WHY STUDY DIAGNOSTIC EXPERTISE?

- If we can understand how experts do it, perhaps we can arrange learning to increase efficiency of becoming an expert.....

More on this later.....

EARLY HISTORY OF CLINICAL REASONING (1973-79)

- Search for general problem-solving skills
- What strategies, skills do expert diagnosticians use?
THE BEGINNINGS - CLINICAL REASONING AS A PROCESS

“Hypothetico-deductive method”
(Elstein, Shulman, Sprafka, 1977)
Expert (and novice) clinicians generate multiple diagnostic hypotheses early in the encounter then gather data to confirm (usually) these hypotheses.

DOES HYPOTHESIS PREDICT ACCURATE SOLUTION?

- Universality of the process
- Content Specificity
  (Elstein, Shulman)
- Central Role of Knowledge

Barrows, Neufeld, Norman, 1981
THE PARADIGM SHIFT – 1980-99

- Expertise as Acquisition of Knowledge
  - Mechanisms (basic science)
  - Rules (signs → diagnosis)
  - Exemplars (Experience)
  +/- Metacognition / Reflection

THE PLAYERS

- Patel – Forward vs. Backward Reasoning
- Patel and Groen – Basic Science vs Clinical
- Bordage and Zacks – Prototypes
- Bordage and Lemieux - Semantic axes
- Papa – Bayesian processes & probabilities
- Norman and Brooks – Instances / Exemplars
- Schmidt – Intermediate effect & Encapsulated Knowledge

Kinds of processing on Kinds of knowledge


Reasoning as a process of application of heuristics
Kahneman and Tversky

Preoccupation with reasoning errors a consequence of cognitive errors

Preoccupation with process, not knowledge
### THE PLAYERS

- Don Redelmeier 2005
- Gordon, 2005
- Pat Croskery 2009
  - Pat Croskery 2010
  - Pat Croskery 2011
  - Pat Croskery 2012
  - Pat Croskery 2013
  - Pat Croskery 2014

### THE PERSPECTIVE FROM PSYCHOLOGY

- The "cognitive bias" perspective is one version of a dual process theory
  - (A fast system using heuristics, a slow system using rules)
- Many "dual process" theories in psychology
  - Attention
  - Perception
  - Judgment
  - Social judgment
  - Memory

### COMMON ELEMENTS

<table>
<thead>
<tr>
<th>SYSTEM 1</th>
<th>SYSTEM 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconscious</td>
<td>Conscious</td>
</tr>
<tr>
<td>Implicit</td>
<td>Explicit</td>
</tr>
<tr>
<td>Automatic</td>
<td>Controlled</td>
</tr>
<tr>
<td>Effortless</td>
<td>Effortful</td>
</tr>
<tr>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Holistic, Old (evolution)</td>
<td>Analytic (New (evolution))</td>
</tr>
<tr>
<td>Does not use WM</td>
<td>Uses WM</td>
</tr>
<tr>
<td>Not distractable</td>
<td>Distractable</td>
</tr>
</tbody>
</table>
TWO PROCESSES, TWO KINDS OF KNOWLEDGE

- Recognition
  - Based on similarity to a specific prior exemplar in memory
  - Rapid, effortless

- Verification
  - Based on application of conceptual rules
  - Slow, effortful

TWO VIEWS OF TWO PROCESSES

- The Heuristic – Analytic View
  - Two processes of thinking

- The Exemplar – Rules View
  - Two kinds of retrieved knowledge

THE HEURISTIC – ANALYTIC VIEW

- Evans, 2006; Kahneman & Frederick, 2001; Stanovich, 2004

- System 1 is used in routine problem-solving
  - Based on cognitive heuristics or shortcuts
  - Frequently error-prone

- System 2 is used to monitor System 1 and correct errors
  - Based on logical, rational reasoning
  - Intervenes to correct errors
HEURISTICS / DEFAULT INTERVENTION

- S1, S2 proceed sequentially, oppositional
- Essence of S1 is application of shortcuts or heuristics
  - Heuristics are innate; ineducable
- More intelligent people can use S2 more effectively (since IQ <- Working Memory)

...two kinds of cognitive processes were involved: heuristic processes which generated selective representations of problem content, and analytic processes, which derived inferences or judgments from these processes. Biases were accounted for by the proposal that logically irrelevant information might be omitted or logically irrelevant information included at this heuristic stage (Evans, 2006)

“...errors of intuitive judgment involve failures of both systems: System 1, which generated the error, and System 2, which failed to detect and correct it.”

D. Kahnemann, 2004
Most errors occur with [System] 1 and may to some extent be expected whereas [System] 2 errors are infrequent and unexpected...

P. Croskerry, 2009

HOWEVER....

- Perhaps the most persistent fallacy in the perception of dual-process theories is the idea that Type 1 processes (intuitive, heuristic) are responsible for all bad thinking and that Type 2 processes (reflective, analytic) necessarily lead to correct responses. Thus, various forms of dual-process theory have blamed Type 1 processing for cognitive biases in reasoning and judgment research and for prejudice and stereotyping in social psychology. Correspondingly, logical reasoning, rational decision making, and nonstereotypical judgments have been attributed to Type 2 processing. So ingrained is this good–bad thinking idea that some dual-process theories have built it into their core terminology.

- It is a fallacy to assume that Type 1 processing is invariably nonnormative (i.e. irrational) and Type 2 processing invariably normative (rational). In fact, Type 1 processing can lead to right answers and Type 2 processing to biases in some circumstances.
A NOTE ON “HEURISTICS AND BIASES”

- The T&K research program is entirely based on “knowledge-free” problems completed by first year psychology students.

Problem 1 (Kahneman & Tversky, 1973, p. 241)

A panel of psychologists have interviewed and administered personality tests to 30 engineers and 70 lawyers, all successful in their respective fields. On the basis of this information, thumbnail descriptions of the 30 engineers and 70 lawyers have been written. The description below has been chosen at random from the 100 available descriptions.

Jack is a 45-year-old man. He is married and has four children. He is generally conservative, careful, and ambitious. He shows no interest in political or social issues and spends most of his free time on his many hobbies which include home carpentry, sailing, and mathematical puzzles.

Please indicate your probability that Jack is an engineer, on a scale from 0 to 100.

Problem 3 (Tversky & Kahneman, 1973, p. 211)

Consider the letter R. Is R more likely to appear in the first position of a word or the third position of a word?
Problem 4:
Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student she was deeply concerned with issues of discrimination and social justice and also participated in antinuclear demonstrations.

Which is the most likely statement?
a) Linda is a bank teller
b) Linda is a woman’s activist
c) Linda is a bank teller and active in the feminist movement

Problem 5) Mr. J. W. is a 55 year old male who is brought in to the emergency room after a car accident. On examination he has diminished breath sounds on the left side and a rigid abdomen.

Which is the most likely statement?
A) He has a pneumothorax
B) He has a ruptured spleen
C) He has a pneumothorax and a ruptured spleen

CONSEQUENCES

In the T&K research program:

- No consideration of effect of experience
- No consideration of error-reduction strategies
- Rapid solutions reflect less use of S2 so greater likelihood of error
The Exemplar-Rules View

- Shiffrin, 1977; Logan, 1988; Sloman, 1996
- System 1 is based on automatic retrieval of solution exemplars
  - With increasing expertise, more solutions are retrievable
- System 2 is based on application of rational rules
  - S2 loads heavily on working memory

The Theory

- [The theory] construes automaticity as a memory phenomenon. Automaticity is memory retrieval; performance is automatic when it is based on a single-step direct-access retrieval of past solutions from memory.

(Logan, 1988, p.492)
• S1 and S2 proceed in parallel

• Errors can arise in S1 (availability, representativeness) or S2 (satisficing, confirmation, premature closure)

EXEMPLARS – ROLE OF EXPERIENCE

• The theory assumes that novices begin with a general algorithm that is sufficient to perform the task. As they gain experience, they learn specific solutions to specific problems, which they retrieve when they encounter the same problems again” (Gordon Logan, 1988, p.493)

“We must be prepared to abandon the traditional view that runs from Plato to Piaget and Chomsky that a beginner starts with specific cases and... abstracts and interiorizes more and more sophisticated rules. It might turn out that skill acquisition moves in just the opposite direction; from abstract rules to particular cases.”

H.L. Dreyfus, 2002
# PREDICTIONS OF THE TWO MODELS

<table>
<thead>
<tr>
<th></th>
<th>EXEMPLAR</th>
<th>HEURISTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed and Accuracy</td>
<td>Fast &gt;= Slow</td>
<td>Fast &lt; Slow</td>
</tr>
<tr>
<td>Interruptions</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Experience</td>
<td>+++</td>
<td>None</td>
</tr>
<tr>
<td>Error reduce strategies</td>
<td>Debiasing</td>
<td>Knowledge</td>
</tr>
</tbody>
</table>
EXPERTISE AND ACCURACY

• Are experts as error prone as novices?
• Are they faster or slower?
• Are errors a consequence of going too fast?

ARE EXPERTS AS ERROR-PRONE AS STUDENTS?

• Many studies:
  • Friedman
  • Groves
  • Many others
• Does expertise relate more to Analytical or Non-analytical?
  • Groves
  • Norman, Brooks, Rosenthal

• Groves, O’Rourke & Alexander, 2003
  • Year 2 med students n = 35
  • Year 4 med student, n = 43
  • GPs n = 21
• 10 Written problems
  • Analysis of low score cases by expertise
ACCURACY AND SOURCE OF ERRORS

NORMAN, BROOKS, ROSENTHAL, 1998

Accuracy and Time in Dermatology
- 100 slides in 20 categories
- Students, clerks, residents, GPs, Dermatologist
- Accuracy and Response Time

ACCURACY BY EDUCATIONAL LEVEL
SHERBINO, 2010

Accuracy and Time in Internal Medicine
- 75 Canadian PGY2 internal medicine
- 20 written I.M. cases

“Proceed as rapidly as you can but try not to make any mistakes”

RAPID INSTRUCTIONS
- You are to make your diagnosis and type it in as quickly but as accurately as possible. Case information will appear on one screen, and you click on a button to go to the diagnosis screen. You may spend as much time as you wish reading the case information, but remember that you only have 30 minutes to complete all the cases.
ACCURACY VS. READING TIME

- Accuracy is associated with \textit{shorter} time
- Experts are both faster and more accurate than students
  - Use of experiential knowledge

SPEED AND ACCURACY

- If errors result from rapid pattern recognition (System 1) processes, then:
  Does slower, more methodical problem-solving reduce errors?
KAHNEMAN ON REDUCING ERRORS

“One way to block errors that originate in System 1 is simple in principle: recognize the signs that you are in a cognitive minefield, slow down, and ask for reinforcement from System 2.”

Kahneman p. 417

NORMAN ET AL., 2011

- Controlled trial
- 20 cases
- PGY2 residents
- 96 Rapid (2010)
- 108 Systematic (2011)

SYSTEMATIC INSTRUCTIONS

- Be careful and thorough. Try not to skip anything. Consider all the data. Take as long as you want on that screen, but when you click on button to go to diagnosis screen, you can’t go back to the information. There is a counter in the upper right corner that tells you how many cases you’ve done. You are to consider all the data and then make your diagnosis and type it in.
COMPARISON OF RAPID AND SYSTEMATIC INSTRUCTIONS

- Residents (n = 152);
- Emergency docs (n=46)
- 16 I.M. Cases
- Half of cases interrupted by:
  - Pager ("Dr. Norman, please call pager 22345")
  - Unrelated multiple choice question
• Experts are faster and more accurate than residents
• Instructions to slow down result in slower processing but no change in accuracy
EFFECT OF INTERRUPTIONS

- Do interruptions disrupt reasoning and cause errors?

“In this milieu, decision-making is often naked and raw, with its flaws highly visible. Nowhere in medicine is rationality more bounded by relatively poor access to information and with limited time to process it, all within a milieu renowned for its error-producing conditions.”

Croskerry, 2003

“…interruptions likely cause emergency medicine providers to compensate through task short cuts or failure to reengage in the task.

Chisholm, 2011

INTERRUPTIONS AND ACCURACY

- Effect on processing time + 6 sec.

- Results in line with cog psych observations. When interruptions are not semantically related to primary task, people “task switch” which causes delay but does not affect accuracy


STRATEGIES TO REDUCE ERRORS

HEURISTIC-BASED STRATEGIES
- Slowing down (Kahneman)
- “Cognitive Forcing Strategies” (Croskerry)

KNOWLEDGE-BASED STRATEGIES
- Reflection (Mamede & Schmidt, Monteiro)
- Active use of S1 / S2 (Ark & Eva)

“What can be done about biases? ...The short answer is that little can be achieved without a considerable investment of effort... S1 is not readily educable...”

“The way to block errors that originate in System 1 is simple in principle: recognize that you are in a conceptual minefield, slow down, and ask for reinforcement from System 2. [emphasis ours]”

(Crosskerry, 2013)

COGNITIVE FORCING STRATEGIES

“Becoming alert to the influence of bias requires maintaining keen vigilance and mindfulness of one’s own thinking. When a bias is identified by a decision-maker, a deliberate decoupling from the intuitive mode is required so that corrective "mindware" can be engaged from the analytical mode.”

Croskerry, 2013
COGNITIVE DEBIASING

(Sherbino et al., 2013)

- 198 students
  - Intervention: 145
  - Control: 46
- Instruction on two biases
  - Search satisficing
    - Locate the second lesion on X ray / ECG
  - Availability
    - Identify the rare diagnosis
- Test on 6 cases
  - Near transfer, far transfer, “False positive”

SEARCH SATISFICING

AVAILABILITY
KNOWLEDGE-BASED STRATEGIES

- Reflection
- Structured
- Self-initiated

STRUCTURED REFLECTION
(MAMEDE & SCHMIDT)

With case description in front of them:
- Write down most likely diagnosis
- Write down alternative diagnoses
- List findings
  - Supporting
  - Against
  - Not present
- Rank diagnoses in order of likelihood

(Psych Res 2010)
- 34 PGY2 residents
- 50 medical students
- 6 complex, 6 easy cases
- Analytic reflective reasoning vs.
- Write down first thing that comes to mind
REFLECTION VS. “FIRST THING” RESIDENTS

SELF-INITIATED REFLECTION (MONTEIRO, 2013)

- 47 residents
  - 27 PGY1, 15 PGY2, 23 PGY3
- 16 cases
- First Impression (Fast) then Reflection
  - After first pass through cases, review case again and either confirm or revise diagnosis

- Pass 1, 746 diagnoses
  - Pass 2, 62 diagnoses (8%) revised
  - Overall effect on accuracy – 2.5%
EFFECT OF REVISION

PREDICTIONS OF THE TWO MODELS

CONCLUSION

- Structured reflection appears to have positive effect, of about 10%.
- Spontaneous reflection has small overall effect.
OVERALL CONCLUSIONS

Clinical reasoning is application of two kinds of knowledge – experiential and analytical

With increasing experience, greater use of experiential knowledge, increased accuracy, reduced time

Strategies directed at identifying bias, slowing down are ineffective

“Intuition is nothing more and nothing less than recognition”

H. Simon
Nobel Laureate