# Medical Decision Sciences

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## Medical Decision Sciences

- *Medical decision making*
- *Data, Information, & Knowledge*
- *Knowledge representation*
- *Bayes rule*
- *ROC curve*
- *Clinical decision analysis*
- *Machine learning*
- *Clinical decision support system*
- *Grade C*

## Clinical practice as decision making

- *The ability to make good decisions is the hallmark of the good performing professional.*
- *Information system can be used for good decision making and decision support.*
- *Therefore, it is important to understand the theory of decision making.*

## A working definition of a decision

*An irrevocable allocation of resources*

- *Resources can be time, money, attention cycles, emotional energy, or anything else of value to the decision maker.*
- *Irrevocable allocation is required, because otherwise there is no crisp way do define when a decision should be made.*

## Decision is different than worrying

*Worrying typically does not involve allocation of resources.*

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# Data, Information, & Knowledge

- **Data**
- **Information**
- **Knowledge**

# Informatics: knowledge about knowledge

*The acts of the mind wherein it exerts its power over simple ideas, are chiefly these three:*

1. *Combining several simple ideas into one compound one, and the all complex ideas are made.*
2. *The second is bringing two ideas, whether simple or complex, together, and setting them by one another so as to take a view of them at once, without uniting them into one, by which it gets all its ideas of relations.*
3. *The third is separating them from all other ideas that accompany them in their real existence: this is called abstraction, and thus all its general ideas are made.*

*John Locke, An Essay Concerning Human Understanding (1690)*

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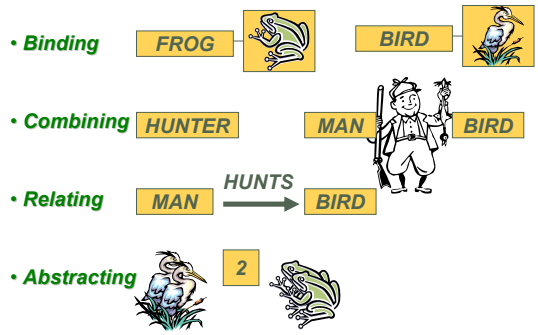
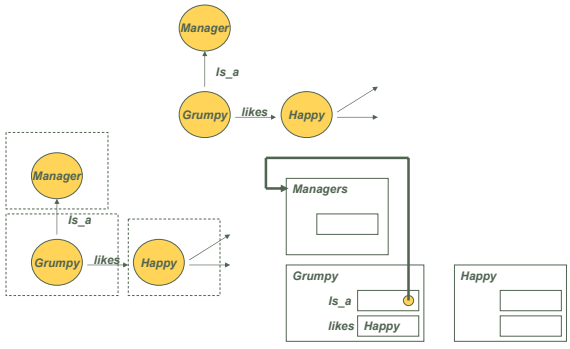
# Data, Data Structure, Abstraction, Representation



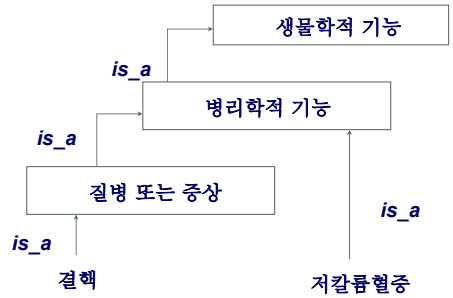

# Data, Data Structure, Abstraction, Knowledge Representation, & Formalism



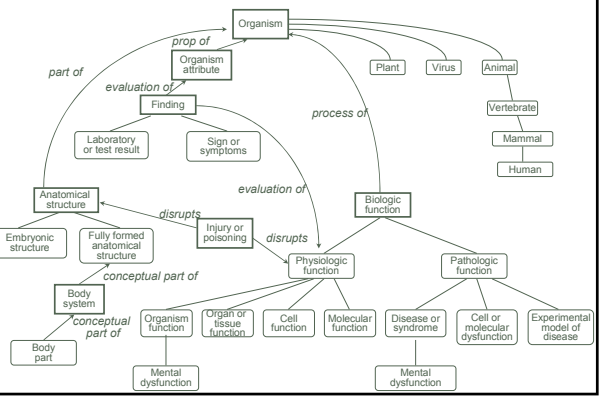

# Frames: an example

| NAME : *Acute glomerulonephritis* | |
|---|---|
| **Triggered by** | facial edema, not painful, not erythematical, symmetrical, etc. |
| **Confirmed by** | malaise, asthenia, anorexia, etc. |
| **Caused by** | recent streptococci infection |
| **Causes** | sodium retention, acute hypertension, nephrotic syndrome, etc. |
| **Complications** | acute kidney failure |
| **Differential diagnosis** | (If chronic high blood pressure then chronic glomerulonephritis)<br>(If recurrent edema then nephrotic syndrome) |

## Semantic Network & Medical Ontology




## Semantic Network : UMLS




## Medical Language & Classification Systems

- ICD
- MeSH
- CPT 4
- SNOMED
- HL-7
- LOINC
- Arden Syntax
- UMLS
  - Metathesaurus
  - Semantic Network
  - Information Source Map
- Controlled Vocabularies and Vocabulary Server
  - PTXT / COSTAR / TMR / RMRS
  - MED (Medical Entities Dictionary)
  - PEN & PAD
  - GALEN

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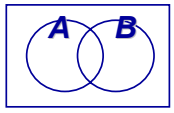
## Probability

$$0 \le p(A) \le 1$$

$$\sum p(A_i) = 1$$

$$p(A \vee B) = p(A) + p(B) - p(A \wedge B)$$




$$p(A \mid B) = p(A \wedge B) / p(B)$$

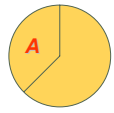
$$\therefore p(A \mid B) \cdot p(B) = p(B \mid A) \cdot p(A)$$

$$p(D \mid S) = \frac{p(S \mid D) \cdot p(D)}{p(S)} = \frac{p(S \mid D) \cdot p(D)}{p(S \mid D) \cdot p(D) + p(S \mid \overline{D}) \cdot p(\overline{D})}$$

## Bayes Rule

- **odds-likelihood ration form of Bayes formula**

$$Odds = \frac{p(A)}{1 - p(A)} = \frac{p(A)}{p(\overline{A})}$$



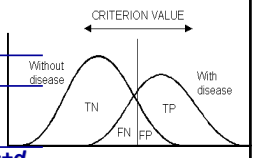

**Prob = 1 / 3**
**Odds = 1 / 2 =0.5**

$$\frac{p(D \mid S)}{p(\overline{D} \mid S)} = \frac{p(D)}{p(\overline{D})} \bullet \frac{p(S \mid D)}{p(S \mid \overline{D})}$$

**Post. Odds = prior odds x likelihood ratio**

## Diagnostic test characteristics

| | D + | D – | |
|---|---|---|---|
| T + | a | b | a+b |
| T - | c | d | c+d |
| | a+c | b+d | a+b+c+d |




- Sensitivity = a / (a+c) = p(T+|D+)
- Specificity = d / (b+d) = p(T-|D-)
- Positive Predictive Value = a / (a+b) = p(D+|T+)
- Negative Predictive Value = d / (c+d) = p(D-|T-)

## Diagnostic test characteristics

*예제) Sensitivity=99.99%, specificity=99.9% 인 최신의 에이즈 검사가 개발되었다. 철수는 이 검사에 양성반응을 보였다. 철수가 에이즈에 감염됐을 확률은 얼마인가? (현재 한국인의 에이즈 유병율은 0.0001이라고 한다.)*

1. 99%
2. 95%
3. 80%
4. 50%
5. 10%

## Diagnostic test characteristics

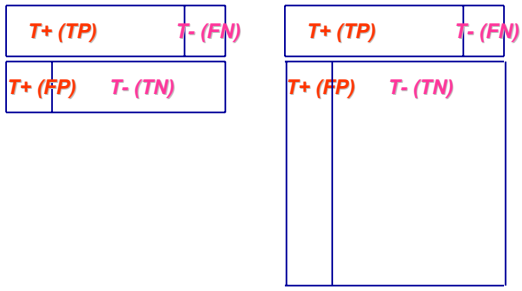
- Sensitivity=99.99%
- Specificity=99.9%

Prevalence=0.0001

| | AIDS | no AIDS | |
|---|---|---|---|
| T + | 9,999 | 1 00,000 | 109,999 |
| T - | 1 | 999 00,000 | 99,900,001 |
| | 10,000 | 1000 00,000 | 100,010,000 |

- Positive predictive value = 9,999 / 109,999 < 10%
- Negative predictive value = 1.0

## Diagnostic test characteristics

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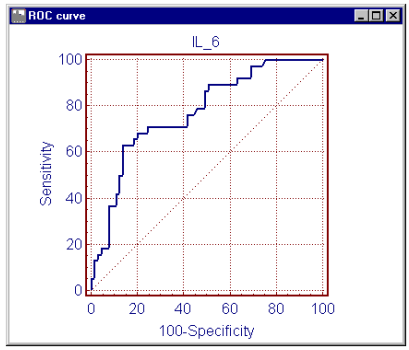
## ROC Curve



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# Why decision making is so hard?

**UNCERTAINTY!!**

- **If you have all information about the probabilities of different events, then it typically is NOT a hard decision**
- **If there is no uncertainty, and the decision is still hard, then the problem is that the utility function is not clear**

# Decision Theory

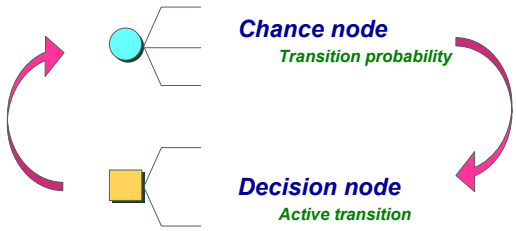
**A theory for decision making that is rational.**

# Expected value decision making

**Maximize expected value among the decision alternatives**

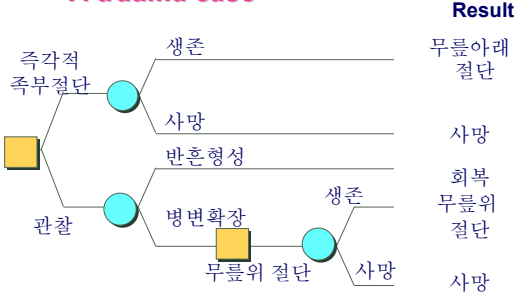
# Clinical Decision Analysis

**Alternating chance & decision nodes**



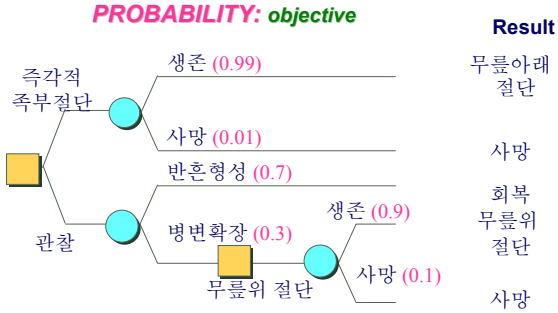

# Simple decision tree

**A trauma case**



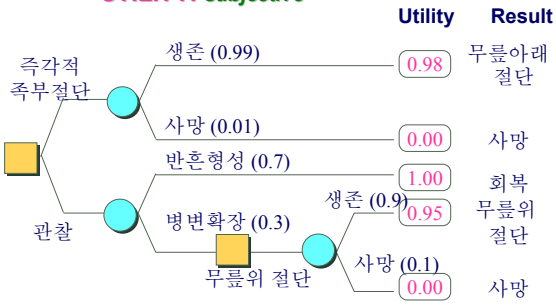

# Simple decision tree

**PROBABILITY: objective**



## Simple decision tree

**UTILITY: subjective**



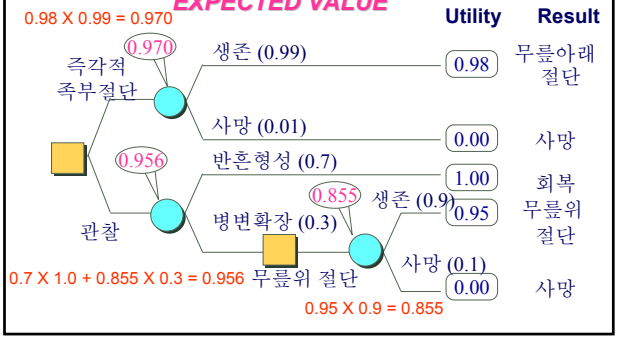

## Simple decision tree

**EXPECTED VALUE**

0.98 X 0.99 = 0.970

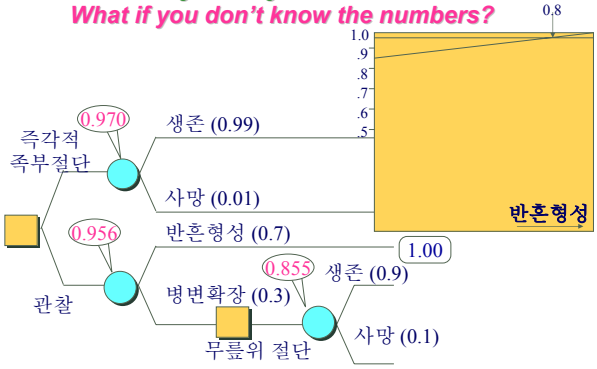
0.7 X 1.0 + 0.855 X 0.3 = 0.956

0.95 X 0.9 = 0.855




## Sensitivity analysis

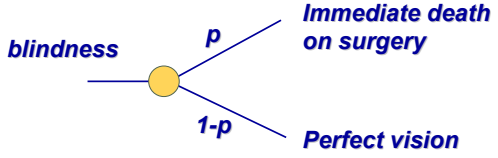
**What if you don't know the numbers?**




## Standard gamble

**Getting utility**

**Utility is not PROBABILITY**




## Risk seeking vs. risk averse