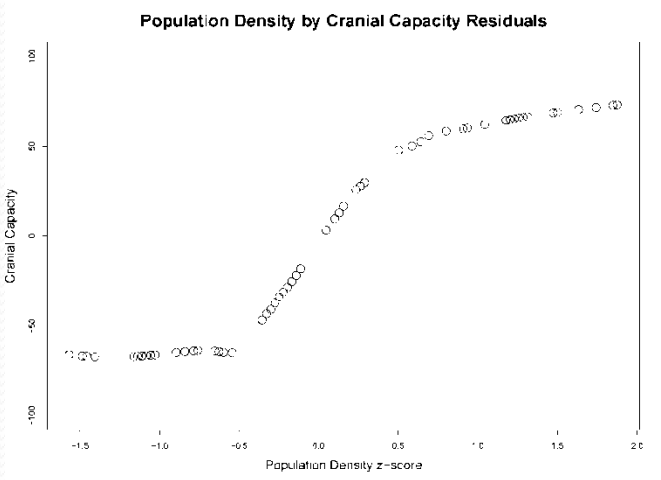
- **Empirical Test of different selection pressures (Bailey & Geary, 2009):**
- **A. 175 hominid fossil crania from 1.9 million to 10,000 years ago**
- **B. Variables representing potential climatic, ecological, and social pressures:**
  - **1. Climatic – Variation in paleoclimate ($0^{18}/0^{16}$, & Sea Surface Temperature based on ocean-floor sediments); latitude, annual temperature and variation at latitude.**
  - **2. Ecological – parasite prevalence**
  - **3. Social – number of crania found in surrounding areas at the time of and prior to the date of each cranium - Estimate of Population density**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **A set of multivariate regressions were used to obtain the best group of predictors:**







Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- Common to all proposed pressures is the need to cope with variation and change within and across lifetimes.
- This places a premium on brain, cognitive, and behavioral mechanisms that allow for coping with evolutionary-novel change and variation

➢Central Executive: Working memory and attentional control – mechanisms that enable the conscious awareness of information represented in short-term memory

A. Enables explicit, conscious problem solving

➢Conscious-Psychological Mechanism:

A. Conscious-awareness of self as a social being
B. Placement of self in center of mental models and simulations
C. Mental time travel
D. Generation of behavioral strategies to cope with projected variant social or ecological conditions

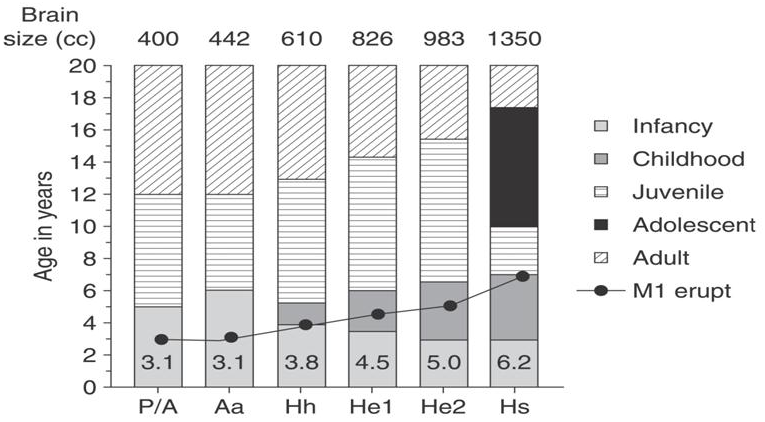
➢Foci: Gaining control of social, biological, or physical resources

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Co-evolving with the emergence of these cognitive competencies is a lengthening of the human developmental period; as much as 50% longer than that of our ancestors**

- **The developmental period evolved to provide children the opportunity to learn about variation and change; specifically about social complexities and the ecology in which they are situated**

- **Proximate Mechanisms:**
  - **Social, ecological, and object play;**
  - **Social learning, selective imitation of competent adults and older children**



From "*Patterns of Human Growth*" (2nd ed.), by B. Bogin, 1999, p. 185.

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Social and ecological resources correspond to the evolved, modular domains of folk psychology, biology, and physics**

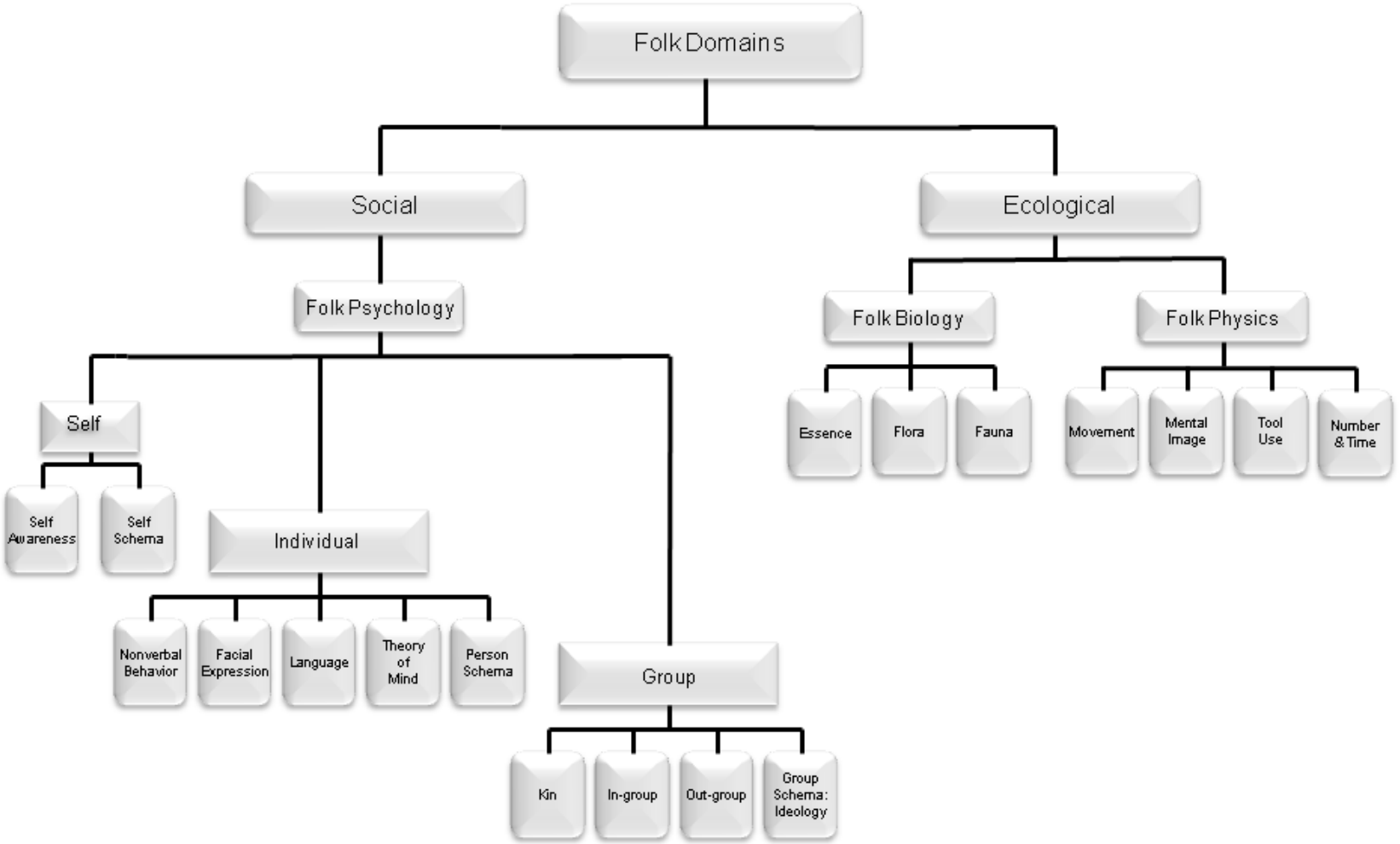
- **Primary attentional and cognitive systems evolved to process information in these folk domains and to guide behavioral strategies**

- **Children are biased to engage in activities that recreate the ecologies of human evolution - through social play and exploration of the environment and objects**

- **These experiences flesh out skeletal folk systems, they adapt them to variation within each domain *without much conscious problem solving***

  - **E.g., learn to discriminate people based on facial features**

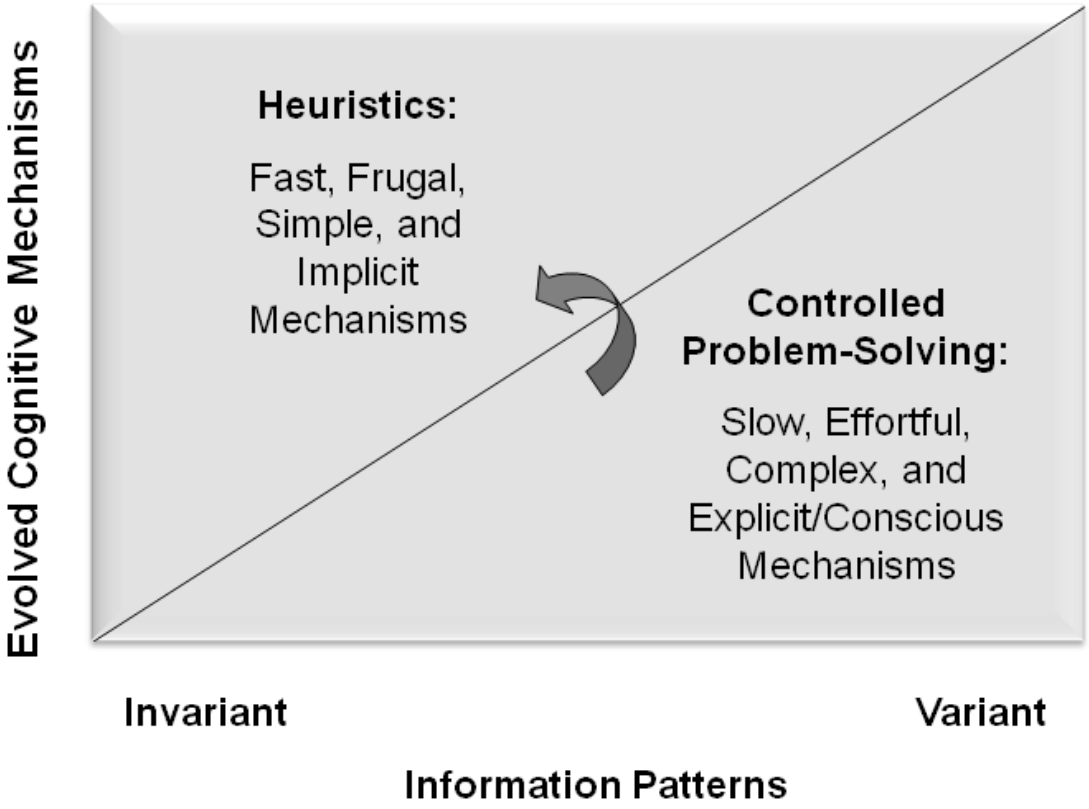
Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture



Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- At the same time, there is variation and novelty that cannot be accommodated by plastic, modular folk systems:
  - Dynamics of social relationships are more variable and less predictable than variation in facial features.
- Ho: The same mechanisms that allow us to consciously and explicitly cope with dynamic variation and change - explicit, conscious problem solving and fluid intelligence - enable the creation of cultural innovation
- They allow us to modify primary folk abilities to create evolutionarily-novel secondary abilities
  - Primary language learning occurs implicitly, but adapting these language systems for written communication requires engagement of conscious, explicit systems (e.g., phonological awareness).
  - The combination of plastic language systems and explicit mechanisms for modifying these underlies the creation of written communication systems and supports our ability to learn to read and write using these systems

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture



Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Result: Run-away cultural "evolution" over the past several millennia**
  - **E.g., Rapid accumulation of knowledge transmitted across generations in books – as contrasted with oral traditions**
  - **There are now cultural institutions – research universities – designed to create new secondary knowledge**
- **These advances result in a gap between folk knowledge and evolutionarily-novel knowledge**
  - **Mechanisms of social learning and play may no longer be sufficient for learning culturally important knowledge and skills**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Scientific, technological, and intellectual advances emerge from a combination of cultural wealth, opportunity and individual traits:**
  - **These advances are disproportionately driven by individuals with high intelligence, creativity, ambition, extended preparation, and lots of work**
  - **Ho: These advances disproportionately engage the conscious, explicit problem-solving mental models that evolved to enable our ancestors to anticipate and plan for change**
    - **Information patterns toward the variant end of the earlier shown continuum**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Newton: "I do not define time, space, place and motion, as being well known to all. Only I must observe, that the vulgar conceive those quantities under no other notions but from the relation they bear to sensible objects."**

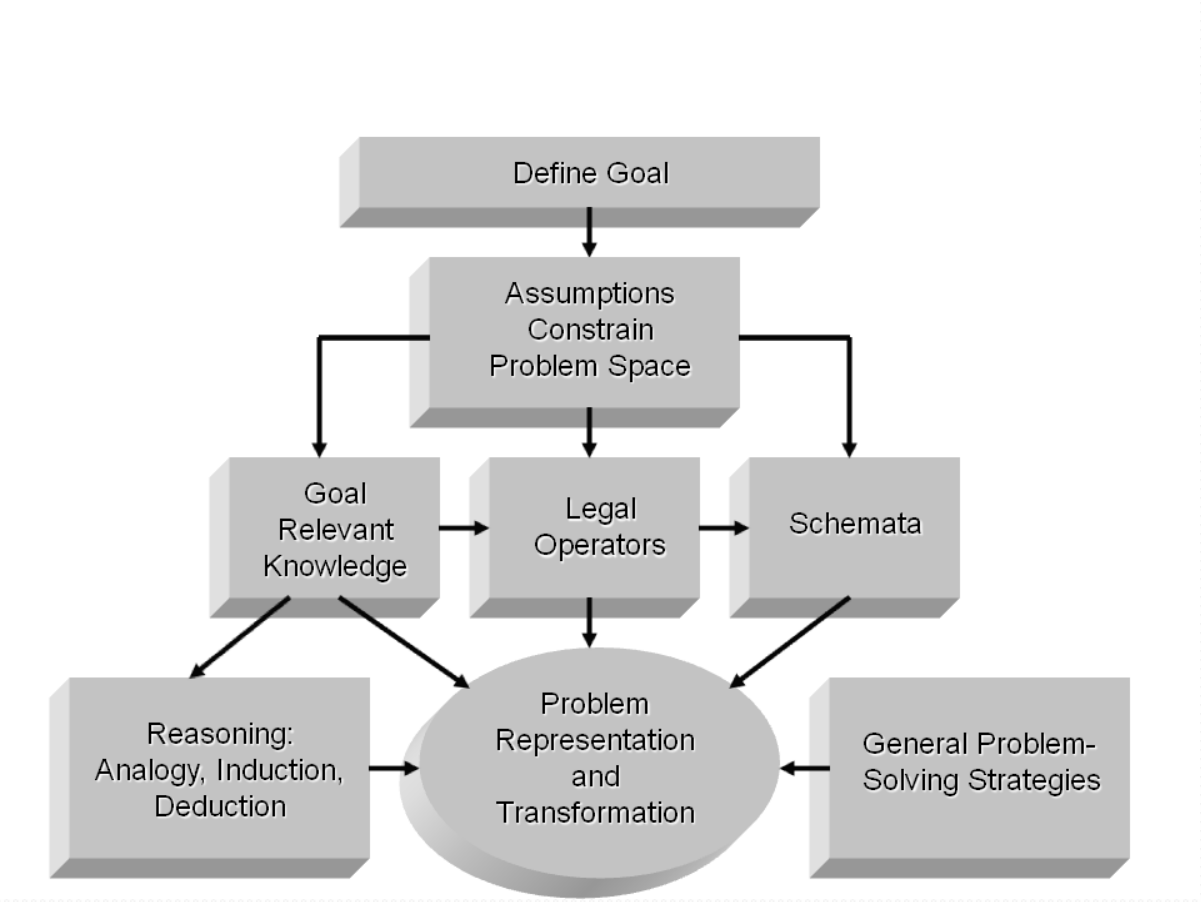
- **Newton's *Principia* created a large gap between people's folk understanding of motion and forces that act on objects and our scientific understanding of these phenomena; only 323 years ago.**

- **Einstein's Description of how he approached problems:**

> **The words of the language as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined. … There is, of course, a certain connection between those elements and relevant logical concepts (Hadamard, 1945, p. 142).**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Darwin & Wallace illustrate the interaction between explicit problem solving and folk interests in the discovery of natural selection**



Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Problem solving in an ill structured knowledge rich domain**
  - **Intense folk interest and experience with other species**
  - **Explicit goal of discovering the origin of species**
  - **Darwin – use of Klahr's experimental and hypothesis spaces, and weak problem solving**
  - **Darwin and Wallace proposed a branching tree analogy for the relations among species**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Critical: Defining the problem space and legal operators:**
  - **Many contemporaries ruled out natural processes and thus made the discovery of natural selection impossible**
- **Inhibition of folk-biological biases – related to IQ and working memory – use of means-ends problem solving and other weak methods to bridge sub-goals**
- **Operators (e.g., for each generation number of offspring > number of parents);**
- **Goal-relevant knowledge (e.g., populations are stable);**
- **Schemata (Malthus – oscillating patterns of population expansions and contractions**

Legal Operators

Operator 1. For each reproductive cycle, the number of offspring produced is greater than the number of parents.

Operator 2. The probability of offspring survival varies with ecological conditions, such as resource availability (e.g., land, food):

- **A.** When resources are plentiful, more offspring survive and populations expand.
- **B.** When resources are scarce, more offspring die and populations contract.

Operator 3. Resource availability varies with population size:

- **A.** Expansion gradually reduces quantity of resources available per individual.
- **B.** Contraction gradually increases quantity of resources available per individual.

Operator 4: The probability of mortality or survival is not entirely random.

Operator 5. Some traits are correlated with the ability to extract resources from the ecology or avoid predation and thus with the probability of mortality or survival.

Goal Relevant Knowledge

Fact 1. Populations numbers tend to be stable across generations.

Fact 2. Predation, disease, climate, and competition result in high mortality.

Fact 3. Individuals of the same species vary on most traits.

Fact 4. The fossil record suggests that species change gradually; some go extinct; and others emerge.

Fact 5. Variations of the same species and related species are found in the same or contiguous geographic regions.

Schemata: Natural Selection

Schemata 1. Same as Operator 1: Populations will expand, if unchecked.

Schemata 2. Schemata 1 is linked with Operators 2 and 3, coupling the oscillating pattern of population expansions and contractions to ecological conditions.

Schemata 3. Schemata 2 is linked to Operator 4, coupling population expansions and contractions with differential mortality and survival.

Schemata 4: Schemata 3 is linked to Operator 4, coupling differential mortality and survival to individual characteristics.

Schemata 5: Schemata 4 is linked with Operator 5, coupling individual characteristics that influence mortality and survival to ecological conditions.

Analogy: Artificial Selection

Feature 1. People selectively breed other species in order to exaggerate desired traits within a species (microevolution)

Feature 2. Selective breeding works because offspring are similar to parents on the selected trait.

Feature 3. Offspring must somehow (genes were not yet understood) inherit the selected trait.

Feature 4. Generations of selective breeding can lead to the emergence of different varieties of the same species (e.g., different breeds of dog) or the emergence of new species, such as domestic species from their wild ancestors (macroevolution).

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Transformed study of natural history (largely classification, description – explicit taxonomy of implicit folk biological knowledge) to the science of biology**
- **Cultural gap between biological science and folk biology that must be bridged with schooling**
- **How do we build an understanding of natural selection from intuitive folk biology?**
  - **Folk biology leads to accurate classification and some correct inferences (e.g., offspring will look like parents) but also many scientific inaccuracies**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Ho: Counter-intuitive features of natural selection discovered by Darwin and Wallace, in part, through explicit, goal directed problem solving may require engagement of the same systems during children's learning**
- **An understanding the mechanisms of variation, selection, and cross-generational change does not follow from folk biology**
- **Inhibition of folk-biological inferences**

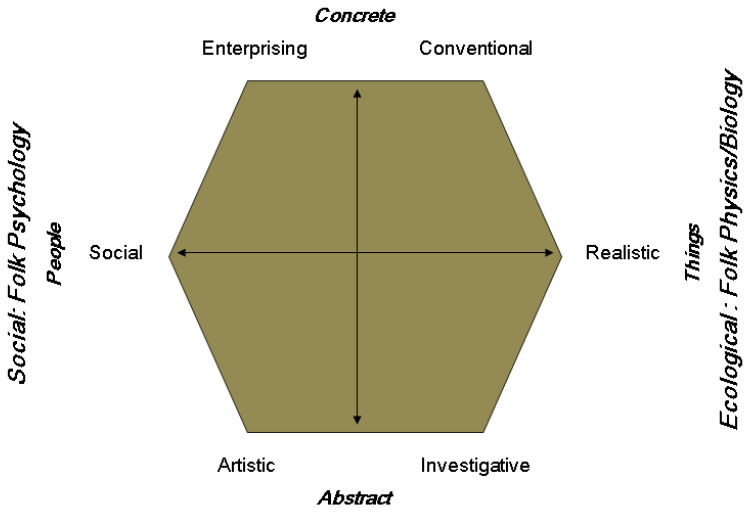
Points of Contrast	Folk Biology	Natural Selection
Goals	Use of plants and animals for food and medicines	Understand cross-generation change within species (microevolution) and the emergence of new species (macroevolution
Variation and Essence	There is an essence shared by all members of the species. The focus is on within-species similarity	Heritable variation is the grist of evolutionary change
Mechanism of selection	The essence can be passed from parent to offspring and changes based on needs of the species	Nonrandom differences in mortality and reproductive success
Foci of change	The species' essence	Traits that influence survival or reproductive prospects
Relations among species	Kingdom, species, subspecies	All species are related

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Folk biases may also inform motivational niche seeking in the modern work force.**

- **The well understood differences in Holland's occupational interests and interest in people vs. things or people vs. natural phenomena can be mapped onto folk domains:**

  - **Ho: Folk biology – interest in living things, 3rd dimension**



- **Also a more concrete to abstract dimension (data/ideas): Engagement in common, everyday activities vs. use of mental models**

- **Darwin and Newton would go in the investigative area, but with different underlying interests and probably folk abilities (e.g., spatial)**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **General Educational Implications:**
  - **Schools are cultural innovations that emerge in societies in which scientific and cultural advances result in a gap between primary folk knowledge and the competencies needed for living in the society**
  - **Schools organize the activities of children so they can acquire the secondary competencies that close the gap between folk knowledge and the demands of the society**
  - **Implications: Define the core competencies (e.g., reading, writing) and knowledge (e.g., principles of natural selection, compound interest) needed to function in the modern world**
    - **Too much for children to learn even a fraction of what is known**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **General Educational Implications:**
  - **Determine the primary systems and biases upon which these are build**
  - **Determine the experiences needed to modify these primary, folk systems to create secondary abilities**
  - **What are the similarities and differences between these experiences and children's primary learning mechanisms, play and social learning?**
  - **Assume that many children will not be inherently motivated to learn everything they need to learn in the modern**
    - **One study found high school students enjoyed hanging out with friends more than math homework**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- **Thoughts on talent:**
  - **Intellectual advantages arise from systems that evolved to anticipate and learn about evolutionary novelty and within-lifetime change**
    - **This is why gifted accelerate in modern schools**
    - **In addition, experiences in solving ill structured problems may be useful, once they have mastered basics**
  - **Dissociations follow from the difference between folk abilities and ability to generate conscious-mental models and problem solve on these abstract representations**
    - **E.g., dissociations between social skills (folk psychology) and academic learning**
    - **E.g., Reading disability and giftedness**
  - **The ability to master what has been discovered by others is only the first step in the creation of novel contributions to science or culture**

Evolved Cognitive Biases, Human Intellectual Talent, and the Creation of Culture

- Novel, creative contributions come after mastery of what is already known

- But, there is more and more to master before the opportunity to create, especially in the sciences and other technical fields

- This is driving much of the specialization in these fields, but comes at a cost to cross-specialty integration and abstraction of general principles

- Gifted people's advantages are centered on the ability to generate abstract representations of phenomena of interest and engage in effortful problem solving but these raw abilities decline after young adulthood

- Potential risk of slowing creative productivity without policies that allow these individuals to master what is know earlier and perhaps specialize earlier according to their interests and motivation