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Lecture 7

Knowledge and Decision: Cognitive Science & Human-Computer Interaction

VO 444.152 Medical Informatics

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1. Intro: Computer Science meets Life Sciences, challenges, future directions
2. Back to the future: Fundamentals of Data, Information and Knowledge
3. Structured Data: Coding, Classification (ICD, SNOMED, MeSH, UMLS)
4. Biomedical Databases: Acquisition, Storage, Information Retrieval and Use
5. Semi structured and weakly structured data (structural homologies)
6. Multimedia Data Mining and Knowledge Discovery
7. Knowledge and Decision: Cognitive Science & Human-Computer Interaction
8. Biomedical Decision Making: Reasoning and Decision Support
9. Intelligent Information Visualization and Visual Analytics
10. Biomedical Information Systems and Medical Knowledge Management
11. Biomedical Data: Privacy, Safety and Security
Learning Goals: At the end of this 7th lecture you ...

- ... are familiar with some principles and elements of human information processing;
- ... can discriminate between perception, cognition, thinking, reasoning & problem solving;
- ... have got insight into some basics of human decision making processes;
- ... got an overview of the Hypothetico-Deductive Method (HDM) versus PCDA Deming approach;
- ... have acquired some basics on modeling patient health, differential diagnosis, case-based reasoning and medical errors;
Advance Organizer (1)

- **Brute Force** = a trivial very general problem-solving technique that consists of systematically enumerating all possible candidates for the solution and checking whether each candidate satisfies the problem's statement;
- **Cognition** = mental processes of gaining knowledge, comprehension, including thinking, attention, remembering, language understanding, decision making and problem-solving;
- **Cognitive load** = According to Sweller (1996) a measure of complexity and difficulty of a task, related to the executive control of the short-term memory, correlating with factors including (human) performance; based on the chunk-theory of Miller (1956);
- **Cognitive Science** = interdisciplinary study of human information processing, including perception, language, memory, reasoning, and emotion;
- **Confounding Variable** = an unforeseen, unwanted variable that jeopardizes reliability and validity of a study outcome.
- **Correlation coefficient** = measures the relationship between pairs of interval variables in a sample, from \( r = -1.00 \) to 0 (no correlation) to \( r = +1.00 \)
- **Decision Making** = a central cognitive process in every medical activity, resulting in the selection of a final choice of action out of alternatives; according to Shortliffe (2011) DM is still the key topic in medical informatics;
- **Diagnosis** = classification of a patient’s condition into separate and distinct categories that allow medical decisions about treatment and prognostic;
- **Differential Diagnosis (DDx)** = a systematic method to identify the presence of an entity where multiple alternatives are possible, and the process of elimination, or interpretation of the probabilities of conditions to negligible levels;
- **Evidence-based medicine (EBM)** = aiming at the best available evidence gained from the scientific method to clinical decision making. It seeks to assess the strength of evidence of the risks and benefits of treatments (including lack of treatment) and diagnostic tests. Evidence quality can range from meta-analyses and systematic reviews of double-blind, placebo-controlled clinical trials at the top end, down to conventional wisdom at the bottom;
External Validity = the extent to which the results of a study are generalizable or transferable;

Hypothetico-Deductive Model (HDM) = formulating a hypothesis in a form that could conceivably be falsified by a test on observable data, e.g. a test which shows results contrary to the prediction of the hypothesis is the falsification, a test that could but is not contrary to the hypothesis corroborates the theory – then you need to compare the explanatory value of competing hypotheses by testing how strong they are supported by their predictions;

Internal Validity = the rigor with which a study was conducted (e.g., the design, the care taken to conduct measurements, and decisions concerning what was and was not measured);

PDCA = Plan-Do-Check-Act, The so called PDCA-cycle or Deming-wheel can be used to coordinate a systematic and continuous improvement. Every improvement starts with a goal and with a plan on how to achieve that goal, followed by action, measurement and comparison of the gained output.

Perception = sensory experience of the world, involving the recognition of environmental stimuli and actions in response to these stimuli;

Qualitative Research = empirical research exploring relationships using textual, rather than quantitative data, e.g. case study, observation, ethnography; Results are not considered generalizable, but sometimes at least transferable.

Quantitative Research = empirical research exploring relationships using numeric data, e.g. surveys, quasi-experiments, experiments. Results should be generalized, although it is not always possible.

Reasoning = cognitive (thought) processes involved in making medical decisions (clinical reasoning, medical problem solving, diagnostic reasoning, behind every action;)

Receiver-operating characteristic (ROC) = in signal detection theory this is a graphical plot of the sensitivity, or true positive rate, vs. false positive rate (1 – specificity or 1 – true negative rate), for a binary classifier system as its discrimination threshold is varied;

Symbolic reasoning = logical deduction

Triage = process of judging the priority of patients' treatments based on the severity of their condition;
Decision Making is central in Biomedical Informatics

Source: Cisco (2008). Cisco Health Presence Trial at Aberdeen Royal Infirmary in Scotland
Reasoning Foundations of Medical Diagnosis

Symbolic logic, probability, and value theory aid our understanding of how physicians reason.

Robert S. Ledley and Lee B. Lusted

The purpose of this article is to analyze the complicated reasoning processes inherent in medical diagnosis. The importance of this problem has received recent emphasis by the increasing interest in the use of electronic computers as an aid to medical diagnostic processes fitted into a definite disease category, or that it may be one of several possible diseases, or else that its exact nature cannot be determined.” This, obviously, is a greatly simplified explanation of the process of diagnosis, for the physician might also comment that after seeing a

ance are the ones who do remember and consider the most possibilities.”

Computers are especially suited to help the physician collect and process clinical information and remind him of diagnoses which he may have overlooked. In many cases computers may be as simple as a set of hand-sorted cards, whereas in other cases the use of a large-scale digital electronic computer may be indicated. There are other ways in which computers may serve the physician, and some of these are suggested in this paper. For example, medical students might find the computer an important aid in learning the methods of differential diagnosis. But to use the computer thus we must understand how the physician makes a medical diagnosis. This, then, brings us to the subject of our investigation: the reasoning foundations of medical diagnosis and treatment.

Medical diagnosis involves processes that can be systematically analyzed, as well as those characterized as “intangible.” For instance, the reasoning foundations of medical diagnostic procedures
Decision Making is central in Medicine!

Example: Visual Information Processing

Source: Department of Neuroscience, The Mount Sinai School of Medicine (2004)
Information processing of words/pictures

a) Processing of visual information (PICTURES)

b) Processing of audio information (SPOKEN WORDS)

c) Processing of visual information (PRINTED WORDS)

Information processing of words/pictures

Multimedia Presentation

Sensory Register

Working Memory

Long-Term Memory

- Words
- Ears
- Eyes
- Sounds
- Verbal
- Prior Knowledge
- Images
- Pictorial

Integrating

Human Attention is central for problem solving

Example: Triage Tags and International Triage Tags

Source: http://store.gomed-tech.com
Example: carcinoid heart disease (chd)

Hepatic venous congestion and carcinoid heart disease secondary to an ovarian carcinoid tumor in a 56-year-old woman with elevated liver enzyme levels and right upper quadrant pain.

Example: bone-marrow depression (bmd)

Example: partial liver resection (plr)

van Vilsteren, F. G. I. et al. (2011) Stepwise radical endoscopic resection versus radiofrequency ablation for Barrett's oesophagus with high-grade dysplasia or early cancer: a multicentre randomised trial. *GUT.*
Let $U \subseteq X$ denote this risk factors and
Let $V = X \setminus U$ denote the complement.

The risk of immediate death $p(\text{health}(t) = \text{death}|X)$ can be expressed as:

$$1 - p(\text{health}(t) \neq \text{death}|V) \prod_{U \in U} p(\text{health}(t) \neq \text{death}|U, \text{health}(t - 1))$$

Further, we obtain

$$p(\text{health}(t) = h|X) = p(h|V) \prod_{U \in U} p(\text{health}(t) \neq \text{death}|U, \text{health}(t - 1))$$

for $h \neq \text{death}$

Two doctors, with equally good training, looking at the same CT scan, will have the same information ... but they may have a different bias/criteria!
Information Acquisition and (subjective) Criteria - bias

- **Information acquisition:** First, there is information in the CT data, e.g. healthy lungs have a characteristic shape; the presence of a tumor might distort that shape (=anomaly).
- Tumors have different image characteristics: brighter or darker, different texture, etc.
- With proper training a doctor learns what kinds of things to look for, so with more practice/training they will be able to acquire more (and more reliable) information.
- Running another test (e.g., MRI) can be used to acquire more (relevant!) information.
- The effect of information is to increase the likelihood of getting either a hit or a correct rejection, while reducing the likelihood of an outcome in the two error boxes (slide 33).
- **Criterion:** Additionally to relying on technology/testing, the medical profession allows doctors to use their own judgment.
- Different doctors may feel that the different types of errors are not equal.
- For example, a doctor may feel that missing an opportunity for early diagnosis may mean the difference between life and death.
- A false alarm, on the other hand, may result only in a routine biopsy operation. They may chose to err toward ``yes'' (tumor present) decisions.
- Other doctors, however, may feel that unnecessary surgeries (even routine ones) are very bad (expensive, stress, etc.).
- They may chose to be more conservative and say ``no'' (no tumor) more often. They will miss more tumors, but they will be doing their part to reduce unnecessary surgeries. And they may feel that a tumor, if there really is one, will be picked up at the next check-up.

Two doctors, with equally good training, looking at the same CT scan data, will have the same information ... but they may gain different knowledge due to *bias/criteria*.


http://www-psych.stanford.edu/~lera/psych115s/notes/signal
Receiver Operating Characteristics (ROC curve)

- For $d' = 1$ (lots of overlap):
  - Hits = 97.5%
  - False alarms = 84%

- For $d' = 3$ (not much overlap):
  - Hits = 84%
  - False alarms = 50%

- For $d' = 4$:
  - Hits = 50%
  - False alarms = 16%

[Source: http://www-psych.stanford.edu/~lera/psych115s/notes/signal/]
Clinical Example:

- \( D \) ... acute heart attack
- \( U_+ \) ... instable chest pain

\[ p(D) \] ... 37 of 1000 = 0,037 (heart attack)
\[ p(D) \] ... 963 of 1000 = 0,963 (no heart attack)

- 40\% of patients report on instable chest pain
- \( p(U_+ | D) = 0,4 \)

- Unfortunately this symptoms also occur in 5 \% of the healthy population
- \( p(U_+ | \overline{D}) = 0,05 \)

- We find the probability for a heart attack during this symptoms therefore by using Bayes’ Rule:

\[
p(D | U_+) = \frac{p(U_+ | D) \cdot p(D)}{p(U_+ | D) \cdot p(D) + p(U_+ | \overline{D}) \cdot p(\overline{D})} = 0,235
\]
Example Clinical Case: Serotonin Toxicity

Differential Diagnosis (1) Serotonin Syndrome

Hunter’s Decision Rules for Diagnosis of Serotonin Toxicity

- Spontaneous clonus → Serotonin toxicity
- Inducible clonus with agitation or diaphoresis → Serotonin toxicity
- Ocular clonus with agitation or diaphoresis → Serotonin toxicity
- Tremor and hyperreflexia → Serotonin toxicity
- Hypertonia, temperature above 100.4°F (38°C), and ocular or inducible clonus → Serotonin toxicity
- No serotonin toxicity

Signs & Symptoms of Serotonin Syndrome

- Agitation (restlessness)*
- Diaphoresis*
- Diarrhea*
- Disseminated intravascular coagulation†
- Fever above 100.4°F (38°C)
- Hyperreflexia*
- Incoordination (ataxia)*
- Mental status changes
  - Confusion*
  - Hypomania*
- Multi-organ failure†
- Myoclonus*
- Ocular clonus
- Rhabdomyolysis†
- Shivering*
- Tonic-clonic seizures†
- Tremor*

*—Sternbach’s diagnostic criteria require three of 10 signs and symptoms.
†—Extremely severe cases.

<table>
<thead>
<tr>
<th>Clinical condition</th>
<th>History</th>
<th>Vital signs</th>
<th>Clinical features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticholinergic syndrome</td>
<td>Use of tricyclic antidepressants or other anticholinergic drugs</td>
<td>Tachycardia, tachypnea, hyperthermia (usually 102.2°F [39°C] or below)</td>
<td>Dry mouth, blurred vision, mydriasis, flushed skin, agitation/delirium, decreased bowel sounds</td>
</tr>
<tr>
<td>Malignant hyperthermia</td>
<td>Administration of halogenated inhalational anesthetics or depolarizing muscle relaxants</td>
<td>Hypertension, tachycardia, tachypnea, hyperthermia (up to 114.8°F [46°C])</td>
<td>Diaphoresis, mottled skin, agitation, decreased bowel sounds, muscular rigidity, hyporeflexia</td>
</tr>
<tr>
<td>Neuroleptic malignant syndrome</td>
<td>Ingestion of antipsychotic medications</td>
<td>Hypertension, tachycardia, tachypnea, hyperthermia (above 105.8°F [41°C])</td>
<td>Sialorrhea, diaphoresis, pallor, stupor, mutism, coma, normal or decreased bowel sounds, lead-pipe rigidity, bradyreflexia</td>
</tr>
</tbody>
</table>

Rough Set Theory (1) for dealing with incomplete data

- ... is an extension of the Classical Set Theory, for use when representing incomplete knowledge.
- RS are sets with fuzzy boundaries – sets that cannot be precisely characterized using the available set of attributes, exactly like it is in medical decision making; based on 2 ideas:
  1) a given concept can be approximated by partition-based knowledge as upper and lower approximation – which corresponds to the focusing mechanism of differential medical diagnosis: upper approximation as selection of candidates and lower approximation as concluding a final diagnosis.
  2) a concept or observations can be represented as partitions in a given data set, where rough sets provides a rule induction method from given data. Thus, this model can be used to extract rule-based knowledge from medical databases.
Diagnostic Procedure (Differential Diagnostic)

Example Symptom: Headache

- Focusing Mechanism (Selection of Candidates)
- Differential Diagnosis
- Detection of Complications

Characterization (Negative Rules)

- Discrimination (Positive Rules)

- Complications

Let $U$ denote a non-empty, finite set called the universe and $A$ denote a non-empty, finite set of attributes:

- $a : U \rightarrow V_a$ for $a \in A$
- where $V_a$ is called the domain of $a$
- Then, the decision table is defined as an information system:
- $A = (U, A \cup \{d\})$.
- The table shows an example of an information system with
- $U = \{1, 2, 3, 4, 5, 6\}$ and
- $A = \{\text{age, location, nature, prodrome, nausea, M1}\}$ and
- $d = \text{class}$.
- For $location \in A$, $V_{location}$ is defined as \{occular, lateral, whole\}

<table>
<thead>
<tr>
<th>No.</th>
<th>age</th>
<th>location</th>
<th>nature</th>
<th>prodrome</th>
<th>nausea</th>
<th>M1</th>
<th>class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50-59</td>
<td>occular</td>
<td>persistent</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>m.c.h.</td>
</tr>
<tr>
<td>2</td>
<td>40-49</td>
<td>whole</td>
<td>persistent</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>m.c.h.</td>
</tr>
<tr>
<td>3</td>
<td>40-49</td>
<td>lateral</td>
<td>throbbing</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>migra</td>
</tr>
<tr>
<td>4</td>
<td>40-49</td>
<td>whole</td>
<td>throbbing</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>migra</td>
</tr>
<tr>
<td>5</td>
<td>40-49</td>
<td>whole</td>
<td>radiating</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>m.c.h.</td>
</tr>
<tr>
<td>6</td>
<td>50-59</td>
<td>whole</td>
<td>persistent</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>psycho</td>
</tr>
</tbody>
</table>

**Definitions.** M1: tenderness of M1, m.c.h.: muscle contraction headache, migra: migraine, psycho: psychological pain.

The atomic formula over

\[ B \subseteq A \cup \{d\} \] and \( V \) are expressions of the form \([a = v]\)
called descriptors over \( B \), where \( a \in B \) and \( v \in V_a \).

The set \( F(B, V) \) of formulas over \( B \) is the least set containing all
atomic formulas over \( B \) and closed with respect to disjunction,
conjunction and negation. For example, \([\text{location} = \text{occular}]\) is
a descriptor of \( B \).

For each \( f \in F(B, V) \), \( f_A \) denote the meaning of \( f \) in \( A \), i.e., the
set of all objects in \( U \) with property \( f \), defined inductively as
follows.

1. If \( f \) is of the form \([a = v]\) then, \( f_A = \{s \in U | a(s) = v\} \)
2. \((f \land g)_A = f_A \cap g_A; (f \lor g)_A = f_A \lor g_A; (\neg f)_A = U - f_A \)

For example, \( f = [\text{location} = \text{whole}] \) and \( f_A = \{2, 4, 5, 6\} \). As an
example of a conjunctive formula, \( g = [\text{location} = \text{whole}] \land
[\text{nausea} = \text{no}] \) is a descriptor of \( U \) and \( f_A \) is equal to \( g_{\text{location}}, \text{nausea} = \{2, 5\} \).
The atomic formula over
B \subseteq A \cup \{d\} and V are expressions of the form \([a = v]\)
called descriptors over B, where \(a \in B\) and \(v \in V_a\).
The set \(F(B, V)\) of formulas over B is the least set containing all
atomic formulas over B and closed with respect to disjunction,
conjunction and negation. For example, \([\text{location} = \text{ocular}]\) is
a descriptor of B.

For each \(f \in F(B, V)\), \(f_A\) denote the meaning of \(f\) in \(A\), i.e., the
set of all objects in \(U\) with property \(f\), defined inductively as
follows.

1. If \(f\) is of the form \([a = v]\) then, \(f_A = \{s \in U| a(s) = v\}\)
2. \((f \land g)_A = f_A \cap g_A\); \((f \lor g)_A = f_A \lor g_A\); \((\neg f)_A = U - f_a\)

For example, \(f = [\text{location} = \text{whole}]\) and \(f_A = \{2, 4, 5, 6\}\). As an
eexample of a conjunctive formula, \(g = [\text{location} = \text{whole}] \land
[\text{nausea} = \text{no}]\) is a descriptor of \(U\) and \(f_A\) is equal to glocation,
nausea = \{2, 5\}. 

Rough Set Theory (4) – Example Symptom: Headache
Definition 1. Let $R$ and $D$ denote a formula in $F(B, V)$ and a set of objects which belong to a decision $d$. Classification accuracy and coverage (true positive rate) for $R \rightarrow d$ is defined as:

$$\alpha_R(D) = \frac{|R_A \cap D|}{|R_A|} (= P(D|R)), \text{ and}$$

$$\kappa_R(D) = \frac{|R_A \cap D|}{|D|} (= P(R|D)),$$

where $|S|$, $\alpha_R(D)$, $\kappa_R(D)$ and $P(S)$ denote the cardinality of a set $S$, a classification accuracy of $R$ as to classification of $D$ and coverage (a true positive rate of $R$ to $D$), and probability of $S$, respectively.
Probabilistic Rules – modus ponens

By the use of accuracy and coverage, a probabilistic rule is defined as:

\[ R \overset{\alpha, \kappa}{\rightarrow} d \quad \text{s.t.} \quad R = \wedge_j [a_j = v_k], \alpha_R(D) \geq \delta_\alpha \]
\[ \text{and} \quad \kappa_R(D) \geq \delta_\kappa, \]

\[ R \rightarrow D \quad \text{s.t.} \quad \alpha'_R(D) > \delta_\alpha, \quad \kappa_R(D) > \delta_\kappa \]

Tsumoto (2006)
Positive Rules

A positive rule is defined as a rule supported by only positive examples, the classification accuracy of which is equal to 1.0. It is notable that the set supporting this rule corresponds to a subset of the lower approximation of a target concept, which is introduced in rough sets [1]. Thus, a positive rule is represented as:

\[ R \rightarrow d \quad s.t. \quad R = \bigwedge_j [a_j = v_k], \quad \alpha_R(D) = 1.0 \]

Figure 4 shows the Venn diagram of a positive rule. As shown in this figure, the meaning of \( R \) is a subset of that of \( D \). This diagram is exactly equivalent to the classic proposition \( R \rightarrow d \). In the above example, one positive rule of “m.c.h.” (muscle contraction headache) is:

\[ [\text{nausea} = \text{no}] \rightarrow \text{m.c.h.} \quad \alpha = 3/3 = 1.0. \]
Before defining a negative rule, let us first introduce an exclusive rule, the contrapositive of a negative rule [7]. An exclusive rule is defined as a rule supported by all the positive examples, the coverage of which is equal to 1.0. That is, an exclusive rule represents the necessity condition of a decision. It is notable that the set supporting an exclusive rule corresponds to the upper approximation of a target concept, which is introduced in rough sets [1]. Thus, an exclusive rule is represented as:

\[ R \rightarrow d \quad s.t. \quad R = \vee_j [a_j = v_k], \quad \kappa_R(D) = 1.0. \]

Figure 4 shows the Venn diagram of an exclusive rule. As shown in this figure, the meaning of \( R \) is a superset of that of \( D \). This diagram is exactly equivalent to the classic proposition \( d \rightarrow R \). In the above example, the exclusive rule of “m.c.h.” is:

\[ [M1 = yes] \lor [nau = no] \rightarrow m.c.h \]

From the viewpoint of propositional logic, an exclusive rule is:

\[ d \rightarrow \vee_j [a_j = v_k], \]

because the condition of an exclusive rule corresponds to the conclusion \( d \). Thus, it is easy to see that a negative contrapositive of an exclusive rule:

\[ \land_j \neg [a_j = v_k] \rightarrow \neg d, \]

Tsumoto (2006)
of conclusion $d$. Thus, it is easy to see that a negative rule is defined as the contrapositive of an exclusive rule:

$$\land_{j} \neg [a_{j} = v_{k}] \rightarrow \neg d,$$

which means that if a case does not satisfy any attribute value pairs in the condition of a negative rules, then we can exclude a decision $d$ from candidates. For example, the negative rule of m.c.h. is:

$$\neg [M1 = yes] \land \neg [nausea = no] \rightarrow \neg m.c.h.$$

In summary, a negative rule is defined as:

$$\land_{j} \neg [a_{j} = v_{k}] \rightarrow \neg d \quad s.t.$$

where $D$ denotes a set of samples which Venn diagram of a negative rule. As in negative region is the “positive region”

Tsumoto (2006)
Example: Algorithms for Rule Induction

procedure Exclusive and Negative Rules;
var
    \( L : \text{List}; \)
    /* A list of elementary attribute-value pairs */
begin
    \( L := P_0; \)
    /* \( P_0 \): A list of elementary attribute-value pairs given in a database */
    while (\( L \neq \{\} \)) do
        begin
            Select one pair \([a_i = v_j]\) from \( L \);
            if \( ([a_i = v_j]_A \cap D \neq \phi) \) then do /* \( D \): positive examples of a target class \( d \) */
                begin
                    \( L_{ir} := L_{ir} + [a_i = v_j]; \) /* Candidates for Positive Rules */
                    if \( (\kappa_{[a_i = v_j]}(D) = 1.0) \)
                    then \( R_{er} := R_{er} \land [a_i = v_j]; \)
                        /* Include \([a_i = v_j]\) into the formula of Exclusive Rule */
                end
            \( L := L - [a_i = v_j]; \)
        end
    Construct Negative Rules:
        Take the contrapositive of \( R_{er} \).
end \{Exclusive and Negative Rules\};
Judgment under Uncertainty: Heuristics and Biases

Biases in judgments reveal some heuristics of thinking under uncertainty.

Amos Tversky and Daniel Kahneman

Many decisions are based on beliefs concerning the likelihood of uncertain events such as the outcome of an election, the guilt of a defendant, or the future value of the dollar. These beliefs are usually expressed in statements such as “I think that . . .,” “chances are . . .,” “it is unlikely that . . .,” and so forth. Occasionally, beliefs concerning uncertain events are expressed in numerical form as odds or subjective probabilities. What determines such beliefs? How do people assess the probability when visibility is good because the objects are seen sharply. Thus, the reliance on clarity as an indication of distance leads to common biases. Such biases are also found in the intuitive judgment of probability. This article describes three heuristics that are employed to assess probabilities and to predict values. Biases to which these heuristics lead are enumerated, and the applied and theoretical implications of these observations are discussed.

Insensitivity to prior probability of outcomes. One of the factors that have no effect on representativeness but should have a major effect on probability is the prior probability, or base-rate frequency, of the outcomes. In the case of Steve, for example, the fact that there are many more farmers than librarians in the population should enter into any reasonable estimate of the probability that Steve is a librarian rather than a farmer. Considerations of base-rate frequency, however, do not
Another Possibility: Heuristic Decision Making

MI = myocardial infarction
N.A. = not applicable
NTG = nitroglycerin
T = T-waves with peaking or inversion

Case Based Reasoning (CBR)

Medical Errors


One jumbo jet crash every day
Definitions of medical errors

- Medical error = any failure of a planned action;
- Serious ME = causes harm; includes preventable adverse events, intercepted serious errors, and non-intercepted serious errors. Does not include trivial errors with little or no potential for harm or non-preventable adverse events;
- Intercepted serious error = is caught before reaching patients;
- Non-intercepted serious error = reaches the patient but of good fortune or sufficient reserves to buffer the error, it did not cause harm;
- Adverse event = any injury (e.g. a rash caused by an antibiotic, deep vein thrombosis following omission to continue prophylactic subcutaneous heparin orders on transfer to the critical care unit, ventricular tachycardia due to placement of a central venous catheter tip in the right ventricle etc.);
- Non-preventable adverse event = Unavoidable injury due to appropriate medical care.
- Preventable adverse event = Injury due to a non-intercepted serious error in medical care.

Thank you!
Sample Questions (1)

- What is still considered the main and central topic in medical informatics?
- Please explain the information flow within the memory system according to Atkinson & Shiffrin!
- Explain the general model of human information processing following the model of Wickens!
- Explain the processing of visual (image, pictorial) information!
- What is so different in the alternative memory model according to Baddeley (1986)?
- Why is Attention of importance for medical informatics?
- Please explain the process of human decision making according to the model of Wickens (1984)!
- What is Triage?
- Please explain the hypothesis-oriented algorithm for Clinicians!
- What is the big difference between the Hypothetico-Deductive Method and the Plan-Do-Check-Act Deming Model?
- How can we model patient health – please provide an example!
Sample Questions (2)

- Please contrast the decision making process with the data mining process!
- Why is Signal Detection Theory important for us?
- Please provide an Example for the application of Bayes’ Theorem!
- How does Differential Diagnosis work?
- How can we apply Rough Set Theory for differential diagnostics?
- What is Heuristic Decision Making?
- What is problematic when dealing with heuristic decision making from an informatics viewpoint?
- What is Case Based Reasoning (CBR)?
- How are medical errors defined?
- How does the framework for understanding human error work?
Some Useful Links

- http://sbml.org
- http://www.hci4all.at
- http://www.lcb.uu.se/tools/rosetta
- http://wise.cgu.edu/sdtmod/overview.asp (excellent Tutorial on SDT)
- http://www.iom.edu (Institute of Medicine)
- http://www.fda.gov/drugs/drugsafety/medicationerrors/default.htm (Food and Drug Administration, FDA, medication errors)