Metacognition – Understanding cognition for adaptive performance

Rob Hutton
Trimetis Ltd

Defence Strategic Leadership Programme (DSLP)
Shrivenham Leadership Centre,
Defence Academy, Shrivenham
0930-1230
8 Nov 17
Purpose of this Session -

• Challenge “accepted knowledge” & “conventional wisdom”
• Not rehash “the same ol’ stuff about how biased we all are”, and how we need to be more logical critical thinkers
• Present some theories/models of thinking and decision making which give you alternative ways to think about thinking
• To be critical, challenging of ourselves and of others...
• To support “reasonable challenge” with more sophisticated ways of thinking about our own (and other’s) thinking
• To support active reflection to develop your own thinking
Session Learning Objectives

Able to understand your own approach to decision making:

(1) Can recall key points from the psychology of thinking and cognition, and the broader subject of decision making.
(2) Can describe some of the main pitfalls in decision making and problem solving.
(3) Have established an understanding of and can describe own thinking and decision-making style.
(4) Can describe the impact of the VUCA environment (and other relevant contextual influences), its impact on decision making and ways to mitigate this.

There is an emphasis on understanding the balance between what makes for successful decision making versus what the limitations of human thinking, reasoning and decision making are, so that you will have developed further self-awareness around decision making.

The programme is further supported on decision making through a session with Cranfield on the “Systems thinking and managing complexity and ambiguity” and Cranfield's Defence Thinking Skills Series.
Overview

• Introduction
• Metacognition
• Decision Making
• VUCA & Adaptation
• So what?
  • Take aways/implications
Warning: there will be a test! 😊

• Please take notes relating to potential applications and/or implications of the content for discussion in the last part of the session...
Metacognition: Decision Making

1. Subconscious/Tacit  Consous/Explicit

2. “Intuitive”  Analytical

3. Biases

4. Heuristics

5. Applications/So What?

Learning from Experience

Developing Expertise

Experience/Expertise
Applied psychological research; Human factors psychology; Cognitive systems engineering
Areas of Professional Interest

• Developing and applying:
  • Models (of behaviour/performance)
    • decision making, (re)planning, uncertainty management...
  • Methods
    • cognitive task analysis and cognitive systems engineering
  • Metrics
    • evaluating cognitive work performance

In support of designing:
• Technology (decision aiding/decision support systems; user interfaces)
• Training
• Doctrine
• Teams
• Ways of working/SOPs
Areas of Application

• Weather forecasters
• Air Traffic Controllers
• Electrical Power Grid control room operators
• Military planners (US & UK; from tactical to operational)
• Military operations (from small unit to operational headquarters/Operations centres; US & UK)
• Intelligence analysts
• Emergency services (e.g. fire fighters; incident commanders)
• Nurses (neonatal; midwives)
• Laparoscopic surgery
• Rugby decision making
• Aviation Safety Inspectors
• Aircraft maintainers (B-2 avionics and F-16 & C-141 ground crews)
A Decision Problem: Eye in the Sky

• **Situation**: No. 4 on the Most Wanted list has been tracked to a house in Nairobi. She leaves before the capture plan can be executed, and moves to a house in the outskirts of a village in Al-Shabab control. She meets with two individuals about to embark on suicide missions. The suicide vests/explosives are in the house. The house is in a civilian neighbourhood with a market nearby.

• **Mission**: to capture/kill the High Value Target

• **Plan/Execution**: An armed USAF Predator drone has eyes on the target house. A micro-UAV has eyes in the house. Limited ground forces (Kenyan SF) are available.

• **Command & Control**: Predator team are in US; UK mission commander is in Northwood; UK govt. officials are in London; Intelligence support is in Hawaii.
Eye in the Sky Exercise

• Watch the clip

• Individually jot down key aspects of the decision making –
  • What factors contributed?
  • What were the sources of information?
  • What strategies or processes were used to make the decision/s?
Group Discussion – Aspects of Decision Making

• As a group (table group) discuss the clip
  • What were the decisions?
  • Why were they difficult?
  • What factors contributed to the decision making?
Some Decision Topics from “Eye in the Sky”

• Adaptive decision making
• Dynamic: things change; “no plan survives first contact”
• Distributed/team decision making
• Technology support – CDE modelling
• Justification vs. Doing the right thing vs. Doing the thing right
• Uncertainty: Positive ID? Blast radius?
• Time pressure: when will they leave the house and disperse?
• Organisational constraints: legal considerations; permissions...
• Moral/Ethical component
Metacognition: Decision Making

1. Subconscious/Tacit vs. Conscious/Explicit
2. "Intuitive" vs. Analytical
3. Biases
4. Experience/Expertise
5. Applications/So What?

Learning from Experience
Developing Expertise
So what? Why are we here?

• Reflecting on someone else’s approach to decision making is not far off reflecting on our own decision making...

• Recognising strengths and deficiencies in thinking, reasoning, assessing, planning, and evaluating in others, is not that dissimilar to reflecting our own strength and limitations

• Improving ourselves

• Improving others in teams we work with
“Metacognition” – SLDP View

• Understand your own intellectual approach
• Utilises its strengths and consults to support decision blind spots
• Willingly utilises subject matter experts to best effect
• Has developed sufficient contextual understanding to retain responsibility and control whilst not being sucked into the detail
• Can develop the environment to allow others to intellectually contribute i.e. to allow greater innovation or challenge to assumptions and group think
• “Leadership is creating the climate in which people will tell you what you need to know”.

© TRIMETIS 2017
Metacognition – Neuroscientific View

• Neuroscientific view - “Executive Control Mechanism” in pre-frontal cortex

• Executive functions include:
  • Basic cognitive processes such as:
    • attentional control
    • cognitive inhibition
    • inhibitory control
    • working memory
    • cognitive flexibility
  • Higher order executive functions require the simultaneous use of multiple basic executive functions and include:
    • planning
    • fluid intelligence (i.e., reasoning and problem solving)
Cognitive Psychology View

• Baker & Brown (1984)
  • knowledge about cognition, and
  • regulation of cognition.
• Gott, Lajoie, & Lesgold (1991)
  • Self-knowledge of thinking
  • Self-regulation of thinking
• Self-
  • monitoring
  • regulation
  • critiquing
  • evaluation
  • control
  • correction
Metacognition

• Fundamentally: “Thinking about thinking”
• Being aware of one’s own processes (within limits)
  • “Intuitive” vs. analytical
  • Automatic vs. Conscious cognitive activity
  • Our own thinking vs. thinking of others (inc. people and intelligent systems)
• Understanding strengths and limitations of human cognition
  • And the factors that influence cognition
• Adapting thinking to account for strengths/limitations
  • Strategies, ways of working, and techniques
Your examples of metacognition in action?

• Think of strategies that you use in your everyday or work life which support adaptation of your cognitive abilities to the task at hand...
e.g. Strategies for Improving Thinking – Individual

• Writing down a phone number
• “Chunking” a phone number (e.g. as a memorable date or word)
• Styrofoam cup on the landing gear
• Sticky notes (“Do not press this button!”)
• Taking a photo of an important piece of information
• Lots of examples of memory and reminders, fewer for decision making...
• Sat Nav strategies (understanding the thinking of others/Al)
e.g. Strategies for Improving Thinking – Coded into Practice

• Red teaming
• Comparing three COAs for planning against enemy’s “most likely and most dangerous”
• Devil’s advocate
• Ritual dissent
• Analysis of Competing Hypotheses
• Commander’s “Prism Group”
• Alternative Thinking Team (JFC/JW; SJFHQ)
How we Reason, Think, Plan and Decide.

• Analysis vs. “Intuitive”
• Automatic vs. Conscious/Deliberate
• “Bounded Rationality”
  • Heuristics vs. Biases

Recognition-Primed Decision Model of “Intuitive decision making”

Data-Frame Model of Sensemaking
BREAK
Conscious vs. Subconscious
Metacognition: Decision Making

1. Subconscious/Tacit  
   Conscious/Explicit

2. "Intuitive"  
   Analytical

3. Biases
   Heuristics
   Experience/Expertise

4. "Intuitive"  
   Analytical

5. Applications/So What?
   Learning from Experience
   Developing Expertise

© TRIMETIS 2017
Understanding and Decision-making
JDP 04 (2nd Edition; p.37)

Figure 2.1 – A conceptual framework for thinking
Subconscious & Conscious Cognitive Activity
(Rasmussen, 1984)
Forms of Error based on Rasmussen’s SRK Model

- **Error: Action not as planned**
  - Not doing what was intended

- **Skill-based Mistake**
  - Errors caused by inattention or misplaced attention

- **Slip (Commission)**
  - A simple, frequently-performed physical action goes wrong

- **Lapse (Omission)**
  - Short-term memory lapse – omission of a required action

- **Rule-based Mistake**
  - Use of inappropriate rule, misapplication of rule, or application of bad rule

- **Knowledge-based Mistake**
  - Due to incomplete or inaccurate understanding, bias, cognitive strain, overconfidence, etc.

- **Human Errors**

- **Inadvertent**
  - Error: Action as planned
    - Did the wrong thing believing it to be right

- **Human Failure**
  - Deliberate
    - Violation: Noncompliance
      - Knowingly take short cuts or fail to follow procedures
Analytical View of Decision Making
Metacognition: Decision Making

1. Subconscious/Tacit - Conscious/Explicit

2. "Intuitive" - Analytical

3. Biases
   Heuristics

4. Experience/Expertise

5. Applications/So What?
   Learning from Experience
   Developing Expertise

© TRIMETIS 2017
Classical Decision Making Model

1. Identify Problem
2. Generate Options
3. Analyze Options
4. Select Best Option
5. Implement Decision
6. Evaluate and Learn from Decision
Decision Making

• Focus on CHOICE
  • Selecting between a choice of action options

• Option Selection?
  • Selection criteria?
    • Well-specified?
    • Data available?

• What about option generation?
Evaluating whether a decision is “good”

- Based on formal logic and probability theory
- E.g. risk assessment
  - Risk = Likelihood (Probability) x Impact (Cost)
- Subjective Expected Utility theory
  - Best decision maximises subjective expected utility
  - Expected Utility = Likelihood (probability) x Subjective Utility (Value)
- Process vs. outcome
- Multi-Attribute Utility Theory
Rational Choice Model of Decision Making

<table>
<thead>
<tr>
<th>Evaluation Dimensions</th>
<th>Options</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Rational Choice Model of Decision Making

Limitations

- Requires too much time
- Requires too much data
- Can result in worse performance
- Little value to training or decision aids
- Depends on intuition
- Gaming the method
- Distortions are introduced
- Zone of Indifference

<table>
<thead>
<tr>
<th>Evaluation Dimensions</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td>1</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3</td>
</tr>
</tbody>
</table>
Zone of Indifference
Reflecting on your own Decision Making...

• (Hopefully...) You’ve prepared at least one example of a critical decision you’ve made in the last year or so...

• “Think of a time when your experience or expertise made a difference to the outcome of a challenging decision/problem situation... a success story/near miss...”
Technique: Active Reflection on Decision Making: Decision Requirements Exercise

• It’s a decision-centred AAR
  • Debriefing your own experiences
  • Learning from experience
  • Reflective practice

• Focused on decision making (and decision context) not process-focused
Debriefing Structure

• What was your assessment of the situation?
  • Information/cues
  • Related factors
  • Deductions
  • Assumptions
  • Alternative assessments considered?

• What did you do?
  • Actions (individual/team)
  • Goals
  • Strategies (decision/thinking and action)
  • Alternatives actions considered?

• What were the challenges? Why was it difficult?

• Potential errors for someone with less experience?
Timeline & Decision Points

- Initial Cordon & Search/Capture Plan
- Targets leaving house
- Positive ID of HVT
- Identification of Suicide vests
- Revised collateral Damage estimate

T-0 | T+1 | T+2 | T+2.5 | T+3
# Decision Requirements Table

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Capture plan</td>
<td>HVT in house in Nairobi</td>
<td>Cordon/Search/Capture</td>
<td>Coordination of ground, ISTAR, &amp; C2</td>
<td>Miscommunications</td>
</tr>
<tr>
<td>Targets moving – capture now?</td>
<td>Don’t know if HVTs are present</td>
<td>Track until PID confirmed Possible air strike</td>
<td>No PID Potential for collateral damage ROEs not appropriate?</td>
<td>Go in but miss HVT Capture and fail to contain assault/CD Lose HVTs in “noise”</td>
</tr>
<tr>
<td>PID of HVT – air strike?</td>
<td>Positive ID All HVTs in single location Surrounding civilian popu ln Not at war with Kenya UK and US citizenships</td>
<td>Assess air strike option Collateral damage assessment Get approval for change of ROE</td>
<td>ROEs not in place for strike mission</td>
<td>Strike without legal coverage and create international incident</td>
</tr>
<tr>
<td>Suicide vests – collateral damage?</td>
<td>Not sure what the explosive yield is</td>
<td>Conduct CDE</td>
<td>Yield is estimate only Targeting factors are various</td>
<td>Strike without consideration for extra collateral damage</td>
</tr>
</tbody>
</table>
Metacognition: Decision Making

1. Subconscious/Tacit
2. Conscious/Explicit
3. Biases
4. Heuristics
5. Applications/So What?

Experience/Expertise

"Intuitive" ← Analytical

Learning from Experience

Developing Expertise
Heuristics & Biases

• Heuristics
  • Rules of thumb (‘short cuts’) that are typically adaptive and ‘satisfice’

• Biases
  • When heuristics go wrong!
  • Patterns of decision error
  • Systematic errors of judgments, analysis, and/or decisions
  • Judged against a (normative) standard of Bayesian probability
Information Processing Stages

Figure 1.3 A model of human information processing stages.
What Should We Remember?

We store memories differently based on how they were experienced.

We reduce events and lists to their key elements.

We discard specifics to form generalities.

We edit and reinforce some memories after the fact.

We favor simple-looking options and complete information over complex, ambiguous options.

To avoid mistakes, we aim to preserve autonomy and group status, and avoid irreversible decisions.

We notice things already present in memory or repeated often.
Cognitive Bias Codex

We store memories differently based on how they were experienced.

We notice things already primed in memory or repeated often.

Bizarre, funny, visually-striking, or anthropomorphic things stick out more than non-bizarre/unfunny things.

We notice when something has changed.

We are drawn to details that confirm our own existing beliefs.

We notice flaws in others more easily than we notice flaws in ourselves.

We tend to find stories and explanations for our experiences.
We project our current mindset and assumptions onto the past and future.

We simplify probabilities and numbers to make them easier to think about.

We we think we know what other people are thinking.

We fill in characteristics from stereotypes, generalities, and prior histories.

We imagine things and people we're familiar with or fond of as better.

We fill in characteristics from stereotypes, generalities, and prior histories.

We we imagine things and people we're familiar with or fond of as better.

We simplify probabilities and numbers to make them easier to think about.

We we think we know what other people are thinking.

Not Enough Meaning

We project our current mindset and assumptions onto the past and future.

We simplify probabilities and numbers to make them easier to think about.

We think we know what other people are thinking.

We imagine things and people we're familiar with or fond of as better.

We imagine things and people we're familiar with or fond of as better.
To get things done, we tend to complete things we’ve invested time & energy in.

To stay focused, we favor the immediate, relatable thing in front of us.

**Need To Act Fast**

To act, we must be confident we can make an impact and feel what we do is important.

We project our current mindset and assumptions onto the past and future.

We think we know what other people are thinking.
How is decision making evaluated?

- What is an error of decision making?
- Against what standard?
- Biases are defined by failure to abide by a formal, logical or mathematical ("rational") standard
- Is that standard appropriate and/or applicable for decision making “in the wild”?

- Herb Simon’s view of human “bounded rationality”.
  - We’re not perfect against standards of logic and probability, but we “satisfice”
Biases Research – Handle with care!

• Experimental situations were contrived to reliably reproduce and study the biases
• Inexperienced participants with unfamiliar/novel problems
• Can’t make predictions; are identified in hindsight
• How do we guard against biases?
  • “de-biasing training” has been shown to generate limited, if any, performance improvements (Cohen, 1993)
Heuristics

• A mental “short cut”
• Allows judgments, assessments, option identification, and option evaluation under VUCA conditions:
  • Volatile
  • Uncertain
  • Complex
  • Ambiguous
• and, Time pressure & Fatigue
• Heuristics are expressions of expertise and experience, typically based on what has worked in the past
Examples of Heuristics

• Anchoring & Adjustment
• Availability
• Representativeness
• Familiarity
• Similarity
• Simulation

• Naïve Diversification
• Affect
• Recognition
• Effort
• Peak-End Rule
• Take-the-Best
Emergency Department Decision making

- “Muddling through in the ED”
DM as “Adaptive Control System”

• Illustrates the decision-making process as an adaptive control system guided by two complementary heuristics:
  • Common Thing, and
  • Worst Thing.
• Not one or the other, but both...

Ill-defined (VUCA) Problems

• Logical puzzles used in laboratory research vs. ‘ill-defined’ or ‘messy’ problems faced by ED physicians

• Lopes [1982] suggested that the normative logic (e.g., deduction and induction logic) that works for comparatively simple logical puzzles will not work for the kinds of ill-defined problems faced by ED physicians.
  • ill-defined problems are essentially problems of pulling out the ‘signal’ (i.e., the patient’s actual condition) from a noisy background (i.e., all the potential conditions that a patient might have).
Review where we are...

• Analytical approaches – based on normative standards
• Heuristic & biases – based on rational/normative standards
• Next:
  • Decision making in VUCA environments where normative/rational standards are in appropriate/unachievable
  • Intuitive (expert) decision making based on experience/expertise
  • Expertise mitigates the limitations of analytical frailties and biases
Metacognition: Decision Making

1. Subconscious/Tacit
2. Conscious/Explicit
3. Biases
4. Heuristics
5. Applications/So What?

Experience/Expertise

Learning from Experience
Developing Expertise

“Intuitive” → Analytical
BREAK
Metacognition: Decision Making

1. Subconscious/ Tacit
   - Conscious/ Explicit

2. "Intuitive"
   → Analytical

3. Biases
   - Heuristics

4. Experience/ Expertise

5. Applications/ So What?
   - Learning from Experience
   - Developing Expertise
“Intuition” View of (Expert) Decision Making
A “Meaning-Processing” System

• Information Processing Metaphor
  • Memory storage
  • Information cues
  • Filters
  • Information/Communication theory

• Meaning-processing
  • Making sense of the world
  • Information in context
  • Explaining & Diagnosing
  • Making sense & Understanding
  • Anticipating & Predicting
Naturalistic Decision Making (NDM) – A different standard?

- Field research with professionals, using their expertise/experience to make decisions...
- How do we explain successful performance (vs. failures/biases)
- Normative vs. Descriptive views of decision making
  - was the answer right?
  - was the process followed?
- Macrocognition, e.g.
  - Recognition-Primed Decision model
  - Sensemaking – Data-Frame model
  - Adaptive Replanning – Flexecution model

- Research in VUCA environments...
Features of Naturalistic Decision Making

- Time Stress
- High Stakes
- Dynamic Settings
- Uncertainty
- Vague Goals
- Multiple Players
- Organizational Constraints
Pioneered by Dr. Gary Klein, colleagues and the NDM community

Explicit Knowledge:
1. Declarative information
2. Routines & procedures

Tacit Knowledge:
3. Pattern recognition
4. Perceptual discriminations
5. Mental models
6. Judging typicality

Six Types of Knowledge
Common Views of Intuition
System I & System II Thinking

- Cognitive Continuum (Hammond, 1992); Cognitive Style Index (Allinson & Hayes, 1996); “Thinking Fast & Slow” (Kahneman, 2011)

<table>
<thead>
<tr>
<th>System 1: Intuitive</th>
<th>System 2: Analytical</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Automatic</td>
<td>• Slower</td>
</tr>
<tr>
<td>• Effortless</td>
<td>• Serial</td>
</tr>
<tr>
<td>• Associative</td>
<td>• Effortful</td>
</tr>
<tr>
<td>• Difficult to control or modify</td>
<td>• Deliberately controlled</td>
</tr>
<tr>
<td></td>
<td>• Relatively flexible</td>
</tr>
<tr>
<td></td>
<td>• Potentially rule-governed</td>
</tr>
</tbody>
</table>

*Kahneman (2003). Thinking Fast & Slow*
So what is intuition?

- Intuition is how you turn experience into action
- A set of hunches, insights, gut feelings, anticipations and judgments stemming from previous experience
- NOT magic, or ESP
- Pre-conscious/sub-conscious mental processing which supports:
  - Recognition of problems (pattern recognition and anomaly detection)
  - Formulation of quick responses (COA option generation in spite of uncertainty)
  - Adaptive use of heuristics (e.g. representativeness and
Intuition is based on...

- Prior experience
- Pre-conscious, non-deliberate
- Tacit knowledge (characteristics of experts)
  - Sense of typicality – or anomaly
  - Perceptual skills
  - Pattern recognition
  - Mental models
A Framework for Thinking about Expertise in Cognitive Work
Macro cognition (the cognitive dimension) is that study of cognitive adaptations to complexity.
Myths:

– To make a decision, generate several options and compare them to pick the best one.
– Decision biases distort our thinking.
– Successful decision makers rely on logic and statistics instead of intuition.
Rational Choice Model of Decision Making

<table>
<thead>
<tr>
<th>Evaluation Dimensions</th>
<th>Options</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
U.S. Army Military Decision Making Process (1990s)

Look familiar?

<table>
<thead>
<tr>
<th>FACTORS</th>
<th>COA 1</th>
<th>COA 2</th>
<th>COA 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FACTORS</th>
<th>COA 1</th>
<th>COA 2</th>
<th>COA 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MASS</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SIMPLICITY</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>DECEPTION</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>FRATRICIDE</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>ASSAULT</td>
<td>8</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SUPPORTING ATTACK</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>PASSAGE OF LINES</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>DECISION</td>
<td>15</td>
<td>15</td>
<td>12</td>
</tr>
</tbody>
</table>
Rational Choice Model of Decision Making

Limitations

- Requires too much time
- Requires too much data
- Can result in worse performance
- Little value to training or decision aids
- Depends on intuition
- Gaming the method
- Distortions are introduced
- Zone of Indifference

<table>
<thead>
<tr>
<th>Evaluation Dimensions</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>1</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Total</td>
<td>3 2 2</td>
</tr>
</tbody>
</table>
Fireground Decision Making Study

- Experts - 23 years (N = 26)
- Critical Incidents
- Context Rich Natural Task
- Dynamic - 5 changes/incident
- Time Pressure - 78% of cases < 1 minute
- Real Consequences
Recognition-Primed Decision Decision (RPD): model of expert decision making
Recognition-Primed Decision Model

VARIATION 1
Simple Match

Experience the Situation in a Changing Context

Perceived as Typical [Prototype or Analog]

Recognition has four byproducts

- Expectancies
- Relevant Cues
- Plausible Goals
- Typical Action

Implement Course of Action
Recognition-Primed Decision Model

VARIATION 1
Simple Match

Experience the Situation in a Changing Context

Perceived as Typical [Prototype or Analog]

Recognition has four byproducts

- Expectancies
- Relevant Cues
- Plausible Goals
- Typical Action

Implement Course of Action

VARIATION 2
Diagnose the Situation

Experience the Situation in a Changing Context

Is Situation Typical? [Prototype or Analog]

Diagnose [Feature Matching] [Story Building] inference

more data

no

Clarify

Anomaly

Recognition has four byproducts

- Expectancies
- Relevant Cues
- Plausible Goals
- Typical Action

Implement Course of Action

yes
Recognition-Primed Decision Model

**VARIATION 1**
Simple Match

- Experience the Situation in a Changing Context
- Perceived as Typical [Prototype or Analog]
- Recognition has four byproducts: Expectancies, Relevant Cues, Plausible Goals, Typical Action
- Implement Course of Action

**VARIATION 2**
Diagnose the Situation

- Experience the Situation in a Changing Context
- More data
- Diagnose [Feature Matching] [Story Building] inference
- Is Situation Typical? [Prototype or Analog]
- Recognition has four byproducts: Expectancies, Relevant Cues, Plausible Goals, Typical Action
- Implement Course of Action

**VARIATION 3**
Evaluate Course of Action

- Experience the Situation in a Changing Context
- Perceived as Typical [Prototype or Analog]
- Recognition has four byproducts: Expectancies, Relevant Cues, Plausible Goals, Typical Action
- Action 1...n
- Evaluate Action (n) [Mental Simulation]
- Modify yes, but
- Will it Work? yes, no
- Implement Course of Action
Key Features of RPD Model

1. First option is usually workable
   Not random generation
2. Satisficing
   Not optimizing
3. Evaluation through mental simulation
   Not Rational Choice
4. Focus on elaborating and improving options
   Not choosing between options
5. Focus on situation awareness
   Not Courses of Action
6. Decision maker primed to act
   Not waiting to complete the analyses
## Role of Analysis: Traditional vs. RPD

<table>
<thead>
<tr>
<th>Evaluation Dimensions</th>
<th>Options</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>1</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Analysis comparing *courses of action*

Analysis of *situations*

Analysis to evaluate the *preferred course of action*
Intuition AND Analysis

- **Intuition**: Using prior experience to recognize situations
- Both intuition and analysis are needed for effective decision making
- The RPD model combines intuition and analysis
## Proportion of Decisions Handled by RPD Strategy

<table>
<thead>
<tr>
<th>Study Domain</th>
<th># Decisions</th>
<th>% RPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Fireground Commanders</td>
<td>156</td>
<td>80%</td>
</tr>
<tr>
<td>Tank Platoon Leaders</td>
<td>55</td>
<td>42%</td>
</tr>
<tr>
<td>Design Engineers</td>
<td>51</td>
<td>60%</td>
</tr>
<tr>
<td>Battle Managers</td>
<td>27</td>
<td>96%</td>
</tr>
<tr>
<td>AEGIS Commanders</td>
<td>80</td>
<td>95%</td>
</tr>
<tr>
<td>Electronic Warfare Technicians</td>
<td></td>
<td>93%</td>
</tr>
<tr>
<td>British Army Officers</td>
<td></td>
<td>87%</td>
</tr>
<tr>
<td>British Offshore Oil Installation Mgrs</td>
<td></td>
<td>90%</td>
</tr>
<tr>
<td>US Navy Command &amp; Control</td>
<td></td>
<td>89%</td>
</tr>
</tbody>
</table>
Replications of RPD Strategies

• Randel et al. (1996) - Electronic Warfare Technicians (93%)
• Pascual & Henderson (1997) - Army Officers (87%)
• Flin, Slaven, & Stewart (1996) - Offshore Oil Installation Managers (90%)
• Hocevar et al. (1998) - Navy Command and Control (89%)
“After considerable research on recognition-primed decision making, we realized that the model was basically a combination of three decision heuristics that had already been well-studied from the microcognition perspective: availability and representativeness to identify the typical course of action, and the simulation heuristic to evaluate the course of action. Therefore, in this case it was possible to trace the macrocognitive phenomenon back to hypothetical microcognitive components. However, several decades of research on the availability, representativeness, and simulation heuristics had not led to a discovery of recognitional decision making. That is why we see the macrocognitive functions as emergent. We discover them by investigating cognition in field settings rather than by continually pursuing explanations of lab findings.”

Klein et al. (2003, p.82)
Conditions favouring intuitive and analytical approaches
Intuitive Decision Making
<table>
<thead>
<tr>
<th>Intuitive</th>
<th>Analytical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be very effective under time pressure and reacting to sudden, unexpected events</td>
<td>Superior when accuracy and evidence are needed, and time and information are available</td>
</tr>
<tr>
<td>Expertise is often based on intuitive thinking developed through experience, and can be very accurate</td>
<td>Novices will rely on analytical thinking until they become more expert</td>
</tr>
<tr>
<td>More vulnerable to heuristics and biases</td>
<td>Skilled analytical thinking is less influenced by emotion and heuristics</td>
</tr>
<tr>
<td>May use valuable situational information that is perceived unconsciously</td>
<td>Can encourage ‘stove-piped’ thinking</td>
</tr>
<tr>
<td>Has been shown to be superior to analytical thinking for some types of complex or unstructured problems</td>
<td>Many tools and techniques have been developed in the tradition of objectivity and determinism and only use conscious means</td>
</tr>
<tr>
<td>General (non-expert) intuition can be more effective than analysis for novel, undefined problems</td>
<td>Training in logic can enhance analytical reasoning</td>
</tr>
<tr>
<td>Large capacity and concurrent</td>
<td>Limited capacity and therefore consecutive</td>
</tr>
</tbody>
</table>
Cognitive Style Index - Discussion

**FIGURE 1**
A Continuum of Cognitive Style

- **INTUITION**
  - Intuitive
  - Quasi-intuitive
  - Adaptive

- **ANALYSIS**
  - Quasi-analytic
  - Analytic

**Synthesis**
- Simultaneous
- Assessment of whole

**Logic**
- Linear
- Focus on detail
<table>
<thead>
<tr>
<th>Style</th>
<th>Score range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intuitive</td>
<td>0 – 28</td>
</tr>
<tr>
<td>Quasi-Intuitive</td>
<td>29 – 38</td>
</tr>
<tr>
<td>Adaptive</td>
<td>39 – 45</td>
</tr>
<tr>
<td>Quasi-Analytic</td>
<td>46 – 52</td>
</tr>
<tr>
<td>Analytic</td>
<td>53 – 76</td>
</tr>
</tbody>
</table>
Critique of CSI

• Role of experience and expertise in the use of intuition?
• Situational factors – adaptive decision making depends on context
• Other topics?
Metacognition: Decision Making

1. Subconscious/Tacit vs. Conscious/Explicit

2. “Intuitive” vs. Analytical

3. Biases

4. Heuristics

5. Applications/So What?

- Learning from Experience
- Developing Expertise

Where is context??

Experience/Expertise

© TRIMETIS 2017
Metacognition: Decision Making

Subconscious/Tacit
Conscious/Explicit

Biases
Heuristics
Experience/Expertise

“Intuitive” → Analytical

Applications/So What?
Learning from Experience
Developing Expertise

Context

1.

2.

3.

4.

5.
Kahneman and Klein: A failure to disagree or a reconciliation of two competing ideas

• Context “Validity”
  • i.e. predictability/stability
  • Degree of “structure” in the environment

• Statistical modelling
  • E.g. base rate probabilities in medical disease diagnosis

• Expertise can be developed for high validity contexts
• “Intuition” can be developed for high validity contexts
• Low validity contexts are the challenge... can we do better than chance?
  • E.g. stock performance
Environments & Structure

• Predictability
  • Stability
  • Causality – Physical vs. “intentional” (human/agent behaviour; NOT physical)

• Statistical models?
  • Baseline probabilities known?
  • Medical judgment – anatomy varies from person to person... degree of unpredictability

• (Human) Mental models based on:
  • Education
  • Experience

• Who knows the “laws that govern” the behaviour of the system?
  • Data? Models? Algorithms?
  • Experts?
  • Wisdom of crowds? / crowdsourcing
Environments & Structure of Information – Sensors and Information Displays

• Sources of data?
  • Reliability?
  • Validity?
  • Sensors (physical or human?)

• Representations of the data influence problem solving, sensemaking, decision making
  • Technology displays/decision support
Adaptive Decision Making

• What is “in the head” (brain) vs. what is the “head inside of” (context)
• Understanding the structure of the environment
  • Learned through experience and “represented” as patterns/mental models/knowledge
• Adapting decision strategies to context
• Context is understood through experience and models (e.g. mental as well as encoded in analytical tools)
Metacognition: Decision Making

Subconscious/Tacit

Conscious/Explicit

Biases

Heuristics

Experience/Expertise

“Intuitive” → Analytical

Learning from Experience

Developing Expertise

Applications/So What?
Discussion: So what?

• How can this information change/improve our decision making/thinking?

• Spend two minutes identifying any key take aways and/or implications...
Applied metacognition is fundamentally about...

• Thinking critically about own (and other’s) performance (assessments, judgments, decisions, plans)
• Reflecting on own (and other’s) performance
• Building more sophisticated mental models to support...
  • Sense of what is normal/typical
  • Sense of what is abnormal/early problem detection
  • Pattern recognition
  • Understanding the past (explanations and diagnoses)
  • Anticipating the future
    • Without action: where is the situation headed?
    • With action: mentally simulating COAs
Identify problems/Recognise expertise

• Allows you to see potential problems in
  • your own thinking
  • the thinking of others (humans and intelligent systems)

• Allows you to understand how to leverage expertise
  • Recognise and utilise it in others (collaborative decision making)
  • Accelerate the development of expertise in others (training/development)
E.g. Ten Tips for Intuitive Decision Making

1. The first option you think of is likely to be the best
2. Use analysis to ‘support’ your intuitions
3. Put more energy into understanding the situation than in deliberating over what to do
4. Don’t confuse desires with intuitions
5. Override intuitions when they mislead you
6. Think ahead
7. Uncertainty adds excitement to decision making (i.e. embrace it!)
8. Use the right decision-making strategy
9. Consult the experts
10. Stay alert for intuition barriers

Barriers to Intuition (for you and your teams)

- Overreliance on procedures and systems
- Process-focused culture
- Under-valuing experience
- Blind followership
- Constant quest for more information
- Simplistic (numerical) goals
- Overreliance on technology as a substitute for people
So What? Developing Your Own Intuition

• Developing Own Expertise
  • Think aloud (like Advanced Driving)
  • Self Reflection/Active Reflection - Making Thinking Explicit (describing your rationale)
  • Decision-centred AAR (using the format I used previously) – reflecting on the decision challenge, why difficult, factors/cues, strategy, errors?
    • Better than sustain/improve which tends to be process focussed
    • Provides a vehicle for unpacking tacit knowledge which is a bottleneck to describing rationale and decision process (the what not the how/process)
So What? Developing Expertise in Others

• “Decision Skills Training”
  • Developing expertise = vaccinating against “flaws”

• Self Calibration Exercise
  • Developing self-awareness = vaccinating against over/under confidence

• Commander’s Intent Exercise (training activity)
  • Did subordinate’s do what you expected, and/or meet intent?

• SA Calibration
  • Is everyone focused on the right threats and the right goals?
  • How can I help them?

• Pre-Mortem
  • Risk management
  • Anticipate/mitigate

• Decision-centred After Action Review
  • Learning from Experience
Improving Decision Making – A Systems View

• The following ideas come from a presentation focused on “knowledge management” and “learning organisations”,

• Fundamentally about supporting and developing improved performance based on “learning from experience” (broadly defined)
Performance Improvement

Tacit Knowledge

Explicit Knowledge

Expertise

Cognitive Task Analysis

Macrocognition

Psychological models

e.g. expert decision making (RPD)

Technology
  e.g. Decision Support Systems

Training
  e.g. Decision Games

Knowledge Resources/
  Modules

Organisational Design
  e.g. career development

Lens
**Context**

Metacognition: Decision Making

- Subconscious/Tacit
- Conscious/Explicit

**Biases**

**Heuristics**

**Experience/Expertise**

- "Intuitive" ➔ Analytical

**Applications/So What?**

- Learning from Experience
- Developing Expertise

© TRIMETIS 2017
Context

Metacognition:
Decision Making

- Subconscious/Tacit
- Conscious/Explicit

Applications/So What?

- Learning from Experience
- Developing Expertise

Biases

Heuristics

Experience/Expertise

"Intuitive" ↔ Analytical

We are here

Other aspects of cognition

- Problem Detection
- Sensemaking
- Adaptive Planning
- Common Ground/Collaboration

Other applications of thinking about thinking

- Ways of working (indiv & team)
- Technology design
- Training & Development
- Organisational design
Metacognition: An understanding of...

- Value of experience/expertise
- How expertise can be exploited and developed
- The limitations of one’s own expertise/intuition
- The limitations of analytical approaches
- The conditions where analysis is/is not appropriate (and the focus of analysis)
- The conditions where intuition is/is not appropriate (where experience/expertise exist)
- Approaches to developing expertise to support intuitive decision making where analytical approaches are inappropriate
- Recognition of the importance of the interaction between expertise and the problem environment/situation (predictability/stability/structure -> models)
Intuition

The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honours the servant and has forgotten the gift. — Albert Einstein
Questions?

“Don’t believe everything you read on the internet just because there’s a picture with a quote next to it”
- Albert Einstein
References/Resources

• Sources of Power – Klein (1999)
• Streetlights & Shadows – Klein (2007)
• Thinking Fast & Slow – Kahneman