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NAVIS-based Knowledge Transfer from System Experts to their Heirs Apparent

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Trending / Operating Experience / Self-Assessment

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Overview

1. Introduction of Problem & Partial Solution
2. Need for Continuity & Growth of Expertise
3. Expertise & Knowledge Transfer
4. The NAVIS-based Taxonomy of Biases
5. Application of NAVIS to Knowledge Transfer
6. Conclusion

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Introduction of Problem

- **Problem:** Knowledge transfer among personnel within organizations is often suboptimal for maintaining desired performance (safety, stability, improvement, innovation) over time.
- **Objective:** Efficient & effective transfer of knowledge and skills from system experts to the next generation of designers, builders, operators, and maintainers. This activity is of critical importance in high-consequence domains (e.g., nuclear power, nuclear weapons, hazardous chemicals, oil & gas production, bridge building, air transport, …)

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Introduction of Problem

Potential Experts ENTER

System Experts:

- Skills
- Heuristics
- Knowledge

Proven Experts LEAVE

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Partial Solution

Apply *portions* of a unique, recently developed decision making process to improve knowledge transfer by:

- **Preparing a willing expert to be an effective teacher**
- **Identifying potential heirs apparent & preparing them to be proficient learners**
- **Helping identify promising matches of heirs apparent & experts**

How?

- Enable greater understanding of backgrounds, biases, & bias mitigation
- Achieve disposition of inquiry, observation, & inference that supports knowledge transfer

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Need for Continuity & Growth of Expertise

Organizations seeking to thrive into perpetuity must:

- **Transfer expertise between generations of personnel**
- **Continually expand system knowledge & skill bases**

<u>Complex, high-consequence systems</u> — need for "knowledge transfer excellence" is heightened due to potential for loss of life, injury, and other damages related to system failure

<u>Organizations expanding science & technology</u> — "knowledge transfer excellence" is key to financial stability & leadership in a global, knowledge-based economy.

- **Natl. Academy of Sciences, Natl. Academy of Engineering, & Institute of Medicine report — *U.S. scientific & technological base is readily declining just as other nations are rapidly gaining strength***

  …Rising Above the Gathering Storm: Energizing & Employing America for a Brighter Economic Future (2006)

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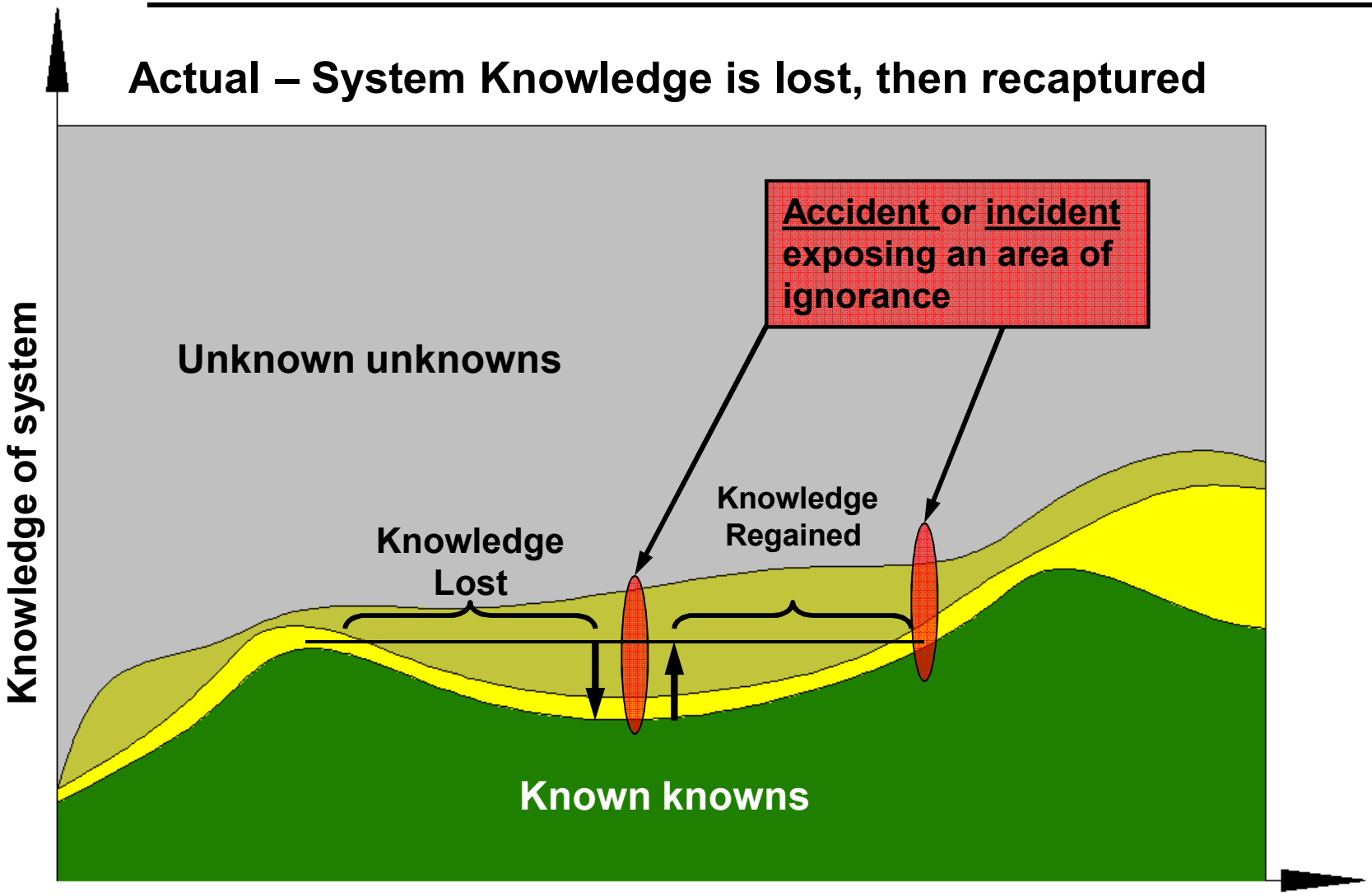
Cyclical Nature of System Knowledge



Known Unknowns – among those who should 'know'

Known Unknowns – somebody somewhere 'knows'

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Expertise & Knowledge Transfer

Characteristics of Expertise (not complete, not exhaustive):

- **Ability to leverage many years of knowledge & skill gained in wide variety of contexts to recognize patterns**
- **Selective retrieval of relevant information with extrapolation to fluidly produce an appropriate response**
- **Know when rules apply & when an unusual pattern requires an exception**
- **Broad and deep tacit knowledge**
- **Technical skills, understanding of management systems & understand the "power perspective"**
- **Provide best estimates for types of risk taking that is deemed judicious (even if the outcome is bad) versus risk taking that is foolish, imprudent, or dangerous**
- **Expertise, contrasted with competence, often takes 10 or more years to develop**

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Expertise & Knowledge Transfer

Types of Knowledge Transfer:

- **Person-to-person**
- **Self-study techniques**
- **Expert systems**
- **Person-to-group** *(lecture, lab, field study)*
- **...**

Ancient History for Person-to-Person Processes: Guild, Artisanship, Apprenticeship

- **Novice (beginner)**
- **Apprentice (intermediate)**
- **Journeyman (advanced)**
- **Master (expert / virtuoso)**

Focus Here: transition from *heir apparent* to *expert*; analogous to transition from *journeyman* to *master*

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Expertise & Knowledge Transfer

Person-to-Person Knowledge Transfer (i.e., Mentoring):

- Formal or informal
- Teaching, guiding, counseling, encouraging, coaching
- Learning directly by doing
- Learning through stories
- Learning by observing (shadowing)
- Learning by 'debriefing' observations (shadowing)
- Informal matching of experts and heir apparent is best

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Expertise & Knowledge Transfer

Benefits of Mentoring:

- **Increased job satisfaction**
- **Higher employee retention**
- **Better performance**
- **More rapid promotions**
- **System performance stability**
- **System performance improvement**

Emphasizes the Criticality of:

- Preparing experts
- Identifying & preparing heirs apparent
- Gently facilitating the matching process

Challenges for Mentoring:

- **Substantial immediate costs in time, training, & relationship facilitation for expert & heir apparent**
- **Shadowing activities often not billable**
- **Experts concerned about being rewarded by management for effort**
- **Loss of promising heir apparent "investments" to other organizations or fields can dampen support**
- **Swap et al. (2001), "mentoring requires a light—and sophisticated—managerial hand"**

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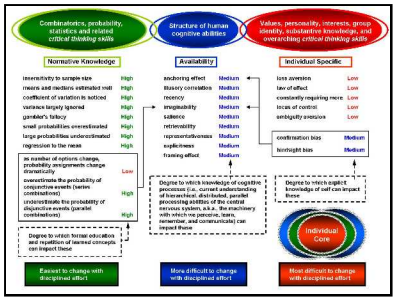
The NAVIS-based Taxonomy of Biases

Overview of Bias Processes

- **Roughly 80%** of information used to understand our relationship to outside world is obtained visually
- **N**ormative, **Av**ailability, & **I**ndividual **S**pecific Bias Processes (27 bias processes in the NAVIS taxonomy)
- **Culture:** e.g., language habits in Western culture → People speak as if they are certain when they are only fairly certain; people perceive opinions to be worthless when they are only weakly supported
- **Limitations of working memory**
  - *"The magical number seven plus or minus two: Some limits on our capacity for processing information"* Miller (1956), Psychological Review, 63, 81-97.
  - Note: from those familiar with the research – stick to 5 or less distinctions that need to be held in working memory during a brief presentation & encoded in long term memory

NAVIS



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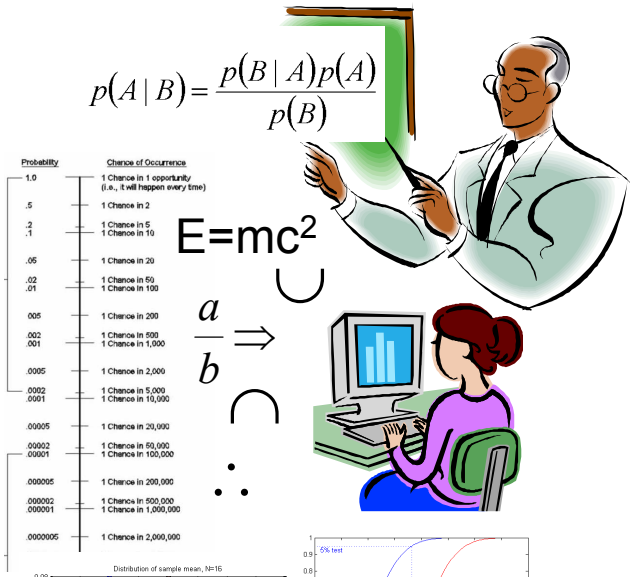
Combinatorics, probability, statistics and related *critical thinking skills*

Structure of human cognitive abilities

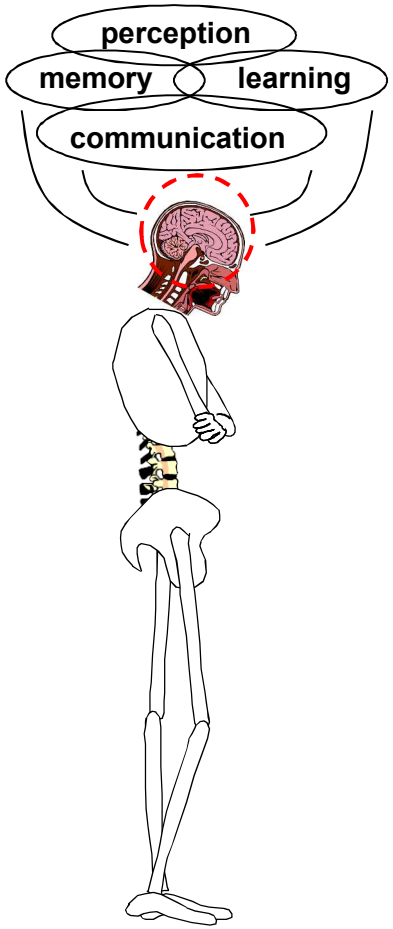
Values, personality, interests, group identity, substantive knowledge, and overarching *critical thinking skills*

Normative Knowledge



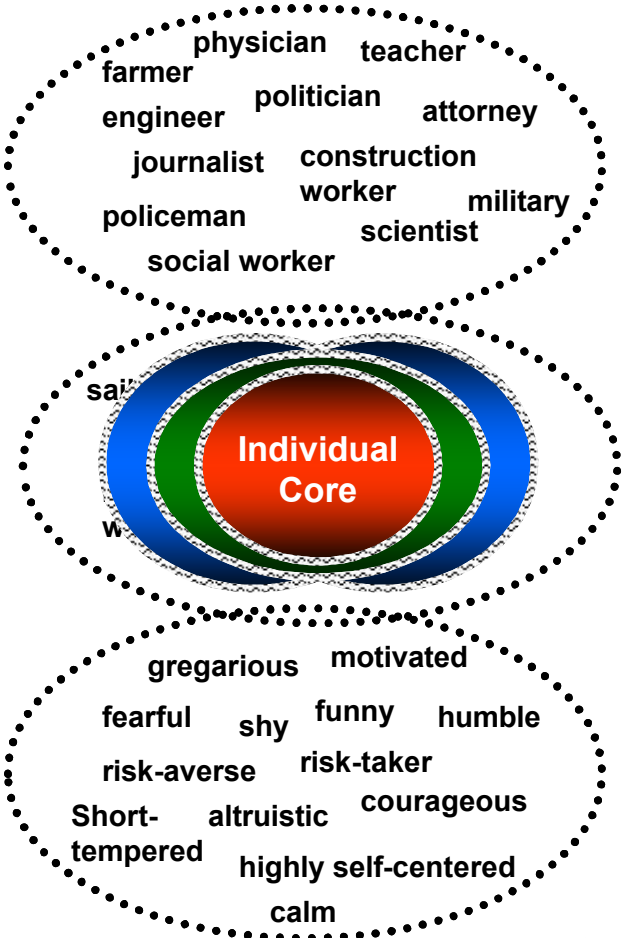
Number sense & analytical skill

Availability



The human 'machinery'

Individual Specific



A specific person

Normative Knowledge

- insensitivity to sample size
- means and medians estimated well
- coefficient of variation is noticed
- variance largely ignored
- gambler's fallacy
- small probabilities overestimated
- large probabilities underestimated
- regression to the mean
- as number of options change; probability assignments change dramatically
- overestimate the probability of conjunctive events (series combinations)
- underestimate the probability of disjunctive events (parallel combinations)

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Availability

- anchoring effect
- illusory correlation
- recency
- imaginability
- salience
- retrievability
- representativeness
- explicitness
- framing effect

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Individual Specific

- loss aversion
- law of effect
- constantly requiring more
- locus of control
- ambiguity aversion
- confirmation bias
- hindsight bias

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27 biases/tendencies that are related to each of the 3 main categories

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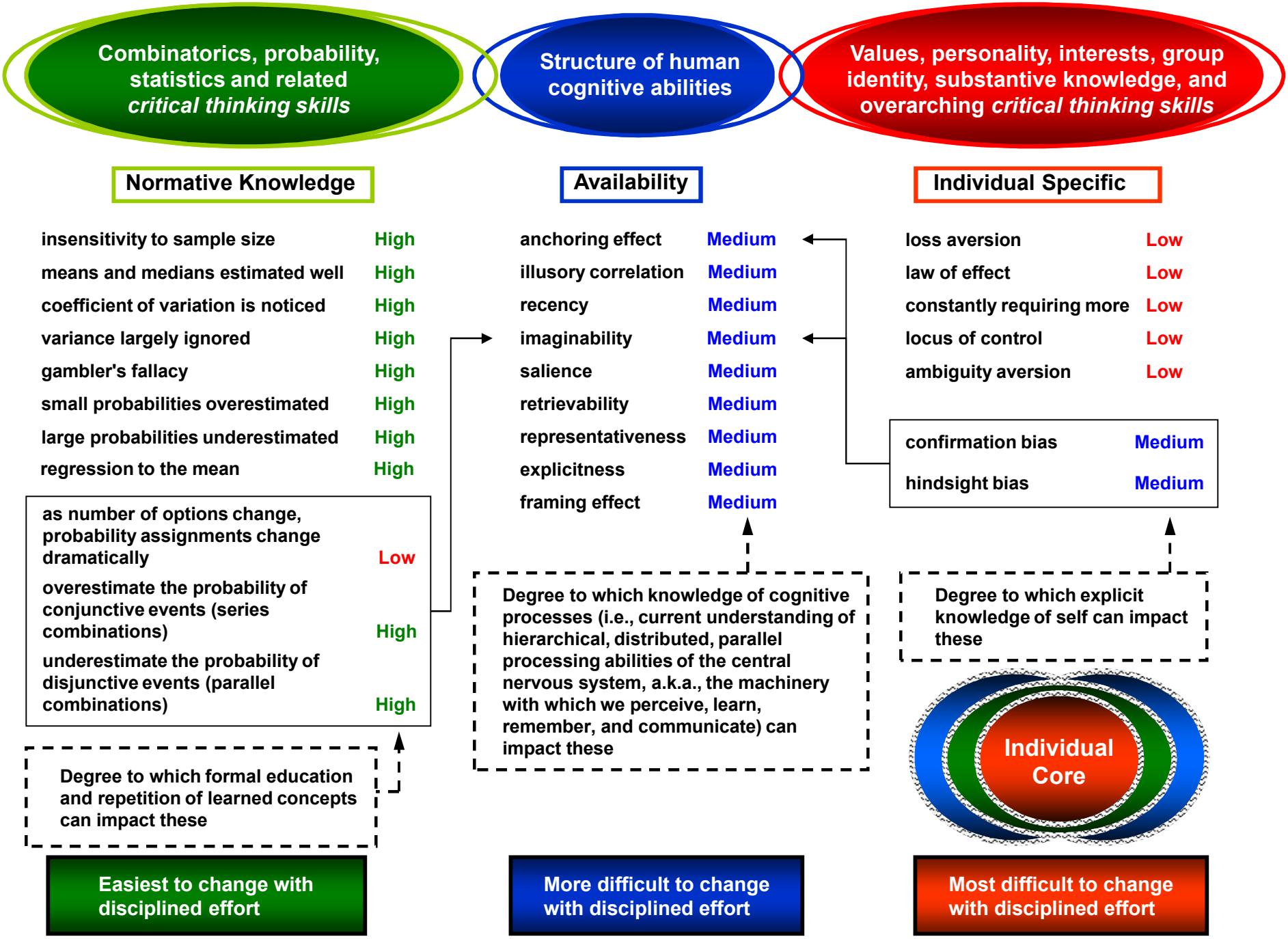
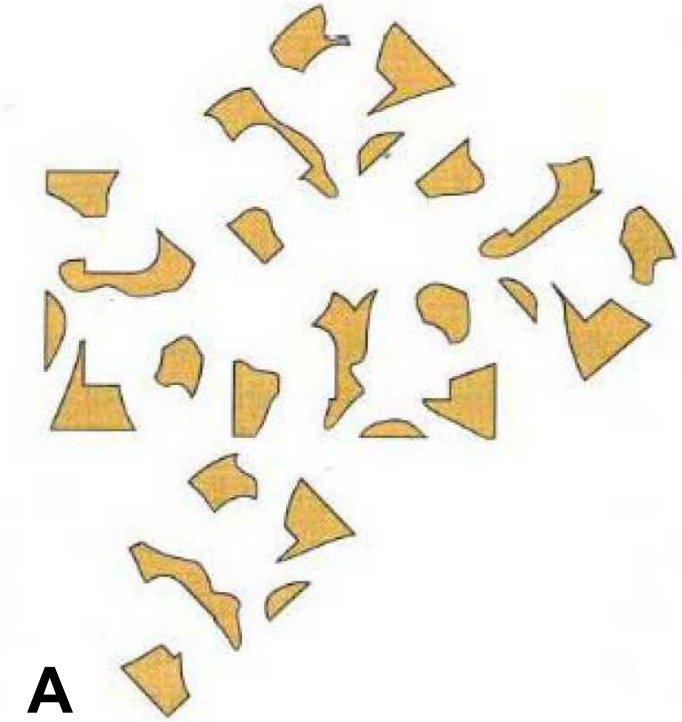
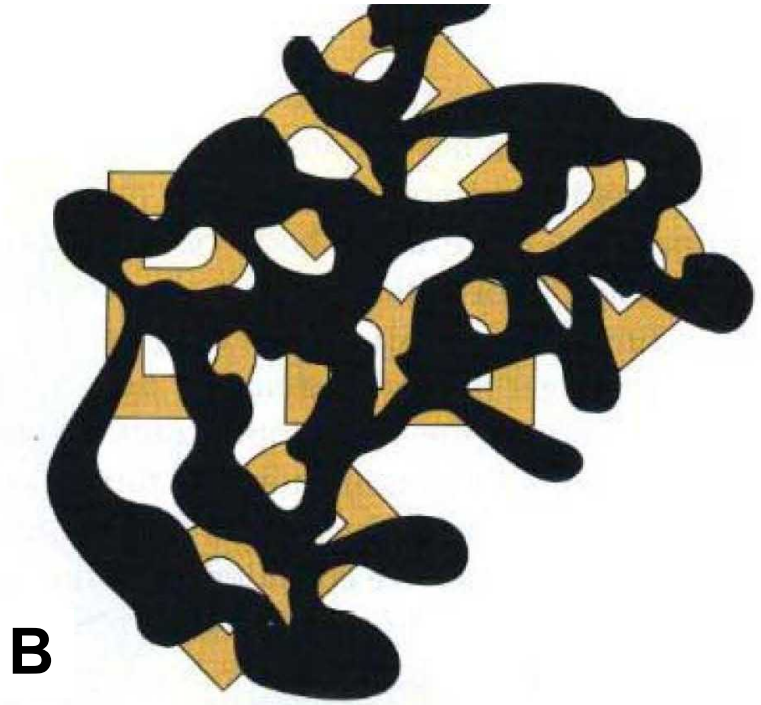
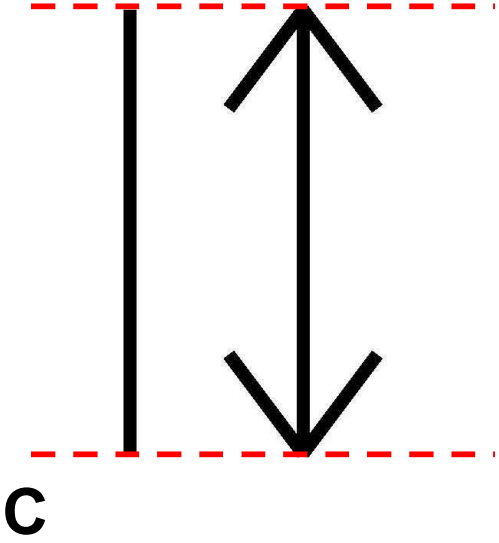

Combinatorics, probability, statistics and related *critical thinking skills*
Structure of human cognitive abilities
Values, personality, interests, group identity, substantive knowledge, and overarching *critical thinking skills*
Normative Knowledge
Availability
Individual Specific
insensitivity to sample size High
means and medians estimated well High
coefficient of variation is noticed High
variance largely ignored High
gambler's fallacy High
small probabilities overestimated High
large probabilities underestimated High
regression to the mean High
as number of options change, probability assignments change dramatically Low
overestimate the probability of conjunctive events (series combinations) High
underestimate the probability of disjunctive events (parallel combinations) High
anchoring effect Medium
illusory correlation Medium
recency Medium
imaginability Medium
salience Medium
retrievability Medium
representativeness Medium
explicitness Medium
framing effect Medium
loss aversion Low
law of effect Low
constantly requiring more Low
locus of control Low
ambiguity aversion Low
confirmation bias Medium
hindsight bias Medium
Degree to which formal education and repetition of learned concepts can impact these
Degree to which knowledge of cognitive processes (i.e., current understanding of hierarchical, distributed, parallel processing abilities of the central nervous system, a.k.a., the machinery with which we perceive, learn, remember, and communicate) can impact these
Degree to which explicit knowledge of self can impact these
Individual Core
Easiest to change with disciplined effort
More difficult to change with disciplined effort
Most difficult to change with disciplined effort

Critical thinking processes

1. Raising the **questions**: "What do we know…? How do we know…? Why do we accept or believe…? What is the evidence for…?
2. Clear and explicit awareness of **information gaps** (i.e., recognizing when one is taking something on faith).
3. Discriminating between **observation and inference**, between established fact and subsequent conjecture.
4. Recognizing that **words are symbols for ideas** and not the ideas themselves. Recognizing the necessity of using only words of prior definition, rooted in shared experience, in forming a new definition and in avoiding being misled by technical jargon.
5. **Probing for assumptions** behind a line of reasoning.
6. **Drawing inferences** from data, observations, or other evidence and recognizing when firm inferences cannot be drawn (i.e., **inference adequacy check**).
7. **Hypothetico-deductive reasoning**; apply relevant knowledge of principles and constraints, and abstract visualization of plausible outcomes from imagined changes imposed on the system.
8. Discriminating between **inductive and deductive reasoning**; that is being aware of when an argument is made from the particular to the general or from the general to the particular.
9. Test one's own line of reasoning and conclusions for **internal consistency**.
10. Develop **self-consciousness** concerning one's own thinking and reasoning processes.







Visual Biases

Application of NAVIS to Knowledge Transfer

- **Provide structured basis for generating *explicit* self-inventories of biases, values, interests, & substantive knowledge**
- **Inventories could be used to identify training needs: bias awareness and mitigation, critical thinking processes, teaching skills**
- **Periodic inventories could help identify when an heir apparent may be ready to seek expert-level capability**

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Application of NAVIS to Knowledge Transfer

- **Periodic inventories could help identify when expertise is achieved**
- **Comparison of NAVIS inventories could aid in identifying potential matches of experts and heirs apparent**
- **Review of *all* or *part* of NAVIS inventories by parties in a knowledge transfer relationship could enable improved communication**

Note: Research is still required to fully articulate an efficient inventory/assessment and training process based upon the NAVIS approach

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Conclusions

Effective & efficient knowledge transfer is essential for maintaining safety, stability, continuous improvement, & innovation within complex, high-consequence systems.

NAVIS-based knowledge transfer is proposed to provide a systematic basis for:

- **Preparing willing experts to be effective teachers**
- **Preparing willing heirs apparent to be effective pupils**
- **Helping identify matches of heirs apparent & experts**
  - **Enabling greater understanding of backgrounds, biases, & bias mitigation**
  - **Achieving disposition of inquiry, observation, & inference that supports knowledge transfer**

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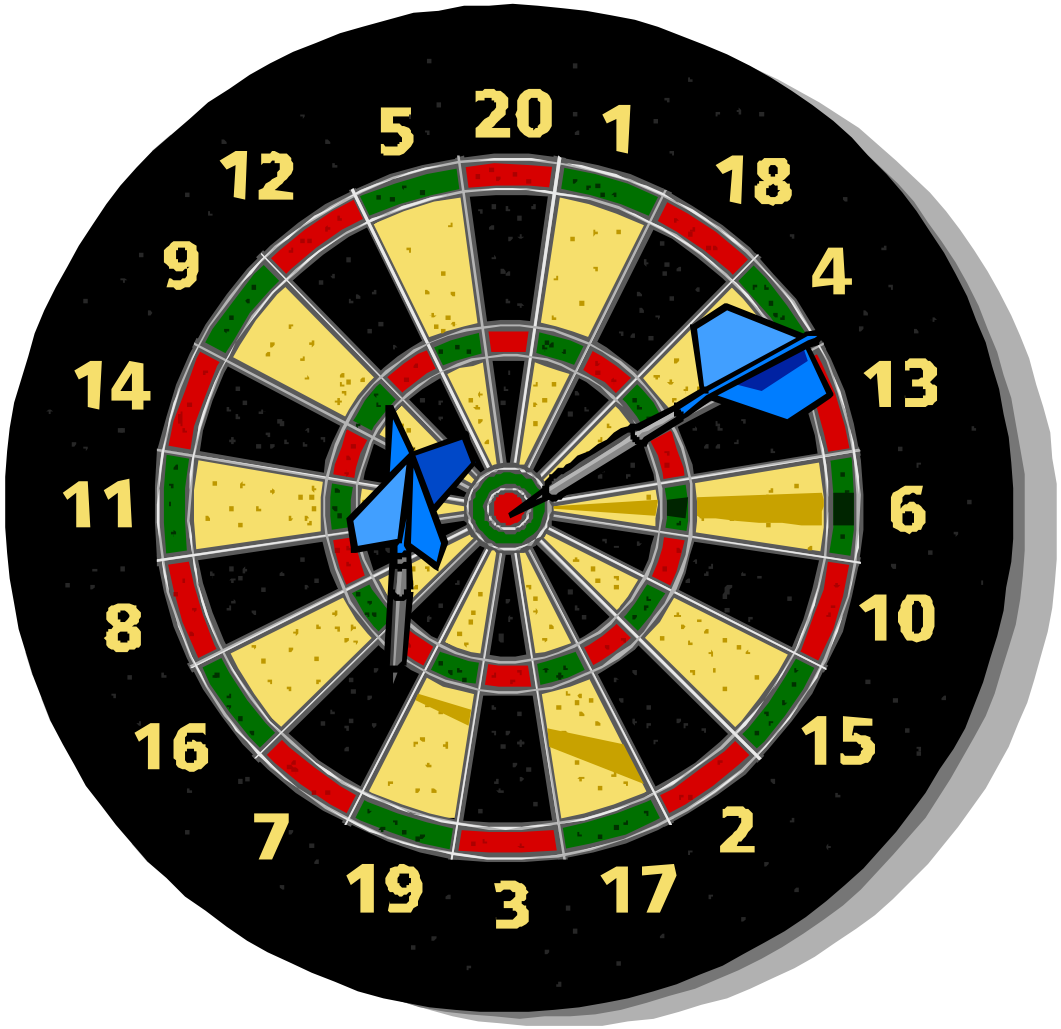
Questions?



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