Citation Key
for more information see: http://open.umich.edu/wiki/CitationPolicy

Use + Share + Adapt

{ Content the copyright holder, author, or law permits you to use, share and adapt. }

- **Public Domain – Government**: Works that are produced by the U.S. Government. (17 USC § 105)
- **Public Domain – Expired**: Works that are no longer protected due to an expired copyright term.
- **Public Domain – Self Dedicated**: Works that a copyright holder has dedicated to the public domain.
- **Creative Commons – Zero Waiver**
- **Creative Commons – Attribution License**
- **Creative Commons – Attribution Share Alike License**
- **Creative Commons – Attribution Noncommercial License**
- **Creative Commons – Attribution Noncommercial Share Alike License**
- **GNU – Free Documentation License**

Make Your Own Assessment

{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

- **Public Domain – Ineligible**: Works that are ineligible for copyright protection in the U.S. (17 USC § 102(b)) *laws in your jurisdiction may differ

{ Content Open.Michigan has used under a Fair Use determination. }

- **Fair Use**: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (17 USC § 107) *laws in your jurisdiction may differ

Our determination **DOES NOT** mean that all uses of this 3rd-party content are Fair Uses and we **DO NOT** guarantee that your use of the content is Fair.

To use this content you should **do your own independent analysis** to determine whether or not your use will be Fair.
Where are We?

• Channel 1
  – Method Lectures
    1. Health information exchange
    2. Knowledge representation
    3. Information retrieval
    4. Imaging and image analysis
    5. Policy development and analysis
    6. Organization/management
    7. Cognition (today)
    8. Quality Measurement
    9. Evaluation
    10. Behavior Change

  – Followed by four “information resource” lectures
Cognition and Health Informatics

Prof. Charles P. Friedman
Introduction to Health Informatics
University of Michigan
November 12, 2013
Key Questions

1. Why is human cognition important?
2. How do people reason, solve problems and make decisions?
3. What are the implications for health informatics?
The “Fundamental Theorem”: It’s About People Reasoning & Making Decisions

Creating an environment of “supported practice” such that an intelligent person (practitioner, scientist, student) working in combination with information resources/technology is “better” than the person without such support, and then demonstrating that we’ve done it.
The Amount of Data Available is Exploding

Slide courtesy of Bill Stead & Dan Masys

- Proteomics and other effector molecules
- Functional Genetics: Gene expression profiles
- Structural Genetics: e.g. SNPs, haplotypes

Decisions by clinical phenotype
i.e., traditional health care

Human Cognitive Capacity
If the Fundamental Theorem is Going to Hold: Information Resources Must...

• Address a problem where human cognition can benefit

• Be able to tell a person (or team):
  – something correct or at least plausible
  – that he/she doesn’t already know

• Conform to:
  – the person’s or team’s cognitive state (thoughtflow)
  – the person’s or team’s context (workflow, culture)
How Human Cognition Can Benefit

An advice-giving resource can suggest:

• Plausible diagnoses
• Best drug and dosage
• Cheaper and equally effective alternative
• Patient is at risk for …
• I am/patient is due for this procedure
• A meal plan for today
• And others
The Challenge: Using this Architecture, Help People Make Better Decisions, Such That:

\[(\text{Data} + \text{Knowledge}) \geq \text{Human Decision-Maker}\]
Key Questions

1. Why is human cognition important?

2. How do people reason, solve problems and make decisions?

3. What are the implications for health informatics?
Key Principles of Human Cognition

What you know, and how that knowledge is organized is the primary determinant of what you can do or learn or do.

This unpacks into:

• Miller’s Law and working memory
• Chunking: Our cognitive workaround
• Pattern Matching
• Forward reasoning and backward chaining
• The nature of expertise
• Biases and heuristics
Let’s See How Good You Are
(No Writing Allowed)

7087521930493268824317
How About This?

12345123451234512345
Or This?
So What’s Going On Here?

70875219304932688243

1234512345123451234512345
Working Memory and Chunking

• Working memory
  George Miller: “7 plus or minus 2”

• “7 plus or minus 2” applies to unrelated elements in short term memory

• Our brains “chunk” related elements so they are processed as one → concept of a “syndrome” in health care

• Meta-chunking (chunks of chunks) creates elaborate knowledge structures that enable reasoning and problem solving
Pattern Matching and Image Recognition

- Warm and muggy
- Very dark sky
- Frequent bright lightning
- Gusty winds
Images and Patterns Have a Context
Patterns: Examples from Health

Person 1
• Sweating
• Fever
• Shaking/Chills
• Worsening cough with pain

Person 2
• Swelling in the eyes
• “Foamy” urine
• Weight gain
So Where Are We?

- Limited capacity in working memory
- But we can “chunk”
- And we can learn patterns
- And we can instantly recognize and interpret images
Expertise

People become experts by:

– Practice, practice, practice—leading to learning of patterns
– Encountering many similar instances
– Coaching, feedback

• Accumulating expertise = developing rich scripts (schemata) for solving problems
• Expertise is highly domain specific
• Experts develop automaticity
• Some experts cannot explain how they do what they do (Ted Williams)
Problem Solving

• When confronted with problems, there are two modes of reasoning:
  – Forward: Apply a schema or script, based on known patterns, to the situation
  – Backward: Hypothesize a solution then collect data to confirm or reject hypothesis

• Forward reasoning is rapid and efficient
• Backward chaining is slow and inefficient
  – Often requires multiple cycles of “hypothesize and test”
Did you Reason Forward or Backward?

Situation 1

- Warm and muggy
- Very dark sky
- Frequent bright lightning
- Gusty winds

Situation 2

- Swelling in the eyes
- “Foamy” urine
- Weight gain
Expert-Novice Studies on the Nature of Expertise

- De Groot (chess): Chess masters can remember an entire chess board if the pattern results from a real game; if not, they are indistinguishable from novices.

- Chi, Feltovich, Glaser (physics): Experts instantly recognize a problem “type” and how to solve it.

- Patel, Bordage, others (medicine): Experts reason forward using “illness scripts”
Varying Expertise in Health Domains

• Patients/Consumers are typically novices
  – (Until many of them, with chronic diseases, become experts…)

• Professionals are experts
  – But only in their own domains

• Trainees are in an uncertain progression to becoming experts.
Heuristics and Biases

Systematic flaws in reasoning, that affect all human decision makers. A few examples…

• Anchoring (confirmation bias)
• Availability (recency)
• Framing

Absent feedback, people are not aware of these biases.

Also, decision analyses must take risk aversiveness into account. People will not always choose maximum utility.
Key Principles of Human Cognition Revisited

In a nutshell, this is how we solve problems and make decisions:

• Very limited working memory
• But we can “chunk” (create scripts)
• And we can match patterns really well
• We can reason forward (when we have well developed scripts) or backward (when we don’t)
• Experts reason forward most of the time
• We’re all susceptible to errors in judgment
Key Questions

This is the complement to the lectures on advice giving systems and CDS/CPOE:

1. Why is human cognition important?
2. How do people reason, solve problems and make decisions?
3. What are the implications for health informatics
Why We Expect the Theorem to Hold

• The Principle of Complementarity
  – Persons do well things that machines do poorly
  – And vice versa
  – Vannevar Bush recognized this in 1945
Why Decision Support Has Largely Underperformed So Far

• Complementarity goes beyond putting the person and machine in the same place at the same time
• We have to meld them

Good at: ( + ) > Good at: 7087521930493268824317
To enable interactive “thinking together”, we must:

• Address a problem where human cognition can benefit

• Be able to tell a person (or team):
  – something correct or at least plausible
  – that he/she doesn’t already know

• Conform to:
  – the person’s or team’s cognitive state (thoughtflow)
  – the person’s or team’s context (workflow, culture)
To enable interactive “thinking together”, we must:

• Address a problem where human cognition can benefit

• Be able to tell a person (or team):
  – something correct or at least plausible
  – that he/she doesn’t already know

• Conform to:
  – the person’s or team’s cognitive state (thoughtflow)
  – the person’s or team’s context (workflow, culture)
How Do We?

To enable interactive “thinking together”, we must:

• Address a problem where human cognition can benefit

• Be able to tell a person (or team):
  – something correct or at least plausible
  – that he/she doesn’t already know

• Conform to:
  – the person’s or team’s cognitive state (thoughtflow)
  – the person’s or team’s context (workflow, culture)
How Do We?

To enable interactive “thinking together”, we must:

• Address a problem where human cognition can benefit

• Be able to tell a person (or team):
  – something correct or at least plausible
  – that he/she doesn’t already know

• Conform to:
  – the person’s or team’s cognitive state (thoughtflow)
  – the person’s or team’s context (workflow, culture)
Summary: Key Questions

1. Why is human cognition important?
2. How do people reason, solve problems and make decisions?
3. What are the implications for health informatics?
Image Attributions

• The image “Human Limitations: Genomic Data and Decision Making” is courtesy of Bill Stead & Dan Masys
• “Palette and brush” by ejmillan is in the Public Domain.
• “Netalloy gears” by netalloy is in the Public Domain.
• “Alarm clock” by Anonymous is in the Public Domain.
• “Books” by Johnny Automatic is in the Public Domain.
• “Brian diagram” by j4p4n is in the Public Domain.
• “Mona Lisa” by Leonardo Da Vinci is in the Public Domain.
• “Tango computer” by warszawianka is in the Public Domain.
• “Vannevar Bush portrait” by the Library of Congress is in the Public Domain.
• “Emoticons: smiling face” by nicubunu is in the Public Domain.
• “Emoticons: crying face” by nicubunu is in the Public Domain.
• “As We May Think” by Life Magazine is All Rights Reserved.
• “Coca-cola 50cl can – Italia” by Antoine Motte dit Falisse is under a Creative Commons license CC BY-SA 3.0. https://commons.wikimedia.org/wiki/File:Coca-cola_50cl_can_-_Italia.jpg
• All other images are courtesy of Dr. Andrew Friedman under a Creative Commons license CC BY-NC-SA 4.0.