U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND (DEVCOM) – AVIATION & MISSILE CENTER (AvMC)

Human vs. Machine: Data for Situational Awareness, Decision Making and Robust Decisions

DoD Human Factors Engineering Technical Advisory Group VTAG 2021

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STANDING ON THE SHOULDERS OF GIANTS

"Nanos gigantium humeris insidentes"

"If I have seen further it is by standing on the shoulders of Giants."
--Sir Isaac Newton (1675)

Special thanks to:

- Dr. Mica Endsley – "Designing for Situational Awareness"
- Dr. Daniel Kahneman – "Thinking, Fast and Slow"
- Dr. Gary Klein – Recognition Primed Decision (RPD) model
- Dr. Larry Shattuck – Director, Human Systems Integration Program, Naval Postgraduate School

SPECIALTIES – HUMAN VS. MACHINE

Human

- Creativity
- Nuance/subtleties
- Abstract thinking
- Operating with scarce information
  - fill in missing info from experience
- Empathy
  - body language, “Reading” emotions
- Spatial awareness and reflexes
- Concentration
  - in-the-moment vs. Strategic
- 3D recognition from 2D sensors
  - eyeballs

Machine

- Quick memory
  - easy to forget (erase)
- Sorting and processing
  - massive data sets
- Performing well defined, modular, or repetitive/boring tasks
- Mathematical calculations

EXERCISE ONE

- For illustration, please refrain from looking-up the answers just yet.

A bat and ball together cost $1.10. The bat costs $1.00 more than the ball.

How much does the ball cost?

EXERCISE ONE (CONTINUED)

How long did it take you to arrive at your intuitive answer?

How long did it take you to arrive at the actual answer?

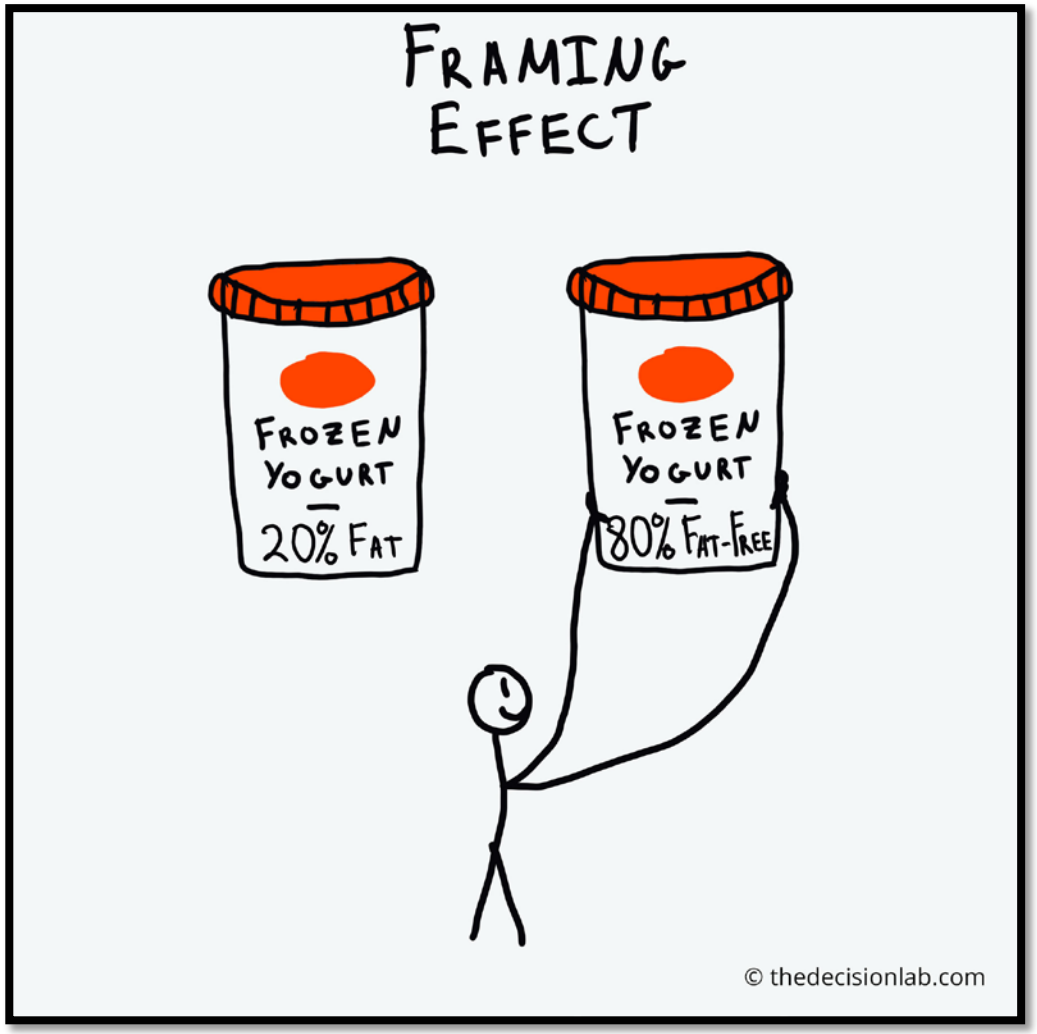
Think about how much more effort it took to arrive at the actual answer.

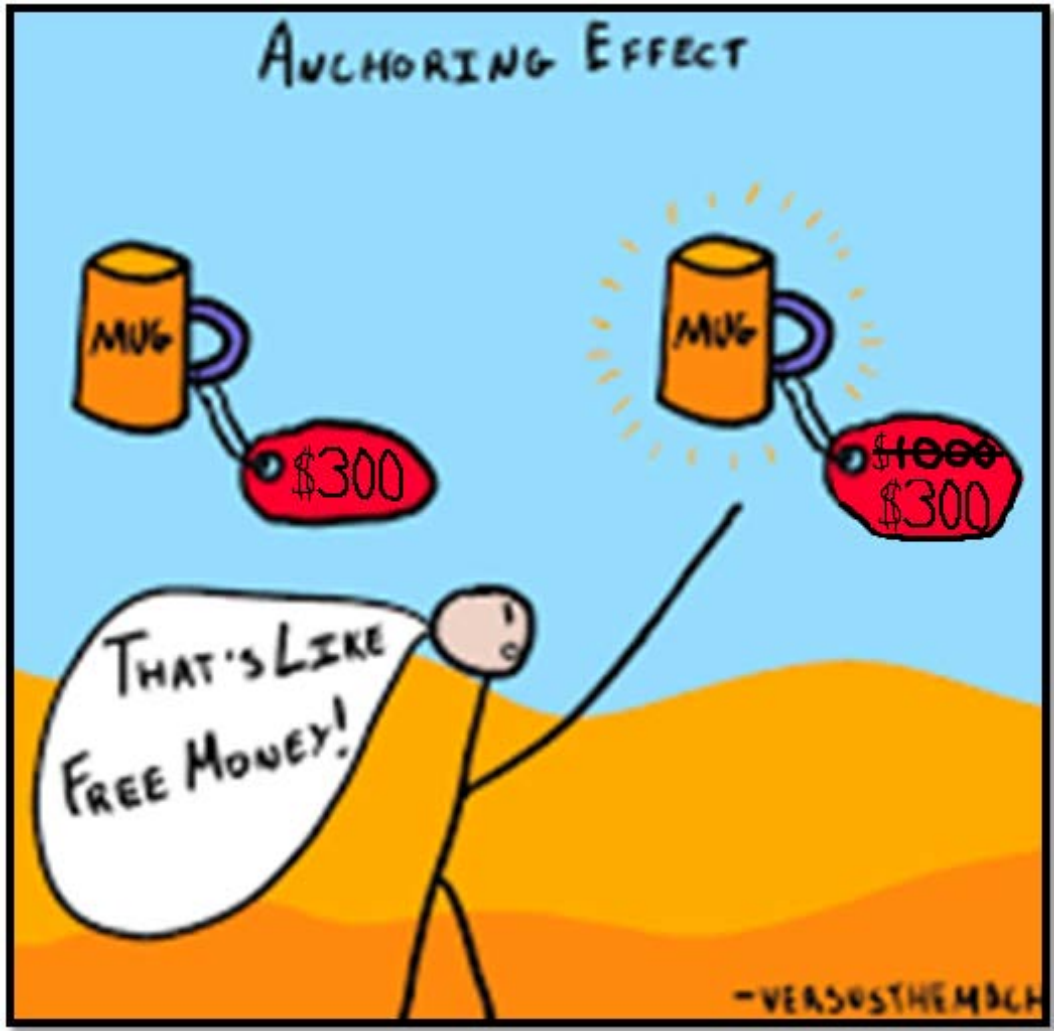
EXERCISE TWO

How would you answer these two questions?

- Is the population of Turkey greater than 35 million?
- What's your best estimate of Turkey's population?

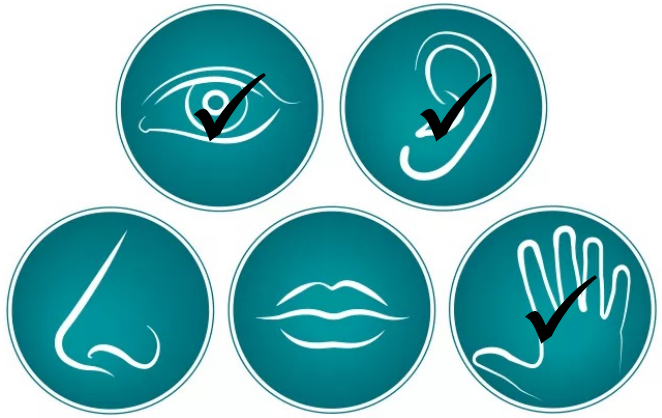
COGNITIVE BIAS EXAMPLES



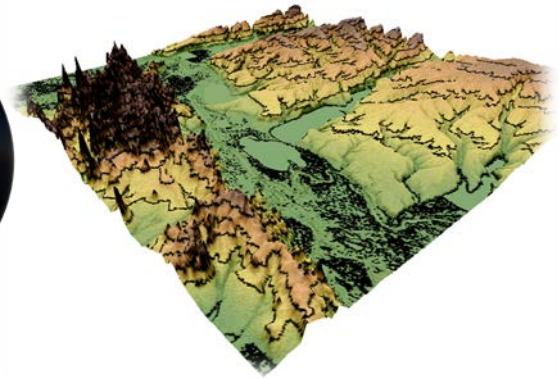


These are just two of at least 188 cognitive biases of the human mind

DATA FOR SITUATIONAL AWARENESS - HUMAN VS. MACHINE



Human



Machine

Visual – many humans get most of their situational awareness data from the visual process – out-the-window, gauges, indicator lights, displays – mission status, elevation, attitude, moving map, cueing

Aural – information from aural sources is the next most important – Radio communications, onboard team members, flight status, and cueing

Tactile – seat-of-the pants, g-forces, cueing, balance, positional awareness

Sensors – visual, IR, Radar, LIDAR

Data sets – Digital Terrain Elevation Data (DTED), mission data, survivability info

System status – engine temp., torque, weapons

System messages – position, location, status, capabilities

Networks and communication

MODEL OF SITUATIONAL AWARENESS IN DECISION MAKING

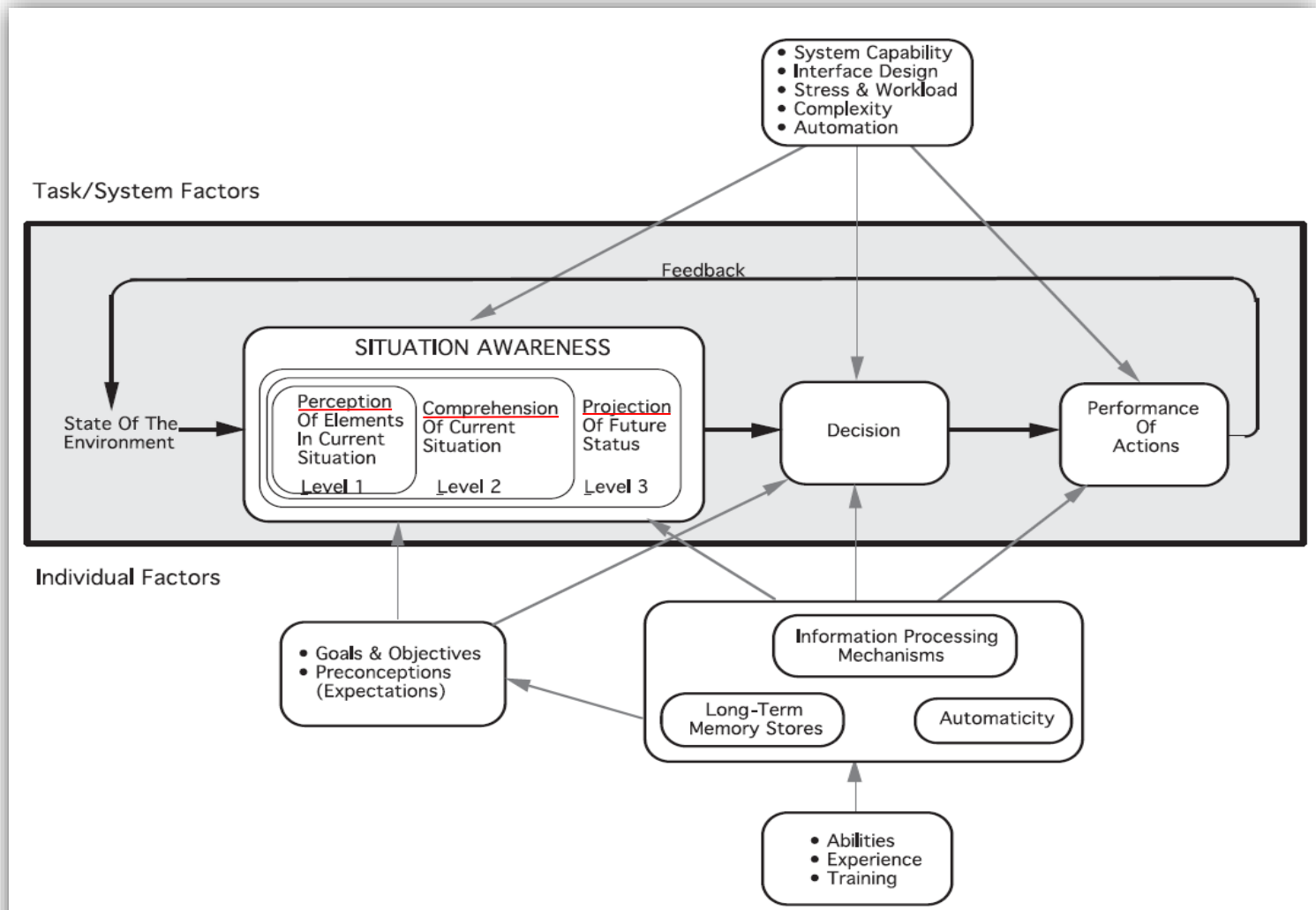


Figure 3 Model of SA in dynamic decision making. (*Source:* Endsley, 1995c. © 1995 SAGE Publications.)

DECISION MAKING - HUMAN VS. MACHINE

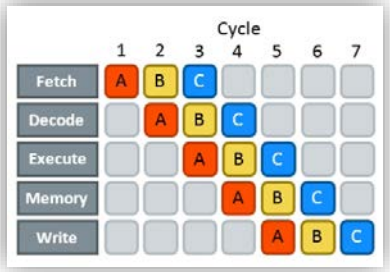
Human

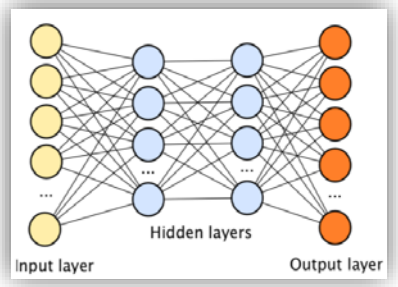
- Many decisions are made quickly (System 1) with intuition or subconscious through many hours of practice or exposure, while the remaining few require careful and concentrated thought (System 2)
- Recognition Primed Decision Making – people use their experience in the form of repertoire of patterns. They quickly match the situation to the patterns they have learned. Thus, people can successfully make extremely rapid decisions (see diagram on next slide)
- Bias, Framing, Anchoring – as in the previous examples, those quick decisions can lead to inaccurate decisions if time is not taken to dig deeper into the situation and engage System 2
- Creativity – However, creativity and abstract thinking help humans adapt to new and different situations

Machine

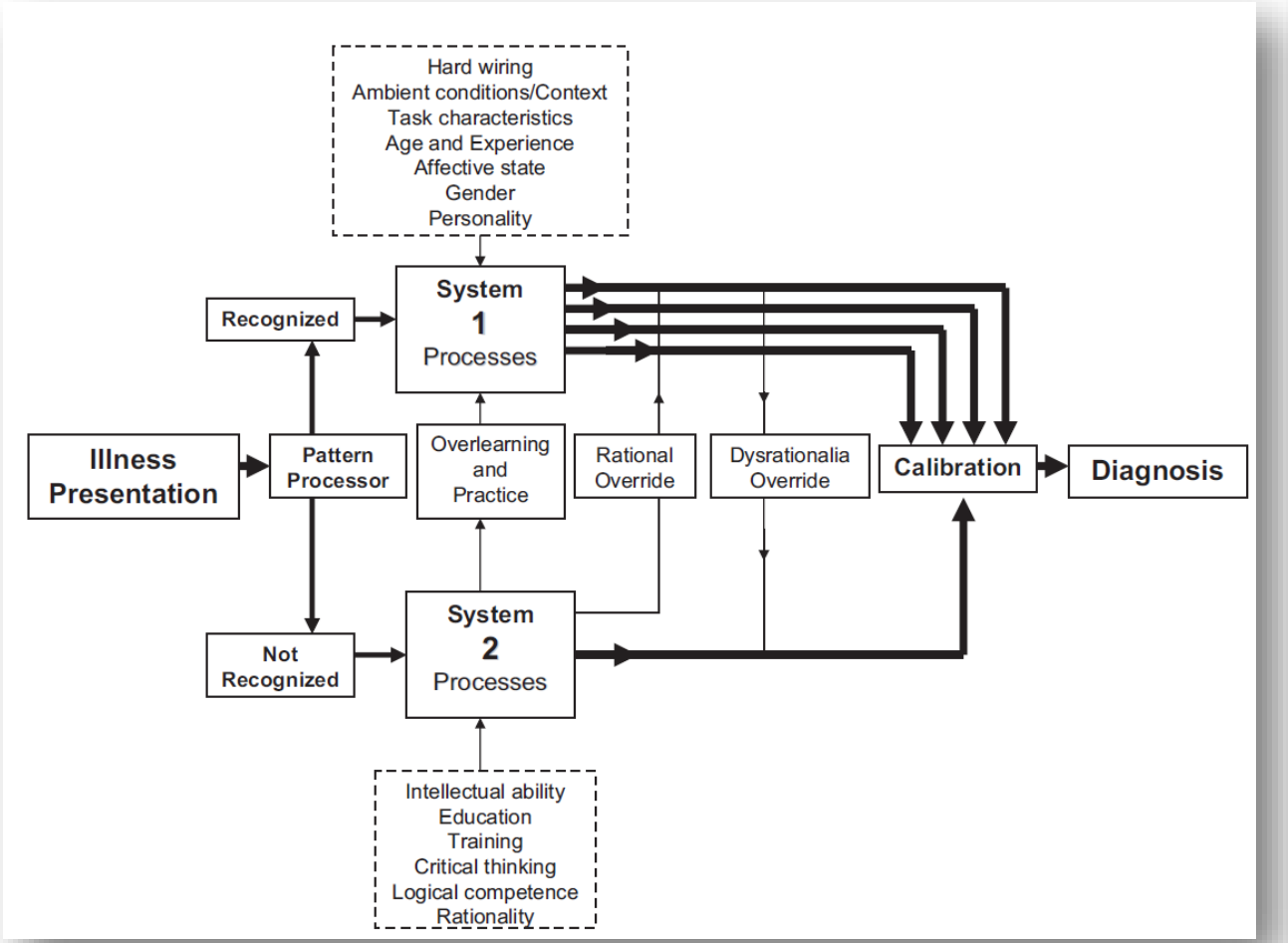
- Procedural
  Algorithmic – hard coded processes: fetch, decode, execute, repeat
- Probabilistic
  Bayesian – probabilistic based on available data
- Next evolution
  Learning through experience

  Artificial General Intelligence
  …but we are many years away from emulating human capabilities





DECISION MAKING MODELS



A Universal Model of Diagnostic Reasoning. Pat Croskerry, MD, PhD, 2009

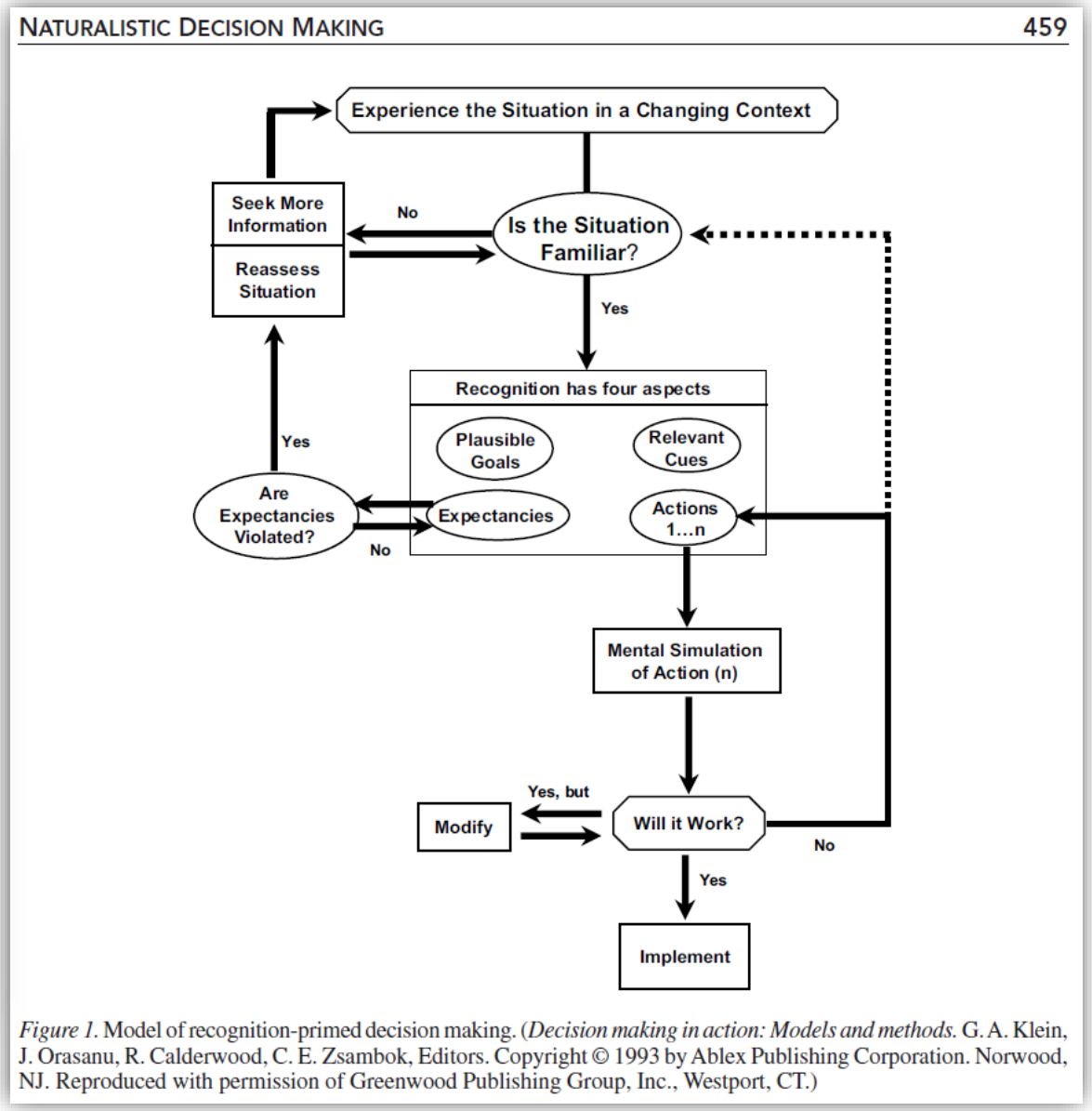


Figure 1. Model of recognition-primed decision making. (*Decision making in action: Models and methods.* G. A. Klein, J. Orasanu, R. Calderwood, C. E. Zsambok, Editors. Copyright © 1993 by Ablex Publishing Corporation. Norwood, NJ. Reproduced with permission of Greenwood Publishing Group, Inc., Westport, CT.)

DECISION ROBUSTNESS - HUMAN VS. MACHINE

	Human	Machine
Bad	Independent Sys1 & Sys2 e.g., Bat & Ball problem	Context awareness e.g., Faulty image recognition
Good	Combinatory Sys1 & Sys2 e.g., calibrating to context	Big Math e.g., weather forecasting Big Data e.g., targeted marketing

HOLISTIC SITUATIONAL AWARENESS AND DECISION MAKING (HSA-DM)

Problem Statement:

- Future operations in complex, highly contested and *dynamically-changing* operational environment
- Aircrews must mentally fuse data from multiple sources to create actionable information while maintaining hands-on control of the aircraft, causing fatigue and human *errors due to cognitive overload* and task saturation.
- *Lack of integration* from numerous sources of situational awareness information (navigation, obstacle avoidance, survivability cueing, tactical maps, intelligent teaming, air-launched effects)

Project Goals:

- Provide optimized task loading for Future Vertical Lift /aviation warfighters (pilots, copilots) by developing *cognitive workload management capabilities*
- Improve combat mission performance of Novice, Busy, Fatigued, and Injured pilots by delivering *decision aiding algorithms*, improved human-machine interface hardware/software, and implementing autonomous flight controls
- Develop products based on *MOSA principles* and aligned with the FVL Architecture Framework utilizing *Model Based Systems Engineering*

HSA-DM Focus Areas

Decision Aiding

- Data & Information fusion for pilot SA
- Situational Awareness data management
- Situation context sensing and awareness
- Supervised autonomy of select tasks

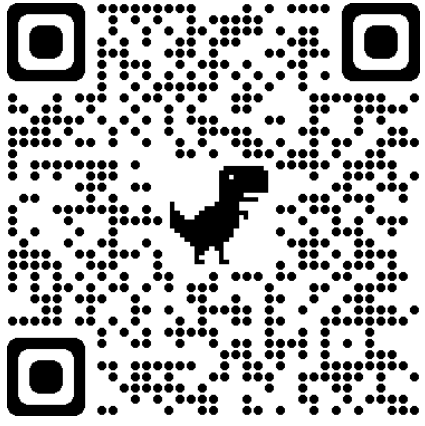
Human/Machine Interface

- Mature operator state monitoring
- Further mature visual and audio cueing to reduce cognitive workload
- Graceful supervised autonomy handoff/recovery

Autonomous flight controls

- Decrease pilotage workload
- Increase in spare cognitive capacity
- Exploit environment – assist in DVE conditions

Thank you for your time!



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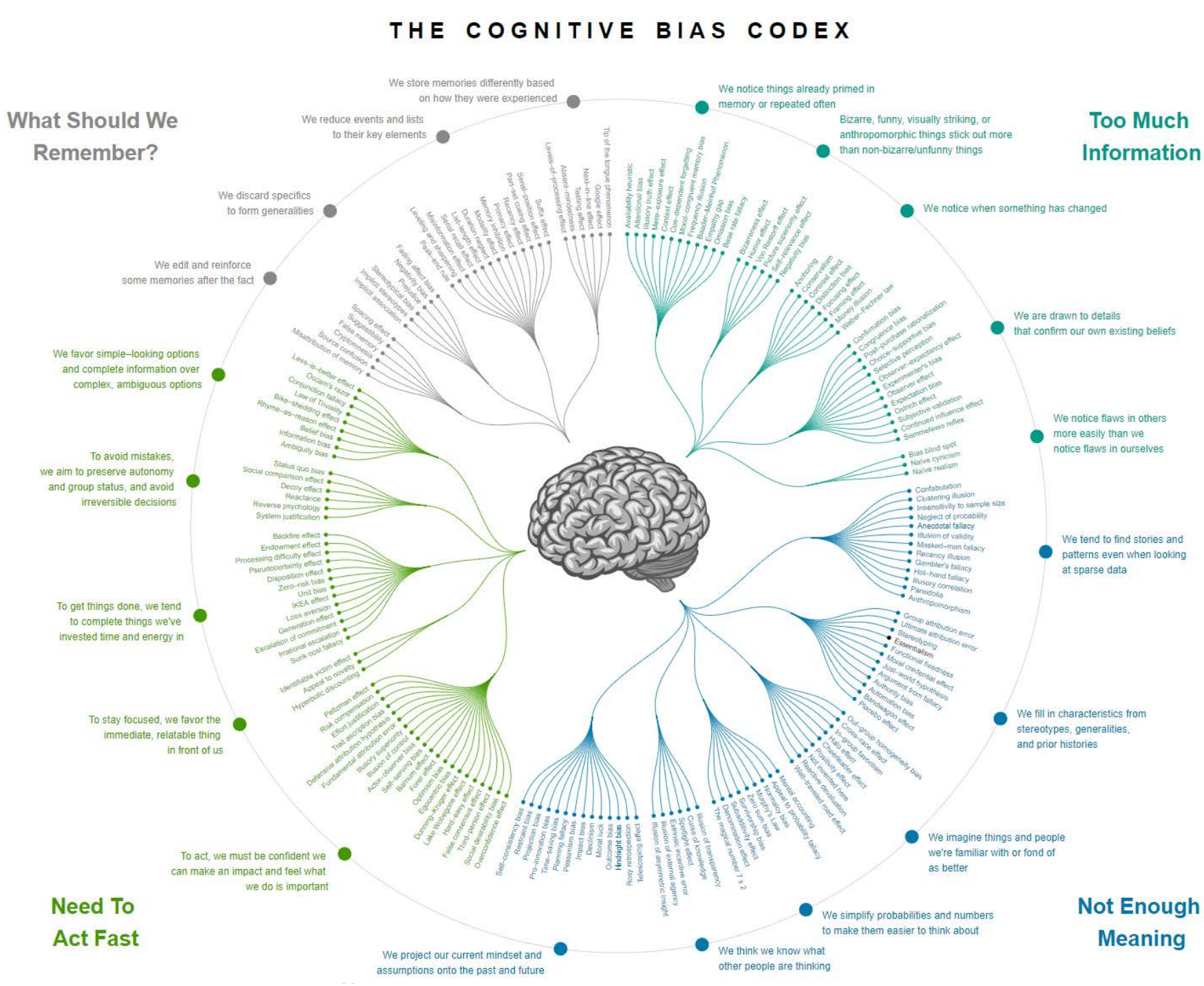

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