COGNITIVE CONSTRUCTS AND THE SENSEMAKING PROCESS

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Presentation Outline

1. INTRODUCTION
2. HOW COGNITIVE CONSTRUCTS EVOLVE FROM SENSEMAKING
3. REVIEW OF EXISING COGNITIVELY-ENABLED CONSTRUCTS
4. THE PAYE MODEL
5. SUMMARY & CONCLUSIONS
Why Sensemaking?
Situation Understanding

Iraqi Problems
- Insurgency
- Terrorism
- Civil Unrest
- Ethnic Rivalry
- Weapon of Mass Destruction
- Despotic Leadership

Solution Approach
- Political
- Economic
- Military
- Social
- Information
- Infrastructure

Adversary Characteristics
- Dynamic, Uncertain, Chaos,
- Complex, Novel, Ambiguous,
- Asymmetric

Enemy Or Friend?
Why Sensemaking?
Dealing with Novel Situations

Lessons Learned (Organizational Memory)

Experience Schema

Cultural Factors

Battlefield Factors

Mission
Enemy
Terrain
Time
Technology

Field Knowledge

Strategic culture

National security
Stability
Collectivism

Organizational culture

Social
Economic
Bureaucracy

Tactical & Operational culture

Prejudice
Uncertainty
Rules of engagement
MET³

Political culture

Power distance
Power struggle
Conflicts

POW: Self Dignity and Respect

The unknown enemy

Ethnocentric Battle Experience

Domain for Military Training & Simulation

The peace keeping soldier
Why Sensemaking?
Information Equivocality—Multiple Meanings and Interpretations

Peace Symbol
USA

Iraq
We want peace
Cowardice
Why Sensemaking?
Interpreting Commander’s Intent
WHAT IS SENSEMAKING?

Sensemaking: A process, design, or techniques of fusing information in context to derive understanding.

Making Sense: The art or science of making meaning and/or interpreting information in context for decision making.
Some Sensemaking Definitions


2. A SYSTEM OF ACTIONS, SYMBOLS AND PROCESSES THAT ENABLES AN ORGANIZATION TO TRANSFORM INFORMATION INTO VALUED KNOWLEDGE WHICH IN TURN INCREASES ITS LONG-RUN ADAPTIVE CAPACITY – (Schandt, 1997; pp. 8)
Some Sensemaking Definitions

3. A THEORY AND A PROCESS OF HOW PEOPLE REDUCE UNCERTAINTY OR AMBIGUITY; SOCIALLY NEGOTIATE MEANING DURING DECISION MAKING ----(Weick, 1985)

Some Sensemaking Definitions

5. COLLECTING “DOTS” and BRIDGING MEANING TO HUGE VOLUME OF DATA---INQ-Tel (Arlington-based company).

6. DERIVING MEANING FROM FRAGMENTARY CUES---(DARPA’S Information Awareness Project).
Knowing why (reason)
Knowing when (time)
Knowing which (enemy & context)
Knowing where (terrain, foe & friend location)
Knowing what (mission, intent, objective)
Knowing how (process)

Domain Story

Dynamic Time-based reasoning
Task scheduling
Identify situated tasks
Situated goal & objectives
Procedure selection
Procedural explanation

Our Sensemaking Inquiry System Research Architecture

The Center for Human-Machine Studies

PAST
What happened?
When did it happen?
Where did it happen?
How did it happen?
What event, activity?
What and why the trigger?
What was the effect?
And so on

PRESENT
What is the current situation?
Who is involved?
What are the options?
How are things changing?
Why are things changing?
Where do the available information useful?
What is the effect?

FUTURE
What will happen next?
Where will it happen?
When should I act?
Why should I act?
What changes are expected?
What are the consequences?
What is the expected effect?

Sensemaking Loop
### Bloom’s Cognitive Schema (tasks)

**Cognitive Readiness:**
- Conceptual level
- Knowledge of specifics
- Knowledge of universal abstractions such as standards and terminology

**Human Performance**
- General attention, memory, and central processing, fine motor control such as using computer mouse: speeds and errors

**Intermediate Skills/**
- Conceptual reasoning, divided attention, auditory & visual processing: speeds, errors, etc.

**Expert Skills/**
- Respond inhibitions, sustained attention, visuospatial classification and sequencing, visual tracking: errors, error rate, speed, etc.
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<tbody>
<tr>
<td>Comprehension of environment:</td>
<td>Organizational level language learning, auditory and visual processing, working memory: speed, time, errors, etc.</td>
<td>Dual task paradigms, divided attention: error rate, number of errors, speed.</td>
<td>Advanced language for human-computer interface, use of special codes for security protection: number of violations, errors, error rate, etc.</td>
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<tr>
<td>• Translation of command &amp; control (C2) intent</td>
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<tr>
<td>• Interpretation of C2 goals</td>
<td></td>
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<tr>
<td>• Extrapolation of C2 goals during uncertainty and novel situations</td>
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### Bloom’s Cognitive Schema (tasks)

|---------------------------------|---------------------------------|----------------------------------------|----------------------------------|
| Sensemaking of Battle Information: | • Discovering relationships between distributed C2 levels.  
• Recognizing enemy messages from friendly.  
• Emerging organizational principles into virtual C2 | Similarity matching based on information features: errors, speed, accuracy, etc. | Pattern recognition based on information objects, maps, link analysis, and other forms of spatial representations: errors, speed, accuracy, duration, etc. | Random search and stochastic pattern matching based on evolving situations: speed, error rate, accuracy, synchronization of actions, etc. |
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<tr>
<td>Information Fusion (Synthesis):</td>
<td>Using information to develop deliberate plan structure, understanding basic battle process: errors, accuracy, etc.</td>
<td>Fusion of various information patterns, choice of automation aids to facilitate communicaton modalities: degree of fit, errors, accuracy, speed, etc.</td>
<td>Coalition information fusion, non-deterministic evolving plans based on novel incidents, ability to override automation aids: speed, response inhibition, working memory, etc.</td>
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<tr>
<td>• Production of a unique battle plan</td>
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<td>• Production of resilient communication across all spectrum of friendly network</td>
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COGNITIVE MAPS

- Mental models of the relative locations and attributes of phenomena in spatial environments (Downs and Stea, 1973).

- Internal representation of experienced world, including cognitive tasks and use of information (Gibson, 2001).

- Anticipatory schema for search, sampling and interpretation of information based on experience (Neisser, 1967).

- Clusters of knowledge landmarks and routes that form minimaps (Sternberg, 1999).

- All elements of physical space with cognitive counterparts (Huff, 1992).
- A spatial mental model (Eden, 1988).
Insurgents at the rooftop of the Mosque
Insurgents embedded in the crowd
Attention to draw Coalition forces
Coalition force engaged with insurgents

Most likely based on history

Civilians are combatants
Deception, there is a plan to attack
An ongoing operation

Ignore
Respond
Ignore/Talk to Emir
Ignore
Respond
OODA MODEL (BOYD, 1987)

**Observe**
- Observation: Data/information collection

**Orient**
- Orient: Data-Information-Knowledge-Wisdom Most Sensemaking Process here

**Decide**
- Decide: Select COA Nominate execution

**Act**
- Act: Execution/Evaluation
Sensemaking is viewed as a sequence of situated acts.

**Situatedness**: “Where you are, when you do, what you do matters” (Suchman, 1987; Clancey, 1997).

**Situation changes** - Require adaptive constructive memory (Dietrich & Markman, 2000).

**Dynamic Model of Situated Cognition (DMSC)**:
- Data flow (environment, sensors, etc)
- The human builds cognitive codes to cope with new (and)
- Situation and context—co-exist and evolve
Situation handling Model (Wiig, 2002)
Situation Awareness is the Perception of the Elements in the Environment within a Volume of Time and Space, the Comprehension of their Meaning, and the Projection of their Status in the Near Future. (Endsley, 1988)
### Levels of SA

<table>
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<tr>
<th>Knowledge Elements</th>
<th>Cognitive structures for information processing (Ntuen, 2004)</th>
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<td><strong>Level 1 SA</strong></td>
<td>Perception of the status, attributes, and dynamics of the individual task-relevant elements in the environment</td>
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### Levels of SA

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<td><strong>Level 2 SA</strong></td>
<td>Holistic comprehension of the current situation, based on a synthesis and understanding of these elements in light of one’s goals</td>
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# OODA Model (Boyd, 1987)

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<th>Levels of SA</th>
<th>Knowledge Elements</th>
<th>Cognitive structures for information processing (Ntuen, 2004)</th>
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<td>Level 3 SA</td>
<td>Projection of the future actions in the environment, at least in the very near term</td>
<td>High-level cognitive control or meta-cognition. Knowledge-based projection of sensemaking activities into the future—&quot;what if&quot;, &quot;what next&quot; situations. Time-invariant controlled by the human mind (Polyani, 1967)</td>
</tr>
</tbody>
</table>
Data / Frame Model, Sieck, et al., 2004)
The Cynefin Model (Kurt and Snowben, 2003)

Quasi Analytical-Intuitive Cognition

Meta-cognition

Analytical/Heuristic Cognition

Reflexive Cognition

OODA

Complex
Cause and effect are only coherent in retrospect and do not repeat
Pattern management
Perspective filters
Complex adaptive systems
Probe-Sense-Respond

Known
Cause and effect separated over time and space
Analytical/Reductionist
Scenario planning
Systems thinking
Sense-Analyze-Respond

Chaos
No cause and effect relationships perceivable
Stability-focused intervention
Enactment tools
Crisis management
Act-Sense-Respond

Known
Cause and effect relations repeatable, perceivable and predictable
Legitimate best practice
Standard operating procedures
Process reengineering
Sense-Categorize-Respond

A study of what people can say about what they know (Hutchins, 1996)
Interpretation of experience to guide action in a range of life domains
(Schank & Abelson, 1977).
Rationales:
• Battlefield realities do not always match notional planning assumptions against the adversary.
• Modern warfare is populated with non-traditional adversaries.
• The enemy is unknown, almost all are embedded with the civilian population.
• Battlespace changes dynamically according to Cynefin model: \( \rightarrow \) Known \( \rightarrow \) Knowable \( \rightarrow \) Complex \( \rightarrow \) Chaos \( \rightarrow \)

Need:
PLAN – AS-YOU-EXECUTE (PAYE) Strategy
• We know more than we can tell (Polanyi, 1967)
THE PAYE MODEL

Situation Awareness

Levels I & II

Level III, SA

Perceptual Exploration

Q-A System

Orient

Observe

Decide

Act

Feedback

Action-orienting base

Reflexive Cognition

Dynamic Cognitive Scripts (Meta-Cognition)

Reflective Cognition

Stimuli change

Stimuli

H=0

H+t

H+nt

n=0,1,...

1. Question-Answering (Q-A) Query System;

2. Reflexive Knowledge: Past knowledge Leading to a retrospective strategy—useful when results structure provides sufficient guidance or knowledge accessing means (Hoc, 1988; pp. 77)
3 Reflective Knowledge: Conscious and thoughtful reaction to situations
It is a thoughtful activity—generating prospective plans
Allows for adaptation to new situations: our ability to learn new things, interact with new behaviors, etc.
4. Meta-Cognition: A compendium of dynamic cognitive scripts:

   A generic footprint of events, activities, episodes, and histories of experiences

Supports cognitive dynamics—”many changes in an organism directly affecting that organism’s cognitive processing or cognitive capacities (Dietrich & Markman, 2000; pp.7)
4. Meta-Cognition:

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<th>Ecological niches</th>
<th>Time scale ((H+nt; n=0,1,2,\ldots))</th>
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<tr>
<td>Situation</td>
<td>(\rightarrow) Situation (change/unchanged)</td>
</tr>
<tr>
<td>Situation</td>
<td>(\rightarrow) Context (center of gravity, focus of effort, etc.)</td>
</tr>
<tr>
<td>Context</td>
<td>(\rightarrow) Context (change/unchanged)</td>
</tr>
<tr>
<td>Context</td>
<td>(\rightarrow) Situation (evolved to higher task dimensions, complexity, and chaos)</td>
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• Sensemaking involves the use of human cognition
• Reviews many of the existing cognitive models/theories supporting the sensemaking process.
• The existing models offers context-specific advantages; often lacks generality and difficult to apply when situation breakdowns or novel conditions arise.
• The PAYE model is developed to reduce the existing problems:
• Provides real-time adaptation
• Recognizes evolving ecological niches
  • Evolving changes of contexts and situations, in time and space
• Supports sensemaking as a continuous cycle of interacting plans
• Open architecture:
  • Captures execution-monitoring in real-time.
  • Provides modules for sensemaking simulation codes.