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INTUITIVE COGNITION AND JOINT SEMIOSIS IN HUMAN-MACHINE SYSTEMS



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Overview



Optimized Human-Machine Systems: possess the capability of meaning making—which is called ‘semiosis**’**

To create such systems, an understanding of human reasoning and decision making, which depend on human semiosis, is critical

Well over 300 articles, book chapters, and books reviewed

Five Literatures on Human Reasoning, Decision Making & Semiosis:

- Dual-Process Theory
- Fuzzy-Trace Theory
- Naturalistic Decision Making
- Heuristics and Biases
- Automatic Processes

- (1) Intuitive Cognition dominates human reasoning & decision making***
- (2) ‘Joint Semiosis’ Human-Machine system***

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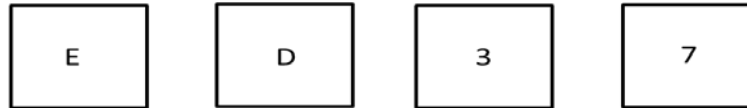
Dual-Process Theory

(e.g., Evans et al., 1983; Sloman, 1996; Stanovich & West, 2000; Evans, 2008; Evans & Stanovich, 2013)



Wason (e.g., 1966, 1968) Selection Task:

'If there is an E on one side of the card, then there is a 3 on the other side of the card'



Participants' task: Select minimum number of cards needed to establish truth value of conditional sentence

Typically 80-90% of individuals give incorrect answer; selected cards matching the cards mentioned in conditional sentence ('*Matching Bias*')

=> *Pattern Recognition*

Wason & Evans (1975):

- Participants' reasons for their selection: implausible and rationalizations
- '*Matching Bias*' mediated by implicit, *intuitive* process
- Conscious thought: part of *analytical* process

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Fuzzy Trace Theory



(e.g., Brainerd & Reyna, 1990; Reyna & Brainerd, 1995; Reyna & Lloyd, 2006; Reyna, 2012)

Brainerd & Kingma (1984):

Children's reasoning & memory for premise: Given $A < B$ & $B < C$, judge $A < C$ or $C < A$?; also state premise; Transitivity / Premise Memory Dependencies:

Probability measure

$P(T/M) \leftrightarrow P(T)$

$P(M/T) \leftrightarrow P(M)$

Experiment 1 (kindergarten)

Length (n = 150)	.65	.63	.62	.59
Weight (n = 150)	.60	.64	.64	.61

Experiment 3 (first grade)

Length (n = 62)	.82	.78	.54	.57
Weight (n = 62)	.65	.70	.58	.58

Transitivity performance independent of memory for adjacent relations

FTT: Two types of information encoded:

- (1) **Verbatim Traces** (rote processing / precise analysis)—faded quickly
- (2) **Gist Traces** (meaningful pattern processing / intuition)—did not fade quickly

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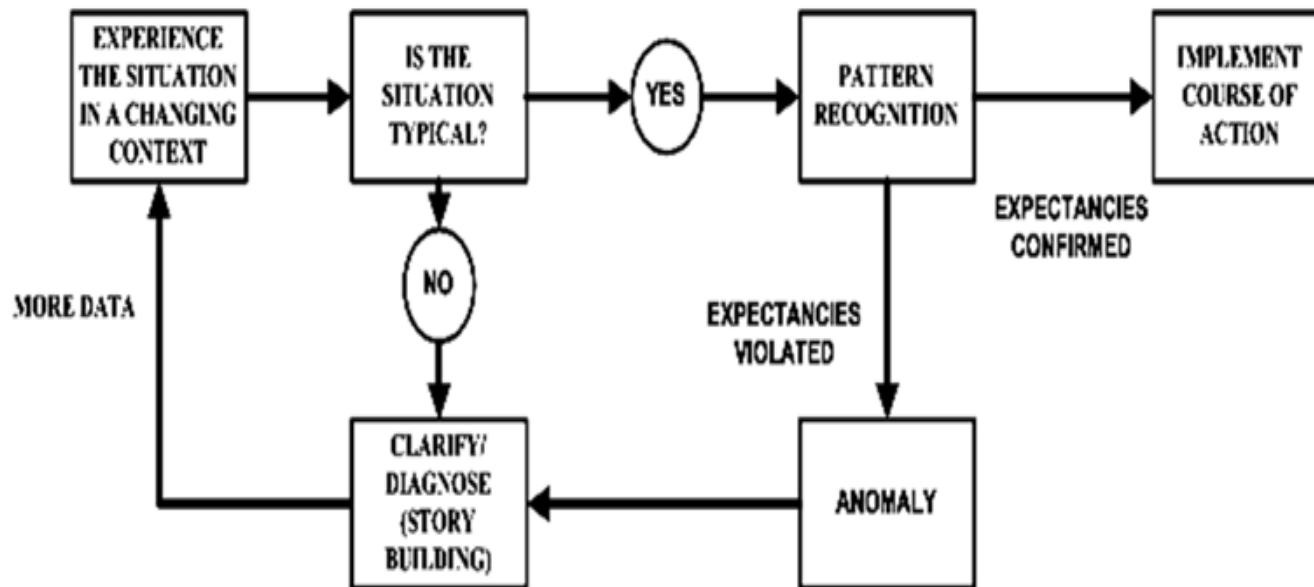


Naturalistic Decision Making

(e.g., Klein, 1987, 1998, 2008; Klein et al., 1995, 2003; Kahneman & Klein, 2009)



**80% or more of people in the field make Intuitive Decisions:
Meaningful Situational Pattern Recognition**



Recognition-primed decision model (Klein, 1997, 1998, 2008)

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Heuristics and Biases



(e.g., Kahneman & Tversky, 1972, 1973; Tversky & Kahneman, 1971, 1973; Tversky & Kahneman, 1974; Kahneman & Tversky, 1979)

Probabilistic reasoning under uncertainty involves heuristics:

- (1) **Representativeness** (assessing prob of event based on similarity);
- (2) **Availability** (assessing prob of event based on ease of recall);
- (3) **Anchoring and Adjustment** (assessing prob of event by taking suggested value and insufficiently adjusting it upward or downward)

K & T: Humans are poor decision makers; ignore / underestimate prior probabilities & base rates

Alternative: Lopes & Oden (1991): individuals engaged in *pattern recognition*

“...pattern-based reasoning substantially reduces the inference problem to ... identification.” (pp. 213-214).

Lopes & Oden (1991): “...not all intelligent thought embodies the sequential, deductive, deliberate, and conscious character that conceptions of intelligence based on the serial computer require...”

Underlying thought processes usually are parallel, inductive, automatic, and, save for their final results, mostly unconscious” (pp. 218).

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Automatic Processes



(e.g. Betsch et al, 2001; Glöckner, 2006; Glöckner & Betsch, 2008; Glöckner et al, 2008; Betsch & Glockner, 2010, 2012; Söllner et al, 2014)

Glöckner & Betsch (2008): information search and decision making:

	City A	City B	City C
State Capital (p = 0.9)	-	+	-
Pro Sports (p = 0.8)	+	-	-
Airport (p = 0.7)	+	-	-

Payne et al. (1988): one piece of information revealed at a time: ave decision time = **44 s**

Lohse & Johnson (1996): open matrix/deliberate strategy: ave decision time = **29.1 s**

Glöckner (2006): open matrix/deliberate strategy: ave decision time = **20.5 s**

Glöckner & Betsch (2008): open matrix/**spontaneous (intuitive) decisions: ave time = 1.5 s**

Intuitive processes: meaningful information integration, extensive thinking, output of preference & choice

Analytic thinking: can guide information search (component processes)

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Automatic Processes



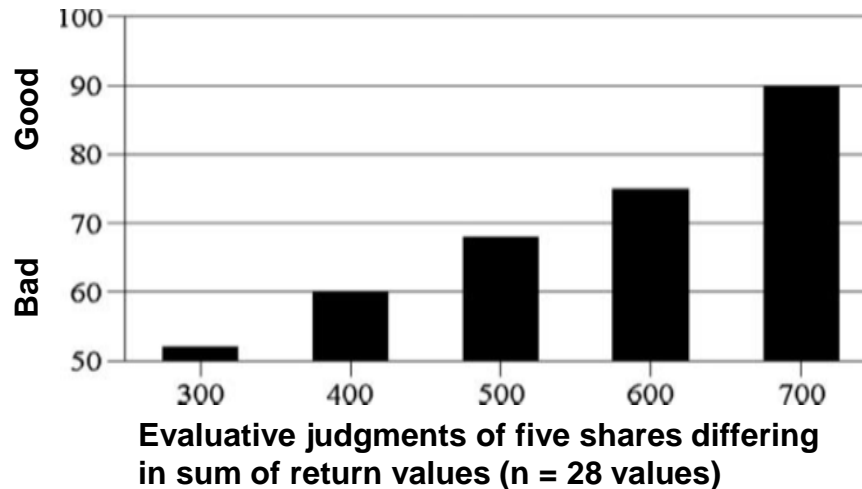
(e.g. Glöckner & Betsch, 2008; Betsch & Glockner, 2010, 2012; Söllner et al, 2014)
Betsch, Plessner, Schwieren & Gutig (2001):

Two simultaneous tasks: (1) memorizing videotaped ads ('primary task');
(2) reading share values (fictitious stocks) scrolling across bottom of display

140 values produced by five different shares; each presented quickly
(simulated stock market activity over 20 trading days); information overload
prevented conscious deliberation

Results: Recall: participants could not reproduce distribution of share values

Spontaneous Affective Evaluation: Participants **could** reproduce distribution of
share values by adjusting scroll bar on an **affective scale**



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Summary



***Intuitive Cognition (unconscious, meaningful pattern recognition):
Dominated human reasoning & decision making in all situations
examined:***

- **80-90% of individuals engaged in 'Matching Bias' (pattern recognition)**
- **Children succeeded on transitivity reasoning problems using intuitive 'gist' (pattern) despite lack of declarative memory for premises**
- **80% or more of people in the field make intuitive decisions (situational pattern recognition)**
- **Individuals likely engaged in pattern recognition over prior probabilities and base rates**
- **Intuitive cognition performed sophisticated information integration under conditions that defeated analytical cognition**

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Intelligence of Intuitive Cognition



Abstract Thinking:

Reasoning based on **relationships among elements** (e.g. *analogical reasoning*)

Holyoak & Spellman (1993): Modeled with predicate calculus: relationships among elements fill roles associated with arguments of predicates:

ABOVE (x, y) → ABOVE (bird, tree), ABOVE (picture, table)

Example: A person repaints whole car simply because of small scratch on one door; a friend walks by and says,

“Painting your whole car to prevent rust from a small scratch is like trimming your nails with a chain saw.”

This kind of sarcasm: fulfills requirements for high-level abstract thinking:
RESTRICT(rust, repaint car) :: RESTRICT(nails, chain saw)

Sarcasm: Incongruence between literal meaning & intended meaning

Schwoebel et al. (2000): people comprehend sarcastic phrase in **650 ms**; high-level thinking in half a sec--too fast for conscious deliberation, thus Intuitive!
(Glockner & Betsch, 2010)

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“*Meaning Making*” (Semiosis):



C.S. Peirce (C.P., 1960): Two-stage mental process: a ‘**sign**’ was a thought in relation to an external object, which took on meaning as an idea by being interpreted by a subsequent thought, called the ‘interpretant’

Neisser (1967): Meaningful thinking entails constructive, **pattern analysis-by-synthesis** operation--constructive secondary processes select among crudely-defined mental ‘objects’ or ‘ideas’ derived from primary processes

Minsky (1975): Meaning is found within **relationships** of frames (data-structures) to terminals, and of super-frames to frames

Empirical data: Human semiosis entails pattern synthesis

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“Meaning Making” (Semiosis): Maier (1931):

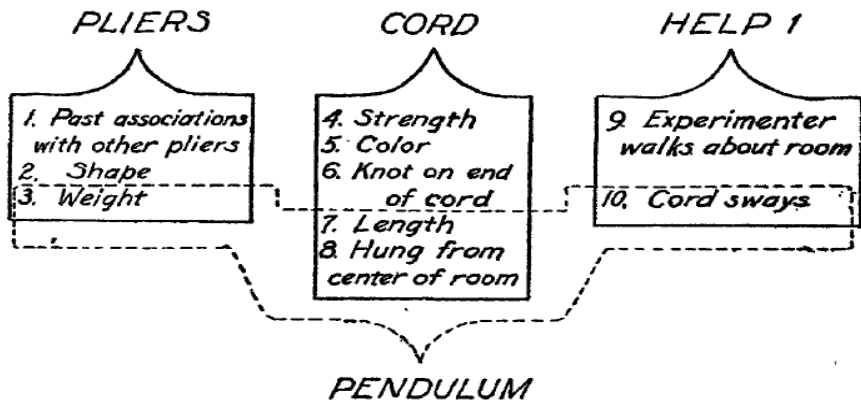
Two cords hung from ceiling (room contained pliers, etc.)
 Participants (61): tie two cords together (could not reach both simultaneously)
Problem solution: Tie weight on end of one cord, make **swinging pendulum**
 After 10 min, hint given (‘Help 1’): (1) experimenter brushed against one cord
 Results: 23% (14) failed to solve problem;

39% Solved Problem w/o Hint (24)

Could not explain origin of pendulum idea (‘just dawned on me’)

38% Solved Problem w/ Hint (23)

70% Solution appeared as whole (16)
 Denied hint played any role
 30% Solution appeared in parts (7)
 Agreed hint played a role



← Reasoning: sudden changes in conceptual organization and meaning

85% of people solving problem: **Solution appeared suddenly w/o consciousness**

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“Meaning Making”(Semiosis) Cont’d:



When the pendulum concept was ***synthesized***, knowledge about:
-The weight of the pliers, how length of cord w free end behaves
had to be retrieved from memory

Intuitive Cognition: synthesizes new situational patterns—from previous memories—and recognizes their significance

Memory exists so as to serve the present and future:

Memory for detail fades rapidly (Mandler & Ritchey, 1977; Gernsbacher, 1985); what is retained is semantics (gist)

Different memories are synthesized in a new context with new details

Imagining future experiences depends on memory for:

- spatial context (Hassabis, Kumaran, Vann & Maguire 2007)
- semantic knowledge (Irish, Addis, Hodges & Piguet, 2012)
- memory, imagination, prediction share common neural substrate (Mullally & Maguire, 2014)

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Intuitive Cognition, Intuitive Semiosis



Maier's (1931) study:

Meaning making based on **memory re-combination**

Accomplished by intuitive cognition for most participants: 85% of them could not consciously describe the basis of their reasoning

Intuitive Cognition: meaningful unconscious situational pattern **synthesis and recognition**, which relies on **memory** → **INTUITIVE SEMIOSIS**

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Machine Semiosis



Artificial **machine semiosis** has been controversial

Searle's (1980) seminal Chinese room thought experiment:
computers use syntactic rules to manipulate symbols, do not think

Solution(?):

- (1) ***Constraint satisfaction***--meaning generated by a system for the purpose of satisfying a constraint (Menant, 2003, 2013)
- (2) ***Symbol grounding***--representations linking symbols to external referents generate semantics (Harnad, 1990, 1992)

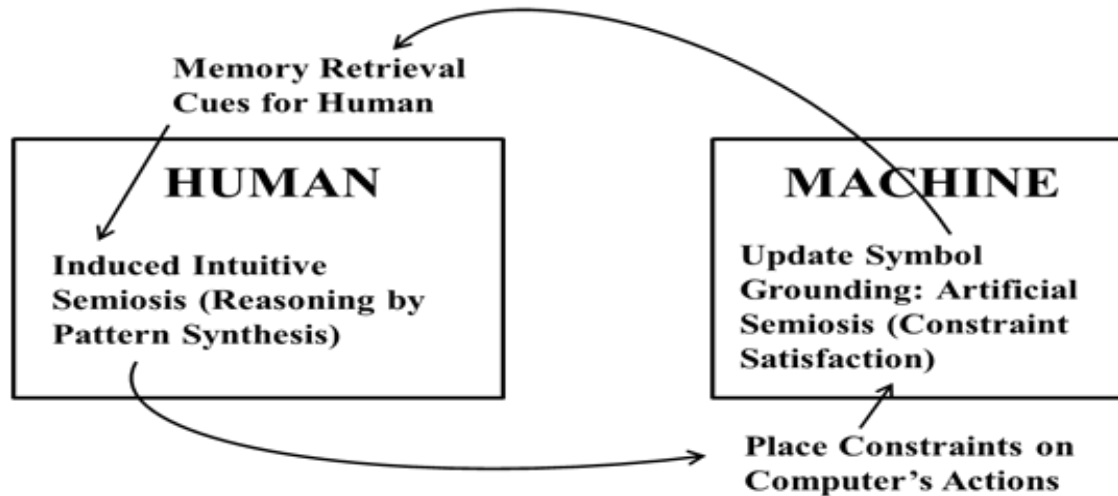
My approach: meaning created by the constraint alters the grounding of machine's internal symbol system using computational semiotics (Gudwin & Queiroz, 2005)

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Joint Semiosis

JOINT SEMIOSIS: Constraint-Cued Memory framework



Constraint-cued memory framework:

Requires human to possess necessary background knowledge and expertise that can be retrieved with cues presented by computer

Computer must possess necessary database and representations whose grounding can be modified by instructions from human

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QUESTIONS?



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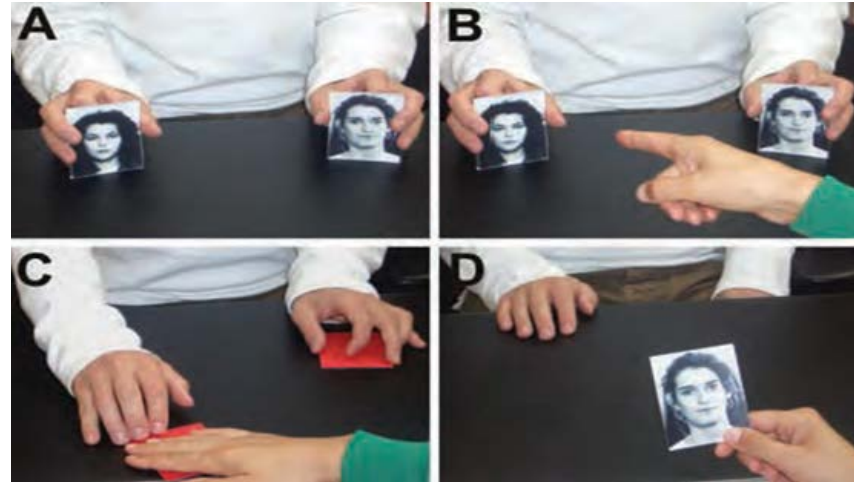


Dissociation of Consciousness from Behavior

Johansson et al. (2005): “Choice Blindness”:



Participants: shown photographs of two women (A), asked to choose most attractive one (B), next experimenter gave participants ‘preferred’ photograph (C), and asked them to explain reasons for their choice (D)



Experimenter covertly switched photographs; on **75% of trials, participants did not notice switch & still gave credible reasons for their choice:**

“She’s radiant. I would rather have approached her in a bar than the other one. I like earrings”

No differences between quality of reasons given for real versus false choices

Thus, people were **likely confabulating reasons in both types of cases**

Individuals can confabulate reasons for their behavior and do not know it!

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