

🗨️ Andreas Holzinger, Regina Geierhofer, Maximilian Errath

Semantic Information in Medical Information Systems: from Data and Information to Knowledge: Facing Information Overload

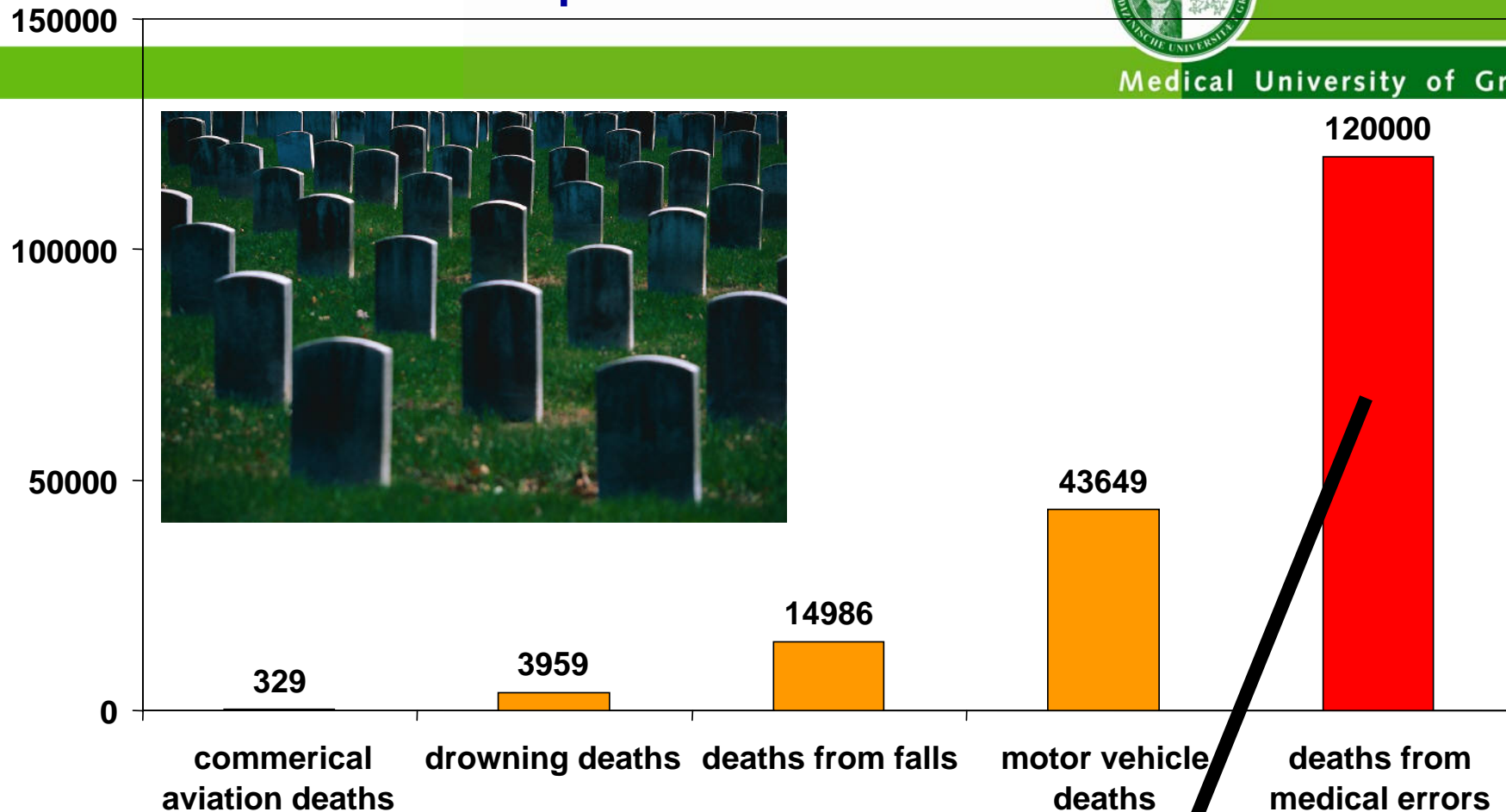
SEP, 5th, 2007, iSemantics Graz



Well-known: IOM rep. Ann. Death rate in US



Medical University of Graz



Sources:

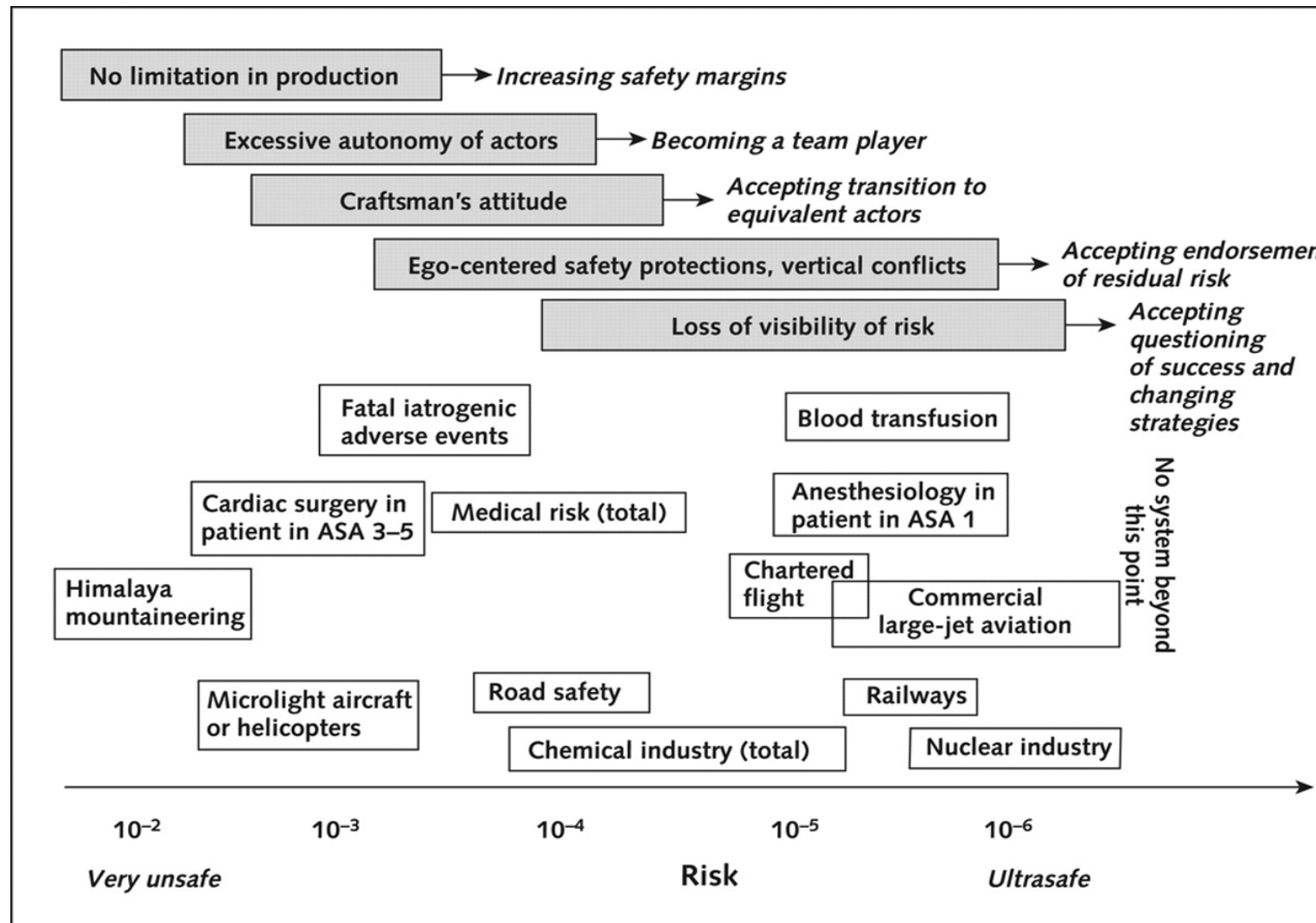
- 1) *Philadelphia Enquirer* (9/12/99)
- 2) *The Institute of Medicine 1999 report*
- 3) "To Err is Human" (Kohn et al., 1999)
"Why do accidents happen"

One jumbo jet crash every day





Rate of Errors/Risk



Amalberti, R. et. al. Ann Intern Med 2005;142:756-764

Introduction and Motivation for Research



- Clinicians are faced with the problem of too much rather than too little information (*cf. e.g. Slawson, 1994*)
- Captured data in Life Sciences per year include approx. 1 Exabyte (10^{18}), (*Neumann, 2005*)
- How much is that?
 - Compare it to the estimate of the total words ever spoken by humans = 12 Exabyte (*Sheth, 2005*)
- Consequently the urgent need is evident for better
 - Search, Integration, Analysis, Decision support, Knowledge Discovery etc.



Introduction and Motivation (2)



- Past research dealt with information from medical literature search, e.g. *(Sullivan et al., 1999), (Hall & Walton, 2004)*, only a few dealt
- with information overload from clinical information systems, e.g. *(Noone et al., 1998)*
- Contrary to a Web information search, there is a much higher recall and precision expectancy from a search within the medical environment



Theoretical Background: Text

- Although we live in the “Multimedia Age”, and multimedia has an important role in medicine, approx. 95 % of all medical information is still textual information ...
- Free-text can be created simply and intuitively, however
- it makes an automatic analysis enormously difficult *(Gregory et al, 1995), (Holzinger et al. 2000, Lovis et al. 2000)*



No fake: 184 (!) TEXT docs for a 2 year old patient

- ▶ Diagnosen (32)
- ▶ Dokumente (55)
- ▶ Dok Radiologie (22)
- ▶ Dok Patho/Histo/Zyto (12)
- ▶ Dok Hygiene/Mikrobiologie (16)
- ▶ Dok Labor (184)
- ▶ Dok. Intensiv/Anästhesie (3)
- ▶ Dok in Archiv (27)
- ▶ Termin/Bew. (233)
- ▶ Anforderungen (20)
- ▶ Leistungen (356)
- ▶ Operationen (3)

Radiologischer Befund

angelegt am 06.05.2006/20:26
geschr. von [redacted]
gedruckt am 17.11.2006/08:24
Anfo: NCHIN

Kurzanamnese: St.p. SHT

Fragestellung: -

Untersuchung: Thorax eine Ebene liegend [redacted]

SB

Bewegungsartefakte. Zustand nach Schädelhirntrauma.

Das Cor in der Größennorm, keine akuten Stauungszeichen.
Fragliches Infiltrat parahilär li. im UF, RW-Erguss li.

Zustand nach Anlage eines ET, die Spitze ca. 5cm cranial der Bifurkation, lieg. MS, orthotop positioniert. ZVK über re., die Spitze in Proj. auf die VCS. Kein Hinweis auf Pneumothorax. Der re. Rezessus frei.

Mit kollegialen Grüßen

*** Elektronische Freigabe durch [redacted] am 09.05.2006 ***

Holzinger, Geierhofer & Errath (2007)



Histologisches Gutachten

Makroskopie: "Resektat nach Whipple": Ein noch nicht eröffnetes Resektat, bestehend aus einem distalen Magen mit einer kleinen Kurvaturlänge von 9,5 cm und einer großen Kurvaturlänge von 13,5 cm, sowie einem duodenalen Anteil von 14 cm Länge. 2 cm aboral des Pylorus zeigt die Dünndarmwandung eine sanduhrartige Stenose. Im Lumen sowohl des Magens als auch des Duodenums reichlich zähflüssiger Schleim, sangoinolent; die Schleimhaut ist insgesamt livide. Anhängend ein 7,5 x 4 x 1,5 cm großes Pankreaskopfsegment sowie ein 4 cm langer derber und bis 2,5 cm durchmessender knotiger Gewebsstrang, der an seinem Ende eine Fadenmarkierung aufweist. Hier auf lamellierenden Schnitten zähfestes weißliches, teilweise nodulär konfiguriertes Gewebe, ohne dass Gallengänge manifest werden. Der distale Anteil des Ductus pancreaticus ist leicht erweitert und von der Papilla Vateri aus 4,5 cm weit sondierbar, wobei er hier in einer peripankreatischen Narbenzone abbricht. Die Mündung eines Gallenganges lässt sich makroskopisch nicht abgrenzen. Die berichtete Stenose im Duodenum liegt 2,5 cm oral der Papilla Vateri und steht mit der beschriebenen Narbenzone in direktem Zusammenhang. Teilweise ist die Dünndarmschleimhaut im Stenosebereich polypoid vorgewölbt. Der kleinen Kurvatur anhängend ein bis 4 cm durchmessendes Fettgewebe. Darin einzelne knotige Indurationen von bis zu 1 cm Größe. 1. Oraler Resektionsrand Magenkorpus. 2. Magenantrum. 3. Bulbus duodeni. 4. Stenosezone mit angrenzendem Pankreas und tuschemarkierten äußeren Resektionsrändern und einem Lymphknoten. 5. Papilla Vateri - Mündung des Ductus pancreaticus. 6. Distales Ende des Ductus pancreaticus im Narbengebiet. 7. Intraparenchymaler Absetzungsrand Pankreas. 8. Peripankreatisches Gewebe. 9. bis 12. Fadenmarkierter Fortsatz an der Arteria hepatica communis von



In the following we consider two factors

- A) Usefulness of Medical Information
- B) Usability of Medical Information





Basic ecological Approach of HCI

$$\text{HCI - Ecology} = \frac{\text{Net Knowledge Gained}}{\text{Costs of Interaction}}$$

- ... HCI-Ecology should go to a maximum!



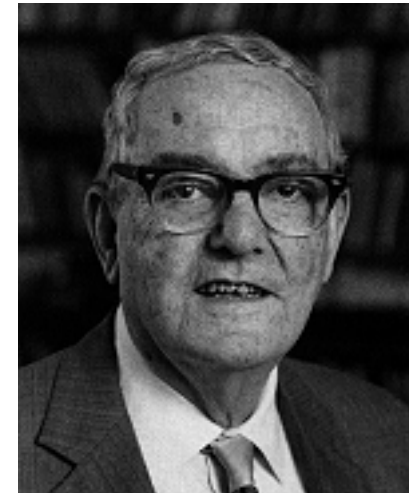
$$\text{Usefulness} = \frac{\text{Relevance} * \text{Validity}}{\text{Work}}$$

- whereas
- Unit of work = time to perform task
- which is clearly measurable (*e.g. Stary & Peschl, 1998*)



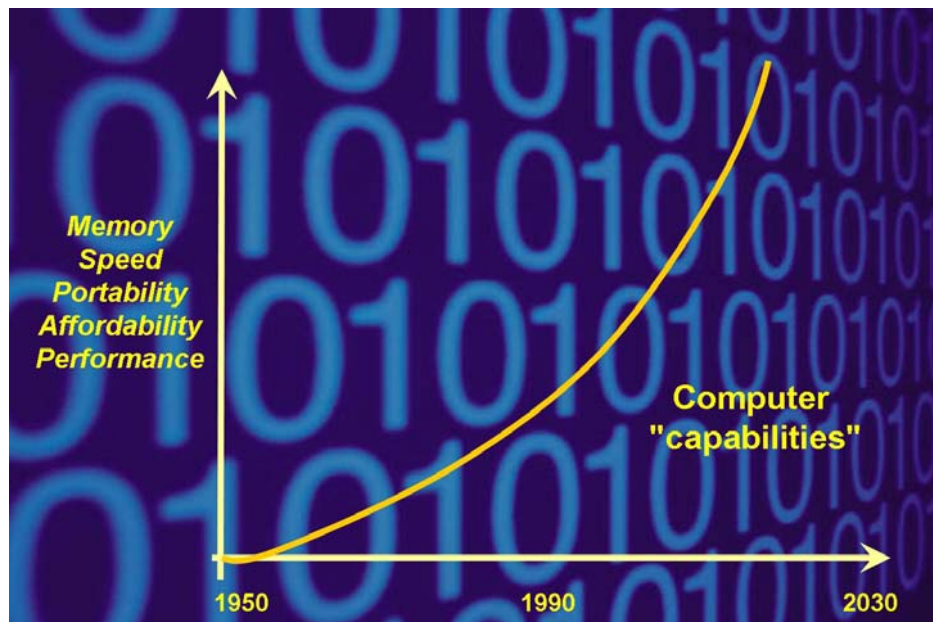
Introduction: A word from Herbert A. Simon

*“A wealth of information
creates a poverty of
attention and a need
to allocate it efficiently ...
Human attention is central,
not precision versus recall”*

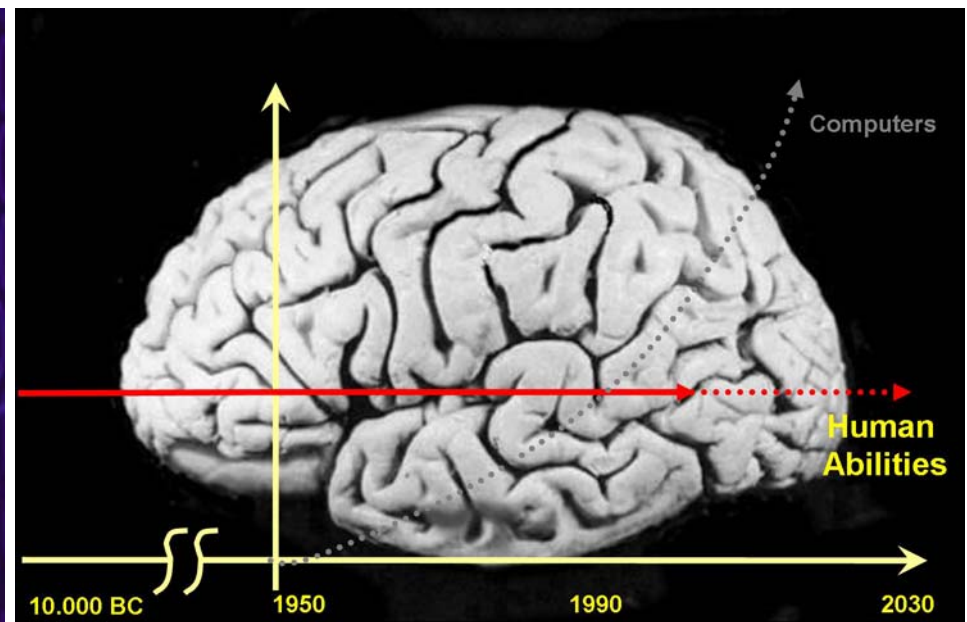


Herbert A Simon

Computer Performance versus Cognitive Performance



Moore (1997), cf. Holzinger (2002)



Atkinson (1965), Hall (1988), Buxton (2001)

- Airplanes get more sophisticated ...



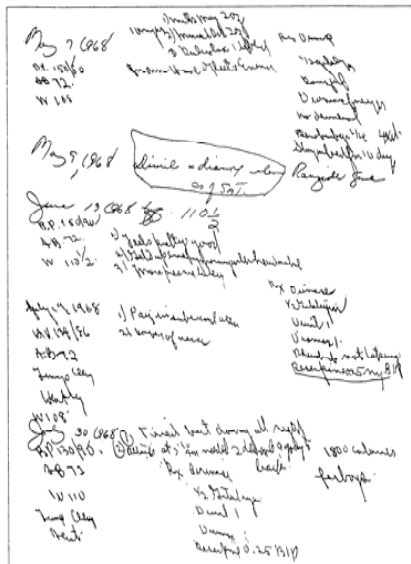
Bleriot Model XI - 1909



Aerospatiale-BAC Concorde - 1969

... but the people who make decisions remain the same.

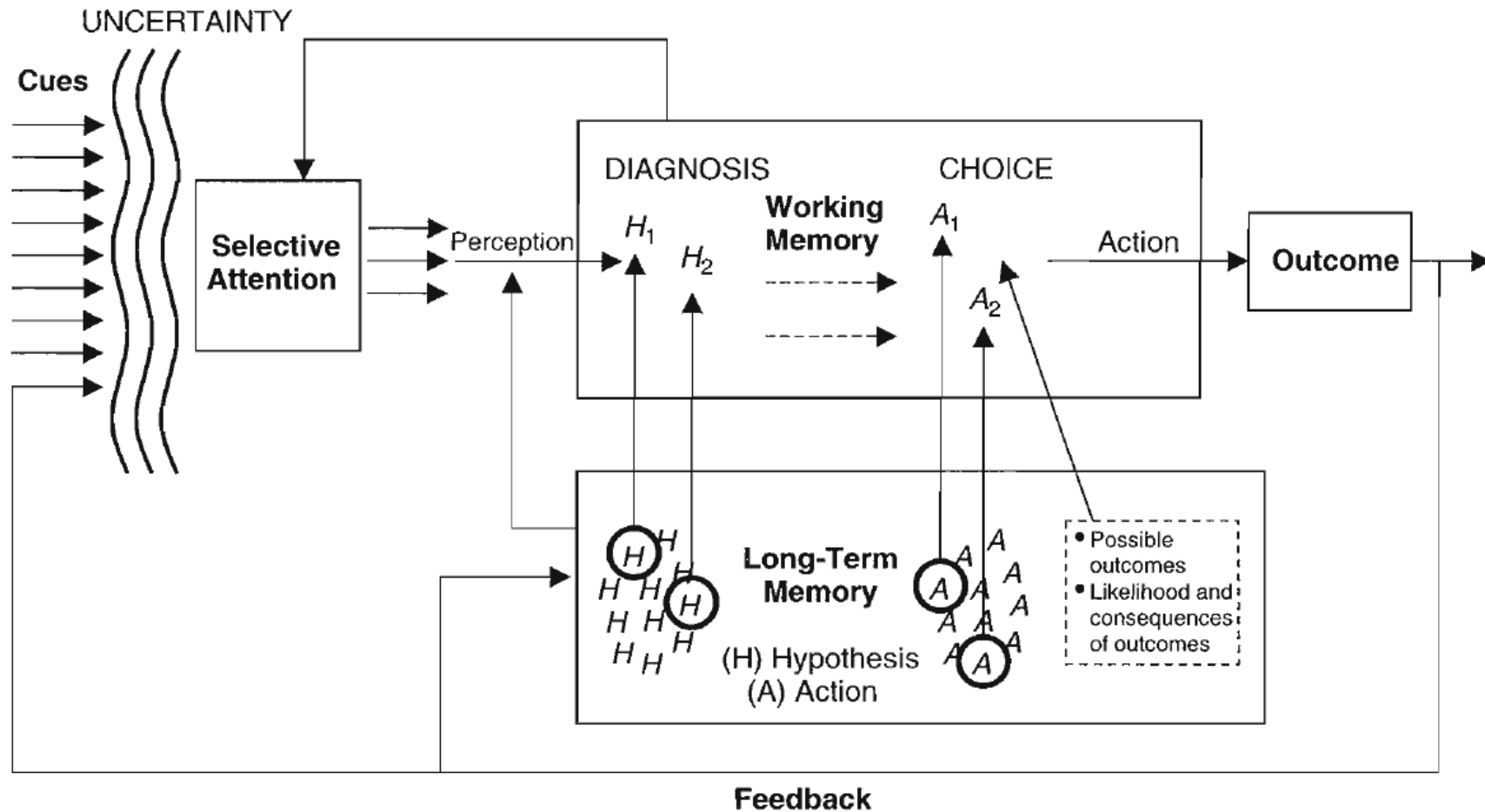
■ Medical informatics gets more sophisticated



Picture removed for data protection

...but the people who make decisions remain the same.

Human decision making

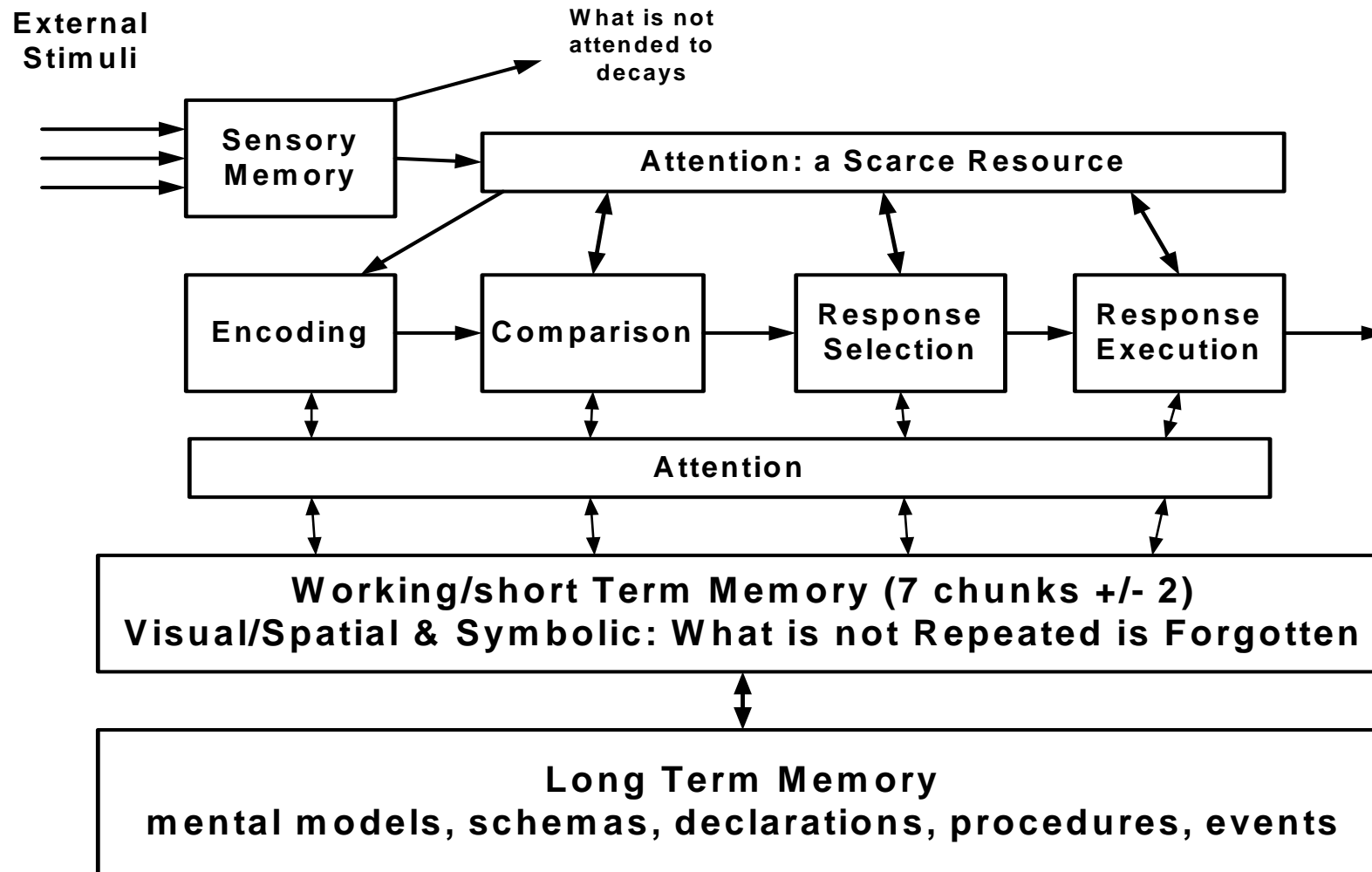


Adapted from Wickens (2000)

Model of Atkinson & Shiffrin (1968)



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Cf. with Atkinson & Shiffrin (1968)



Model of Human Information Processing

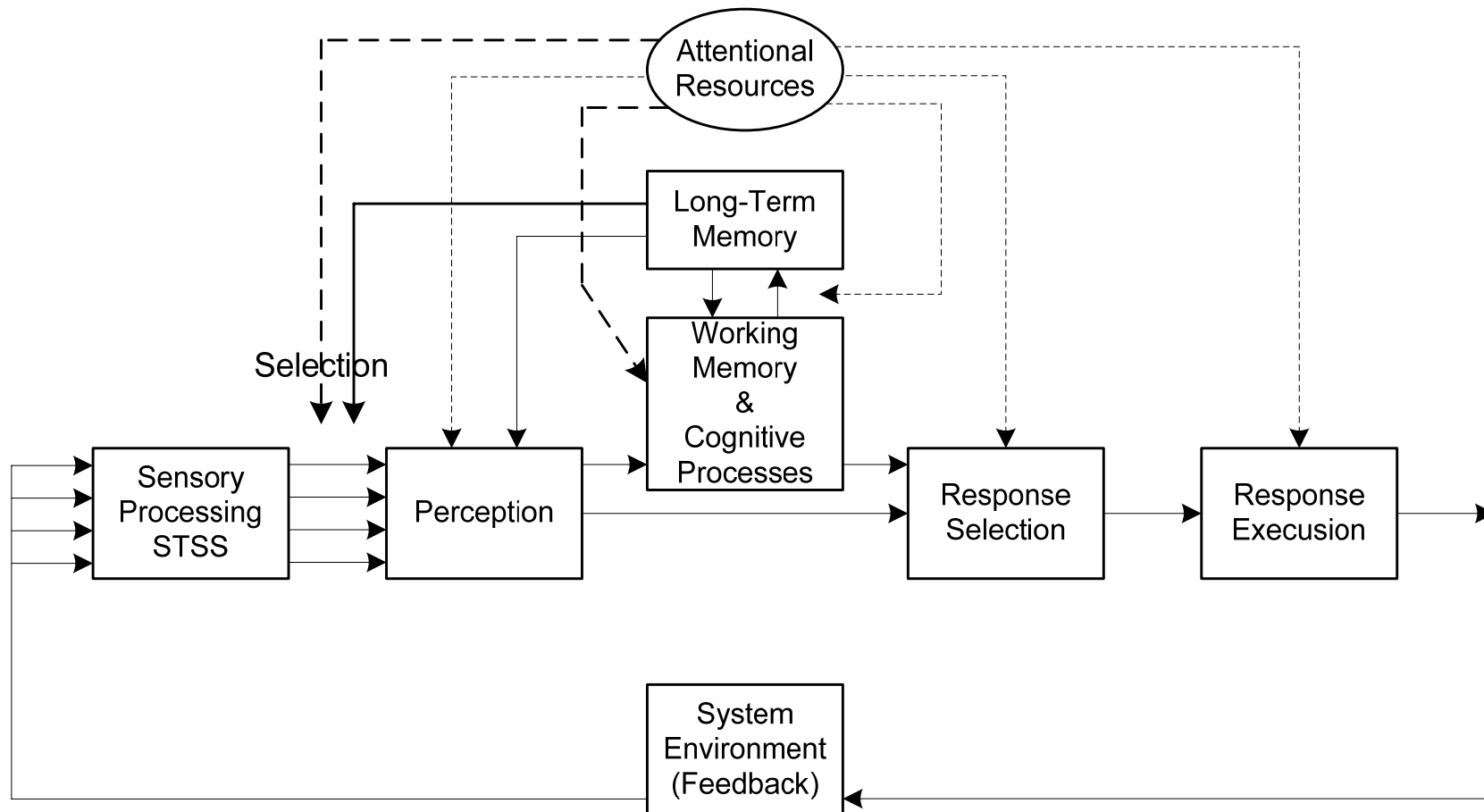
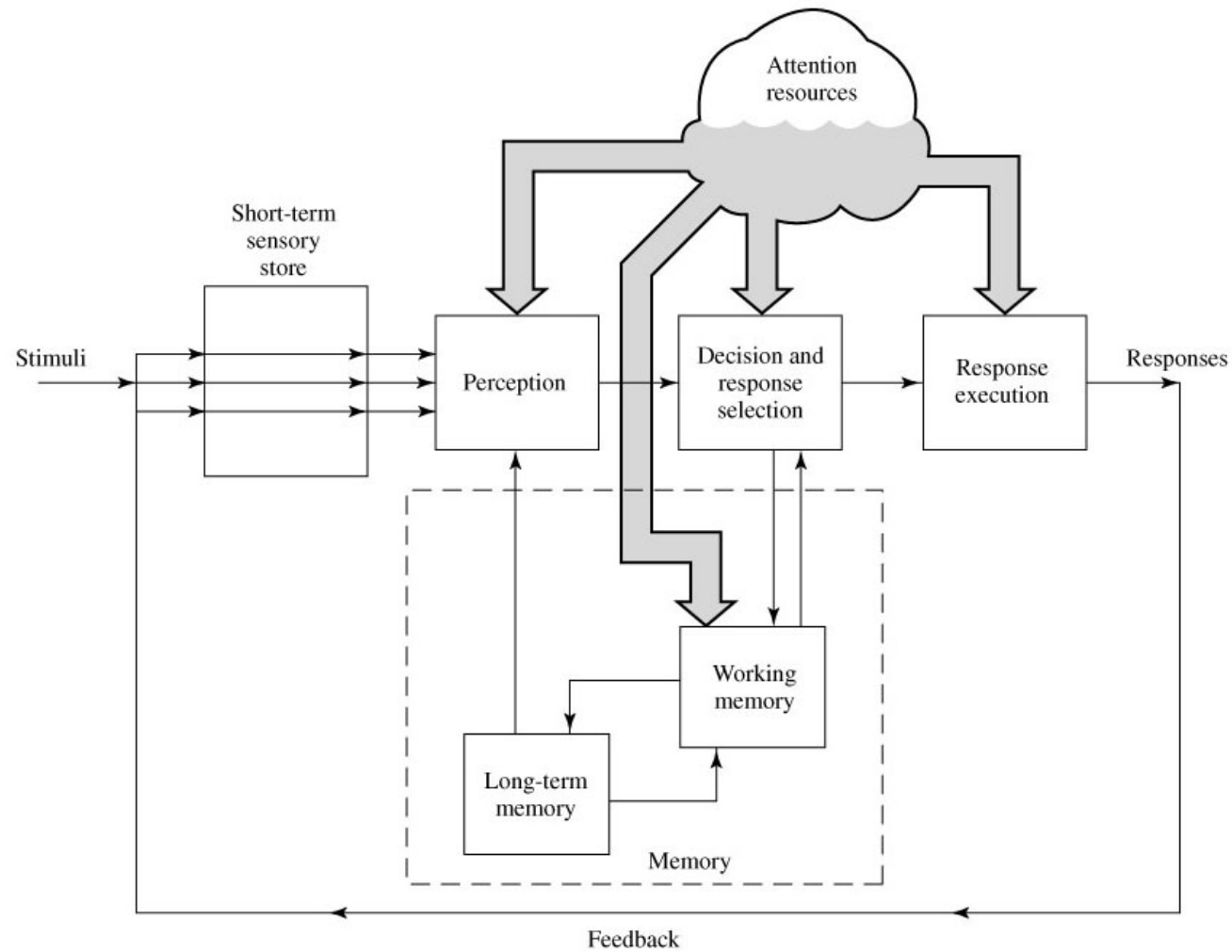


Figure adapted from Wickens (2000)



Scarce Resource: Attention



According to Sanders and Mc Cormick, (1993)

Information Overload

- Information Overload >
- Memory Overload >
- Cognitive Overload.
- Theoretical Concept behind:
- Cognitive Load Theory (CLT), *Sweller (1988)*





- Intrinsic Load = caused by the information itself, dependent on complexity & intrinsic nature
 - ... unfortunately, we can do very little as developers;
- Extraneous load = is dependent from Design, Presentation and Structuring of the Information Interface
 - here we can do much; also with regard to previous knowledge, skills etc. of the end users
- Germane load = specific load, which is **NECESSARY** for proper info processing, i.e.
 - Exactly this is often ignored, should be optimized

cf with Sweller (1998); Sweller, Chandler, Tierney, Cooper, (1990)

What can we as developers do?



We should

- 1) optimize, support and adapt Germane Load
- 2) reduce Intrinsic load (if possible), and
- 3) adapt and reduce Extraneous load.



How to cope with Information Overload

- Avoid information overload if possible
- If not
 - Assist the attention processes of the end-users
 - Assist the higher analysis processes of end-users
- Examples
 - Attract attention to what they first need to know
 - Use layout design to indicate meaningful structure

Conclusion



- A flood of information causes a scarcity of attention and a greater need to efficiently use that attention
- The real design problem is not increased access to information, but greater efficiency in
 - a) finding *useful* information and
 - B) to be presented with *usable* information



Psychology

HCI 4MED

Informatics



**Human-Computer Interaction
& Usability Engineering**

**Let us together
bridge the gap and
build this bridge**

Thank you!





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