ACT-R+
the architecture's potential *beyond* rationality

Bill Kennedy

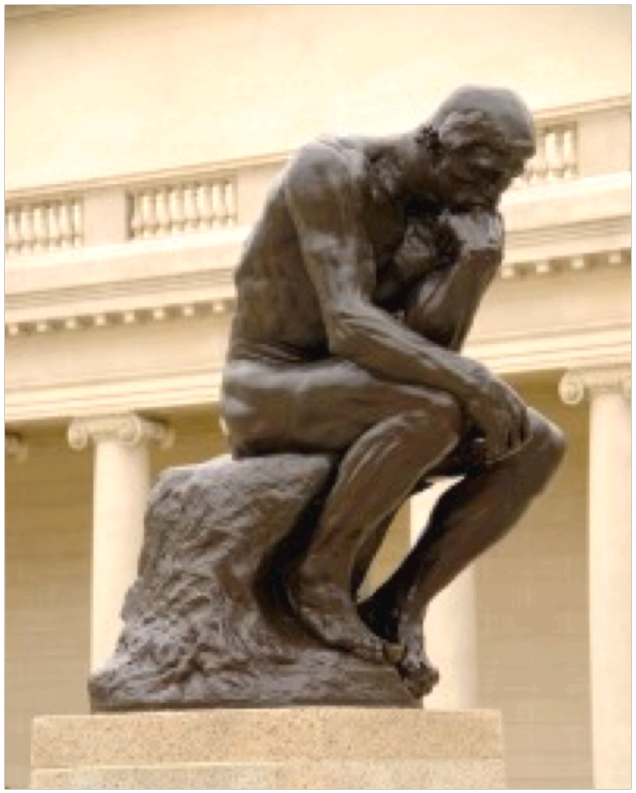
ACT-R PGSS

16-19 Aug 2011

Think. Learn. Succeed.

GEORGE MASON UNIVERSITY

A Modest Proposal



ACT-R+

Motivation

- **It has been said that man is a rational animal.**

  All my life I have been searching for evidence which could support this.

  Bertrand Russell

- **The central characteristic of agents is not that they reason poorly but that they often act intuitively.**

  Kahneman in his 2002 Nobel acceptance speech

Motivation

- **The guiding ideas are (i) that most judgments and most choices are made intuitively; (ii) that the rules that govern intuition are generally similar to the rules of perception.**

  Kahneman in his Nobel acceptance speech

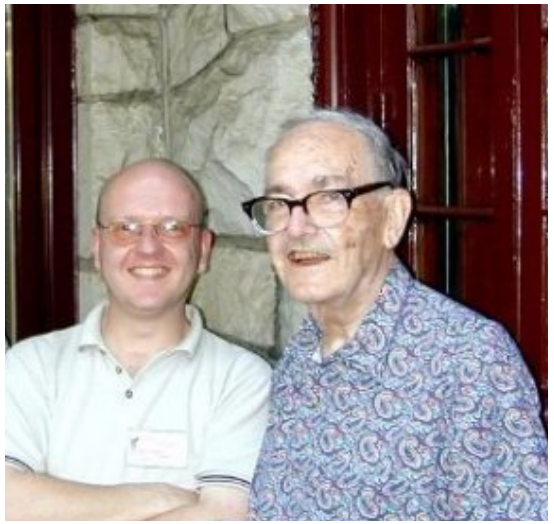
- **Eighty percent of our life is emotion, and only 20 percent is intellect.**

  Frank Luntz

Motivation

- ***Hence, in order to have anything like a complete theory of human rationality, we have to understand what role emotion plays in it.***

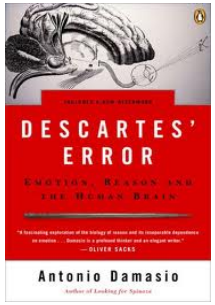
Herbert A. Simon, Reason in Human Affairs, 1982



Beyond Rational

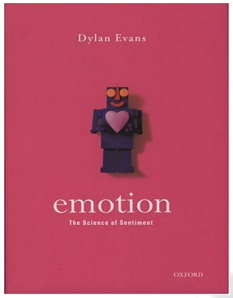
- Humans rational only part of the time
- Much of behavior driven by "other" reasoning
- "Other" = irrational, emotional, unconscious, intuitive, instinctual, heuristic, "hot thought", "gut feelings", … *"beyond rational"*
- But is it credible science?

Recent Emotional Publications

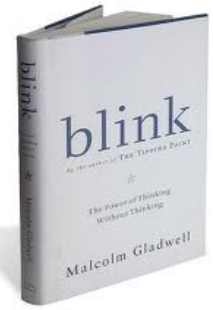


1994

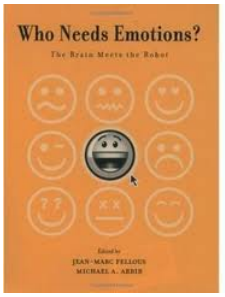
2002



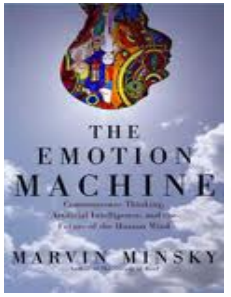
2002



2005

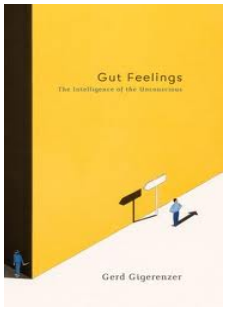


2005

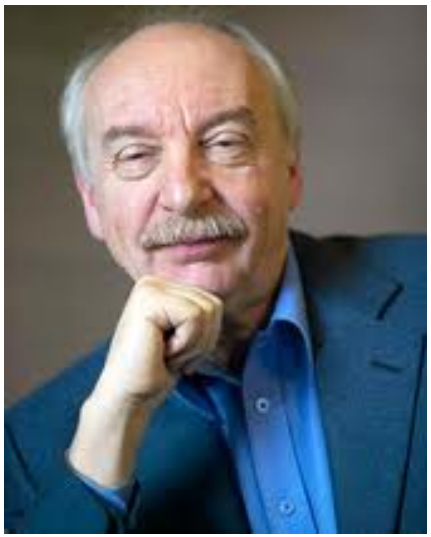


2006

2006



2007

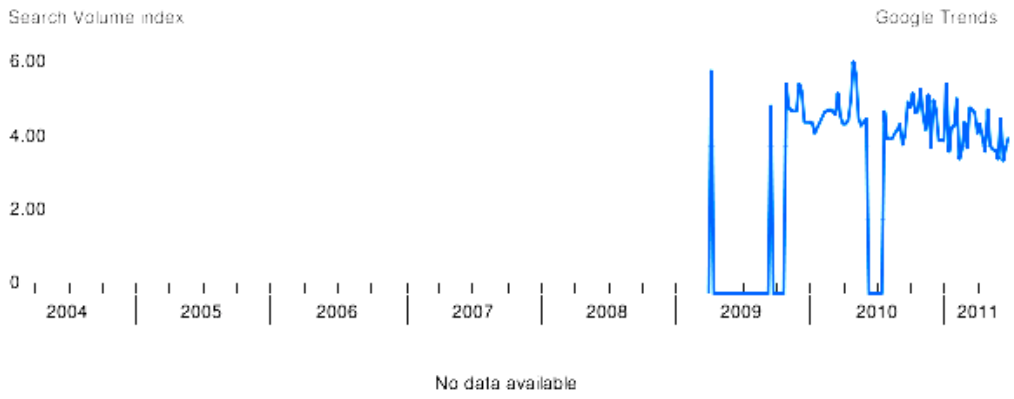


Dual Process Theory

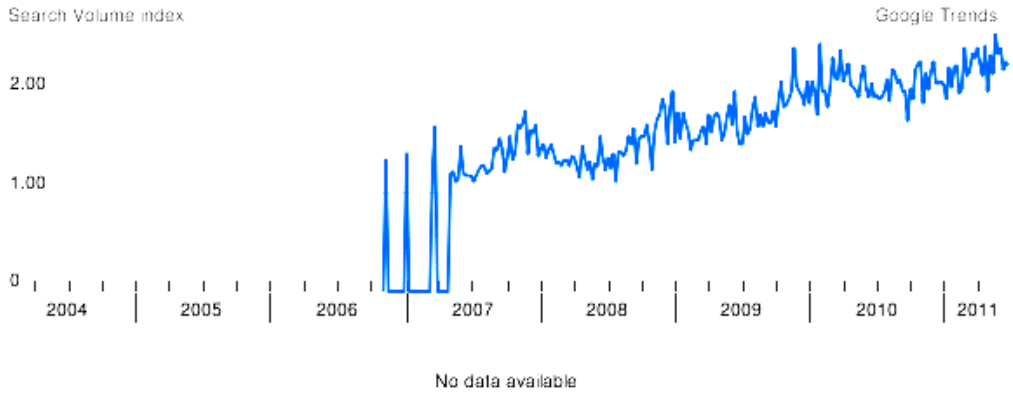
- Ancient issue, two forms, many names (+/-)
- Evidence for both
- Sloman, S.A. (1996) The Empirical Case for Two Systems of Reasoning. Psychological Bulletin 119(1): 3-22.
- Neutral terms: System 1 and System 2

Google Trends

Dual Process Theory



System 1 System 2



System 1 -- System 2

System 1

Unconscious

Rapid

Automatic

High capacity

System 2

Conscious

Slow

Deliberative

Evans, J. St. B. T. (2008) Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 58:255-278.

System 1 -- System 2

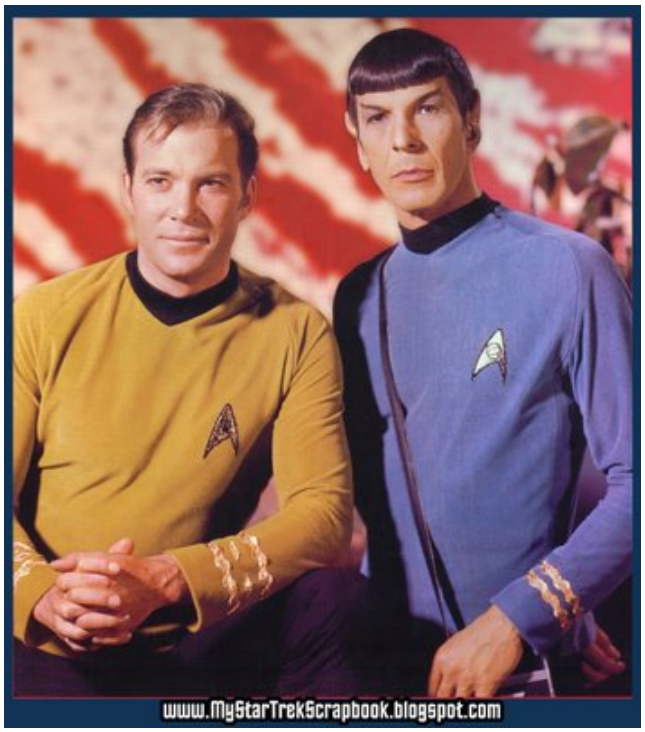
System 1

Unconscious

Rapid

Automatic

High capacity



System 2

Conscious

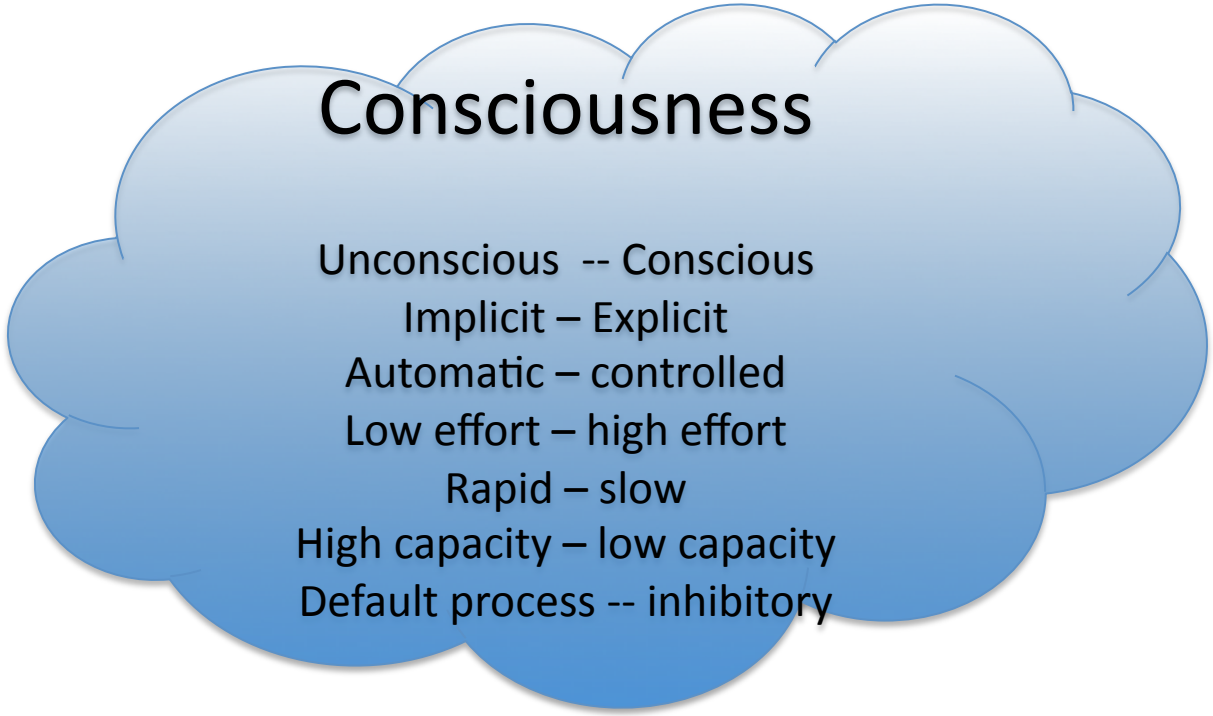
Slow

Deliberative

Evans, J. St. B. T. (2008) Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 58:255-278.

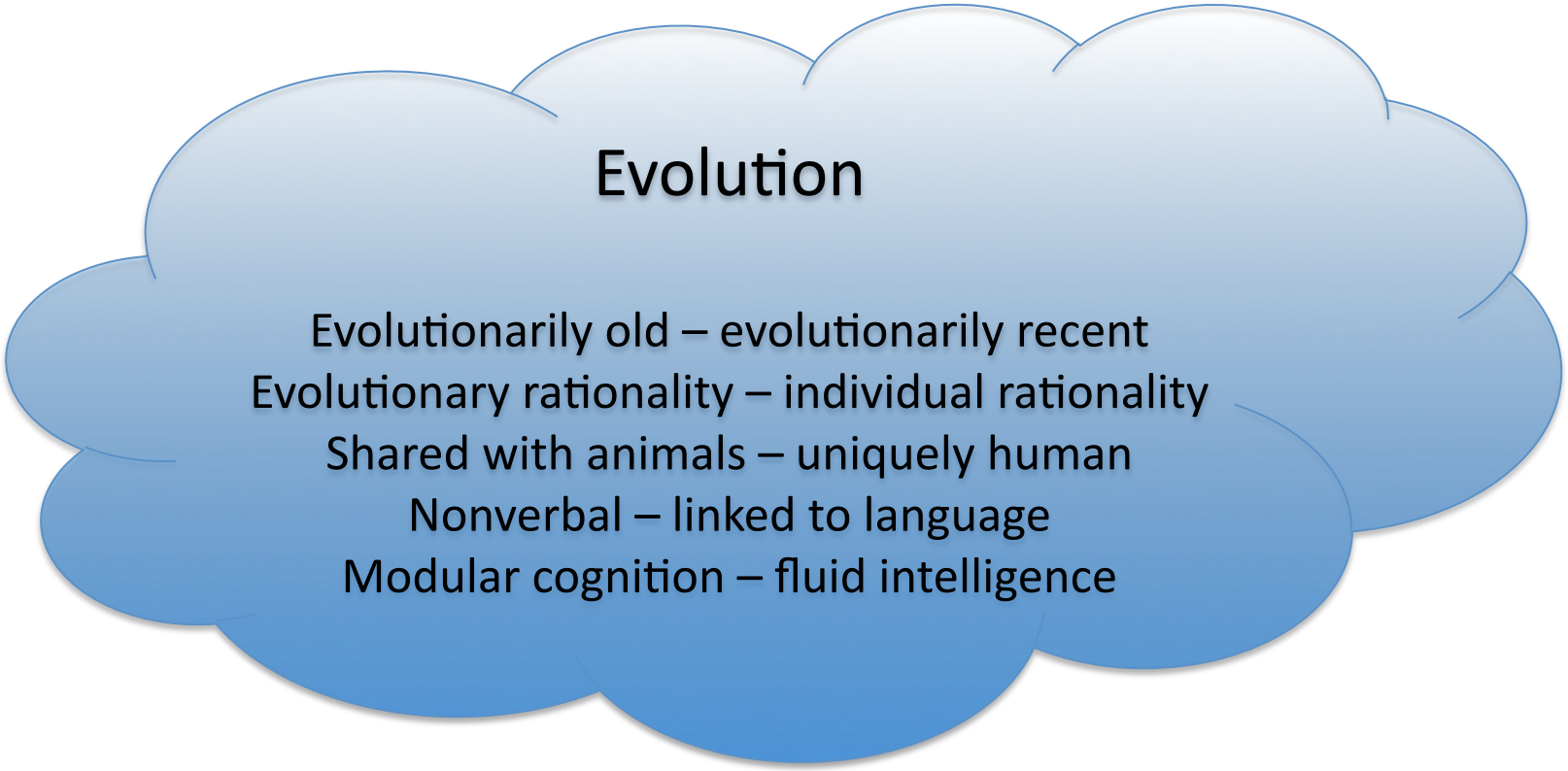
Evans, D. (2001) emotion: The Science of Sentiment. Oxford University Press Chapter 2: Why Spock could never have evolved

System 1 -- System 2



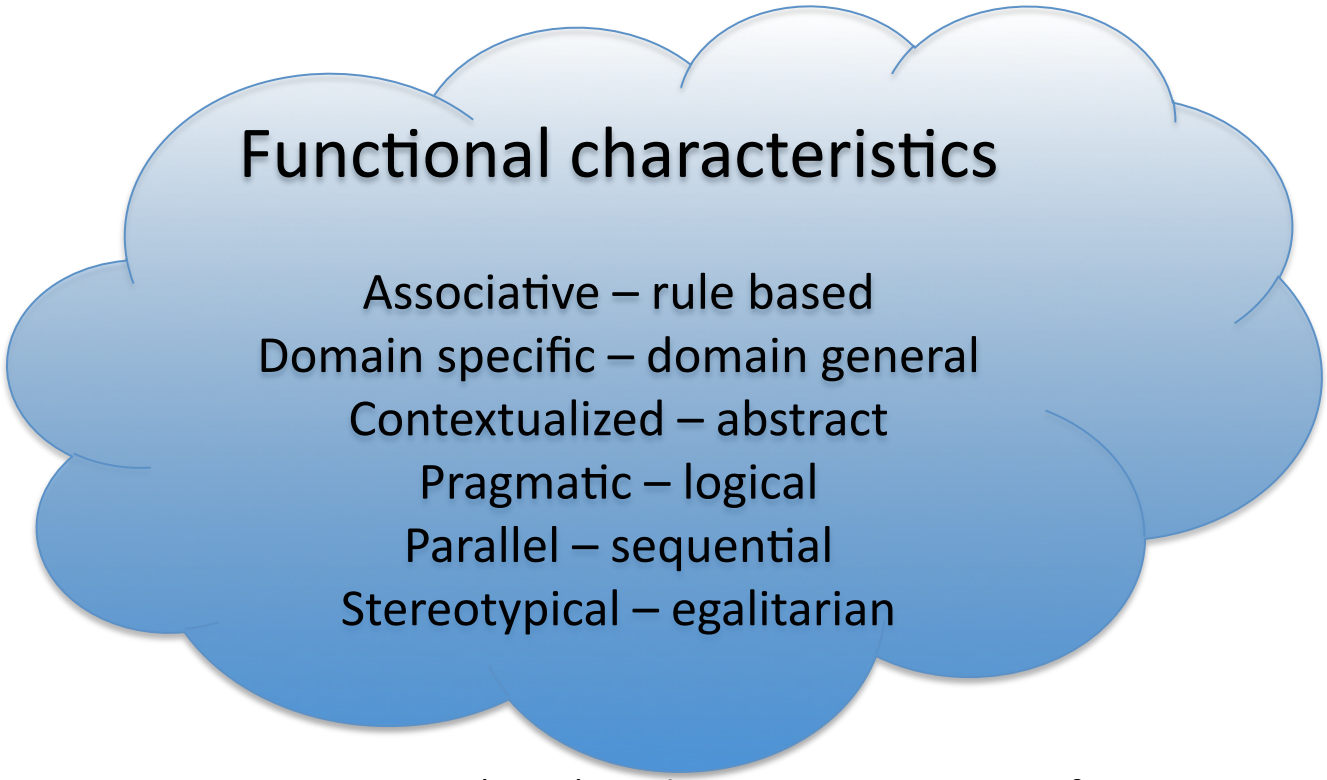
Evans, J. St. B. T. (2008) Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 58:255-278.

System 1 -- System 2



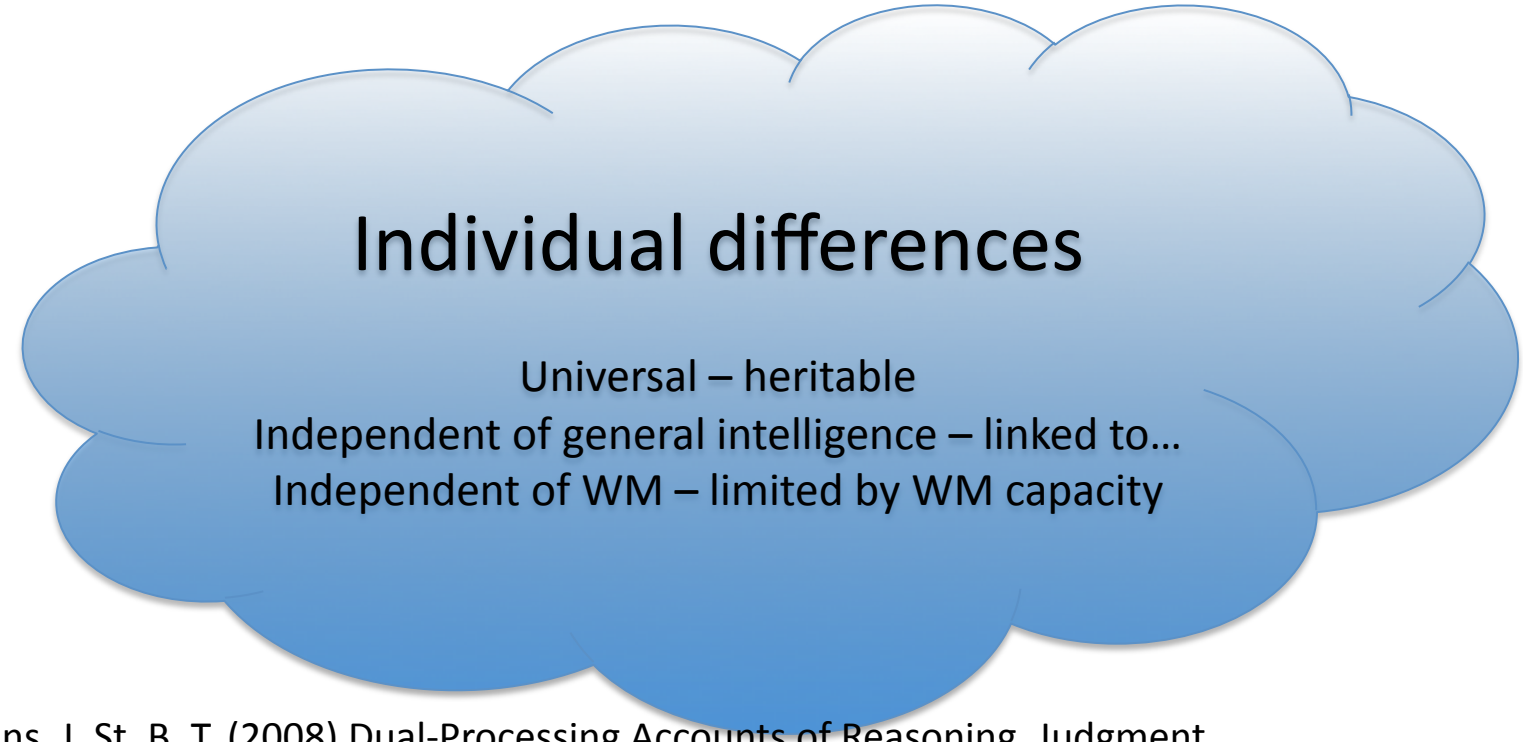
Evans, J. St. B. T. (2008) Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 58:255-278.

System 1 -- System 2



Evans, J. St. B. T. (2008) Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 58:255-278.

System 1 -- System 2



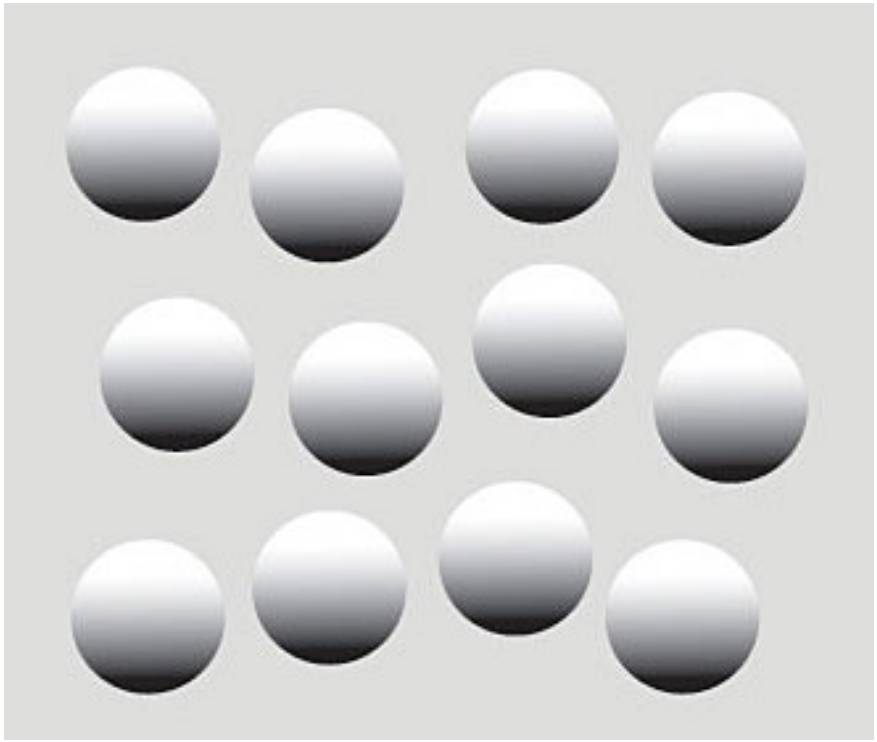
Evans, J. St. B. T. (2008) Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. Annual Review of Psychology 58:255-278.

System 1 vs. System 2

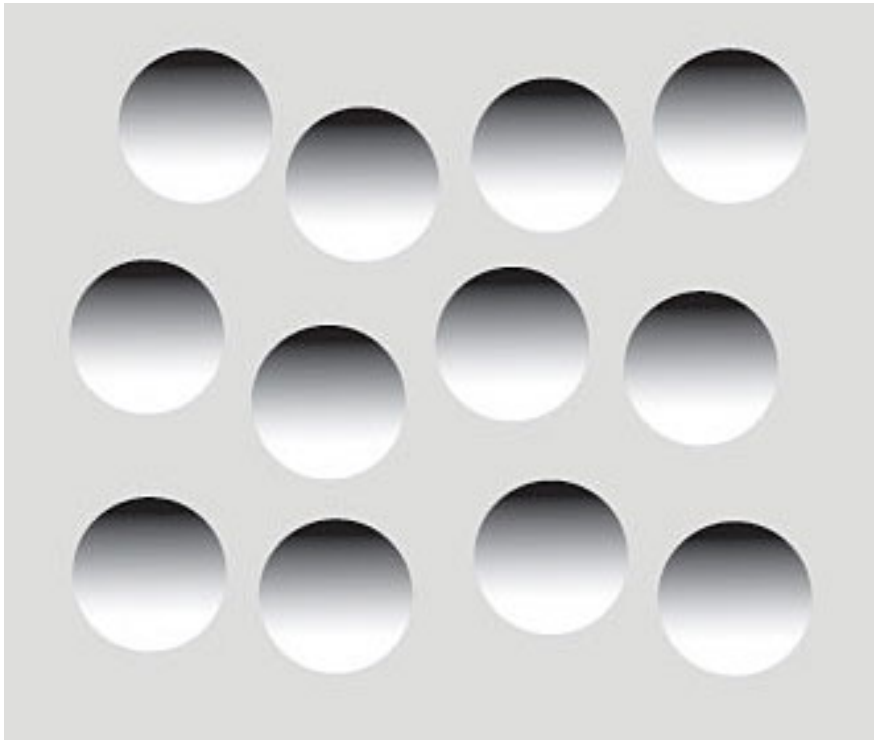
System 1 vs. System 2

"In or out?" Demo of System 1 "reasoning"

System 1 vs. System 2



System 1 vs. System 2



Architectural Impacts

"A *cognitive architecture* is a specification of the structure of the brain at a level of abstraction that explains how it achieves the function of the mind." (Anderson 2007, pg 7)

What others have done

- Soar 9 implements a specific appraisal theory (Scherer 2001)
  - Evaluates situation
  - "Intensity becomes intrinsic reward (Singh et al., 2004) for enforcement learning, which significantly speeds learning (Marinier & Laird 2008)."

Laird (2008) Extending the Soar Cognitive Architecture. Proceedings of the Conference on Artificial General Intelligence. ISO Press: Memphis, TN.

What's Nec'y in ACT-R+?

- Productions that evaluate sensory inputs (nothing new)

- A "proprioceptual" buffer to represent and process own traits (unchanging), emotional history (mood), and current emotional state

ACT-R++?

- May need (if experimentally justified): second production firing track
    - Parallel to the rational track
    - Most parameters same as rational track
    - No use of declarative memory, all procedural

Research Program

1. Pure System-2: long history & ongoing research
2. Pure System-1: phenomena simple enough to model within existing architecture, e.g., optical illusions(?)
3. Piecewise serial, dual process phenomena: some System-1 mixed in with System-2 (dual-task: one cognitive, one “automatic”) e.g., current dual-task research
4. Full, dual-process phenomena: demonstrating need for dual processes, e.g., Stroop

Dangers of ACT-R+

- "**Controversy** abounds over
  - The **definition** of emotion,
  - The **number** of emotions that exist,
  - Whether some emotions are **more basic** than others,
  - The commonality of certain emotional response patterns **across cultures and across species**,
  - …
  - The role of **nature and nurture** in emotion,
  - The influence of emotion on cognitive processes,
  - The dependence of emotion on cognition,
  - …"

Joseph LeDoux Annual Reviews of Psychology, 1995.

Benefits of ACT-R+

- Opens ACT-R modeling to the rest of behavior
- Address perception & instinctual reasoning of optical illusions
- Address susceptibility to magical tricks & humor
- Address emotions directly
- Address recognition-primed decision-making

- Challenge getting funding(?)

Will this be true of ACT-R+?

"This shows that psychology has moved beyond its former indecisive, verbal arguments to precise statements that have enabled theories to be tested and rejected. With such theoretical precision comes scientific progress."

John Anderson (2000) Learning and Memory, 2ed, pg 29.

Bottom Line:

One Brain,

One Mind,

Dual Processes,

One Architecture: ACT-R+