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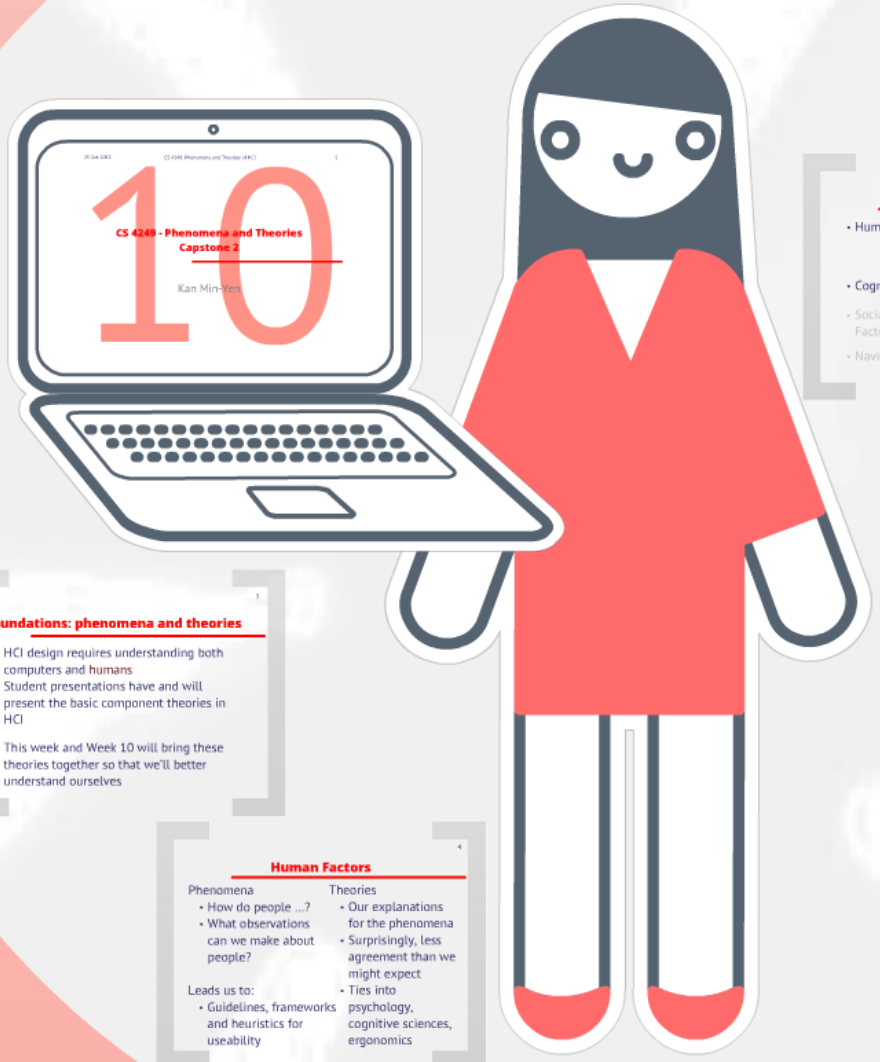
CS 4249 - Phenomena and Theories
Capstone 2

Kan Min-Yen



Outline

- Human Information Processing
  - Memory and Attention
  - Human Abilities
- Cognitive Models
- Social, Emotional and Affective Factors
- Navigation and Wayfinding

Foundations: phenomena and theories

- HCI design requires understanding both computers and humans
- Student presentations have and will present the basic component theories in HCI
- This week and Week 10 will bring these theories together so that we'll better understand ourselves

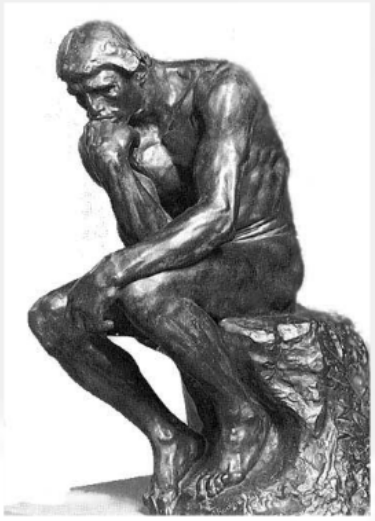
Human Factors

Phenomena	Theories
• How do people ...?	• Our explanations for the phenomena
• What observations can we make about people?	• Surprisingly, less agreement than we might expect
Leads us to:	• Ties into psychology, cognitive sciences, ergonomics
• Guidelines, frameworks and heuristics for useability	

GOMS (Goals, Operators, Methods and Selection)
Hick-Hyman's Law
Distributed and External Cognition
Seven Stages of Action
Situated Action
Plans and Scripts

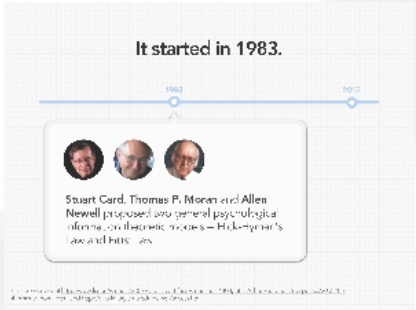
Cognitive Models

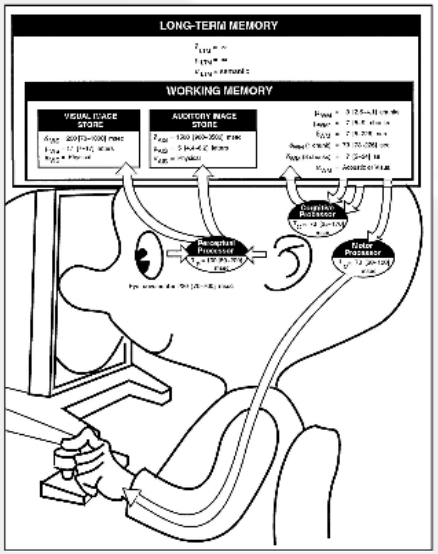
Models for how we think and decide.
Started with an empirical motivation to measure individuals.



Later, other models add context to these notions.

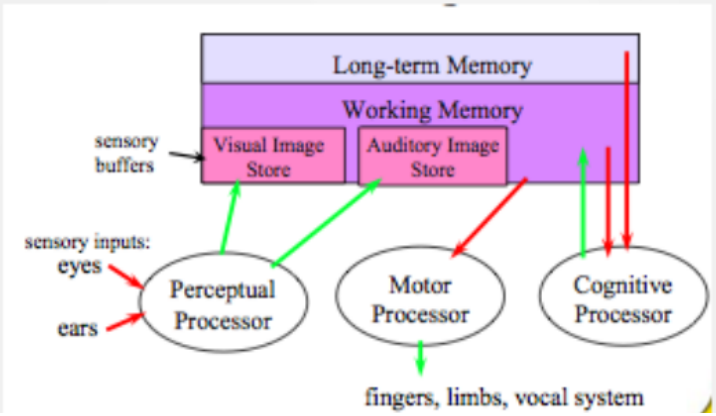
Human Processor Model & GOMS





The Human Processor Model and GOMS were both developed by Card, Moran and Newell.

- Both are predictive models of an single person, conceptualizing a task as a series of processes whose time can be added up sequentially.
- The Human Processor Model models individuals as a set of three processes: perceptual, motor and cognitive. Sound familiar?



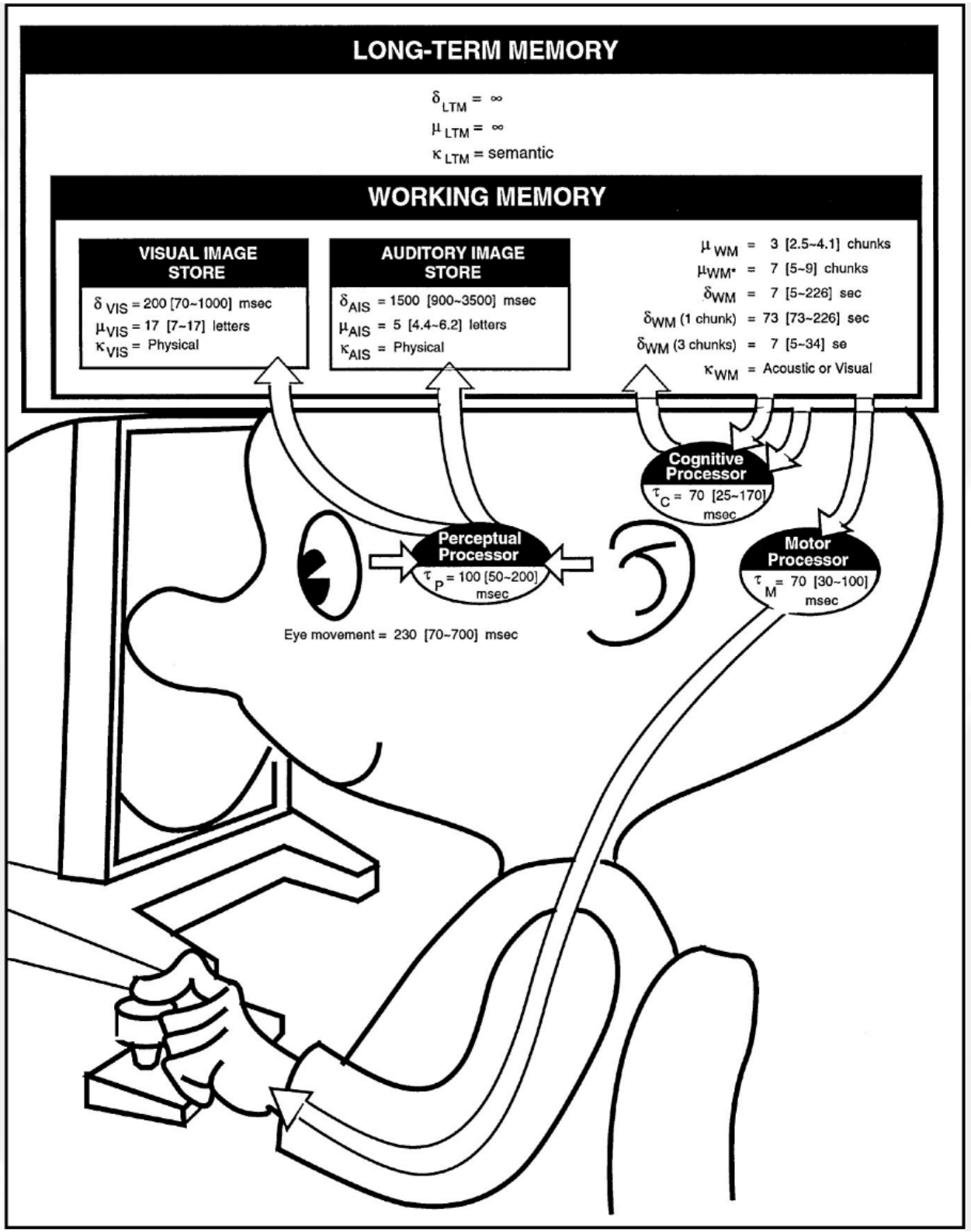
It started in 1983.

1983 — 2012



Stuart Card, **Thomas P. Moran** and **Allen Newell** proposed two general psychological information theoretic models -- Hick-Hyman's Law and Fitts' Law.

Photos courtesy of http://www.fi.edu/winners/2007/card_stuart.faw?winner_id=4403, http://shaokezhang.blogspot.sg/2008/11/thomas-p-moran.html and http://diva.library.cmu.edu/newell/access.html


LONG-TERM MEMORY
$\delta_{LTM} = \infty$
$\mu_{LTM} = \infty$
κ_{LTM} = semantic
WORKING MEMORY
VISUAL IMAGE STORE
δ_{VIS} = 200 [70~1000] msec
μ_{VIS} = 17 [7~17] letters
κ_{VIS} = Physical
AUDITORY IMAGE STORE
δ_{AIS} = 1500 [900~3500] msec
μ_{AIS} = 5 [4.4~6.2] letters
κ_{AIS} = Physical
μ_{WM} = 3 [2.5~4.1] chunks
μ_{WM*} = 7 [5~9] chunks
δ_{WM} = 7 [5~226] sec
δ_{WM} (1 chunk) = 73 [73~226] sec
δ_{WM} (3 chunks) = 7 [5~34] se
κ_{WM} = Acoustic or Visual
Cognitive Processor
τ_C = 70 [25~170] msec
Perceptual Processor
τ_P = 100 [50~200] msec
Motor Processor
τ_M = 70 [30~100] msec
Eye movement = 230 [70~700] msec

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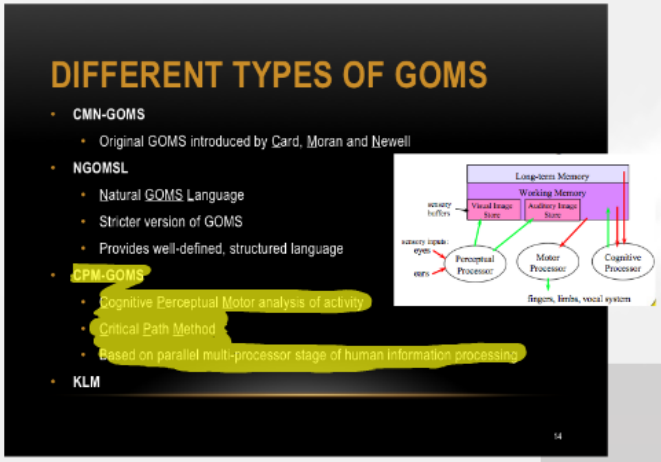
Goals, Operators, Methods and Selectors

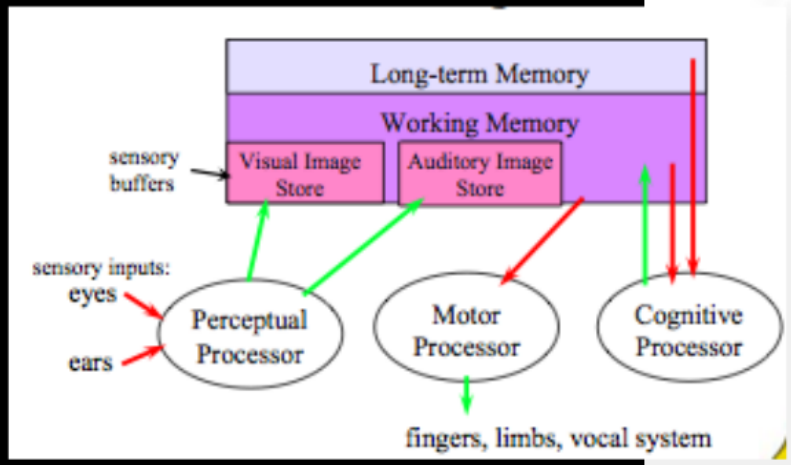
GOMS can be thought of as an elaboration on the human processor model. A task to be accomplished has a Goal and Methods (a series of steps to accomplish them. Methods can be broken down hierarchically into a series of Operators that carry out a task. Selectors are the decision logic (if-then-else rules) that specify what to do after observing an outcome.

If this sounds like a programming language, that's because it almost is one. Simulations of task completion time are done in computer-facilitated versions of GOMS.

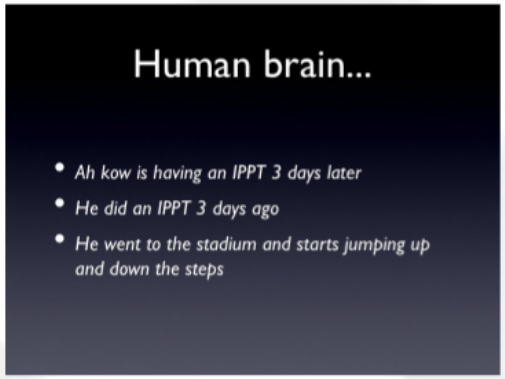


DIFFERENT TYPES OF GOMS

- **CMN-GOMS**
  - Original GOMS introduced by Card, Moran and Newell
- **NGOMSL**
  - Natural GOMS Language
  - Stricter version of GOMS
  - Provides well-defined, structured language
- **CPM-GOMS**
  - Cognitive Perceptual Motor analysis of activity
  - Critical Path Method
  - Based on parallel multi-processor stage of human information processing
- **KLM**



Scripts (and Plans*)



Originated in the precursors to Artificial Intelligence.

A key factor is that missing descriptions are supplied by recall of other related experiences.

Scripts also have metadata that describe when they are applicable. For us, this is how scripts relate to situated action. Using metaphor, we can overcome the gulfs of execution and evaluation by invoking scripts and the situated knowledge of other experiences.

Plans, as defined by Schank, are the series of actions needed to satisfy goals. I think of this as equivalent to GOMS's goals and methods. To me, GOMS offers a more compelling (operational) description of this.

Rate of Information Gain in Hick's Law

$$T = b \log_2(n + 1)$$

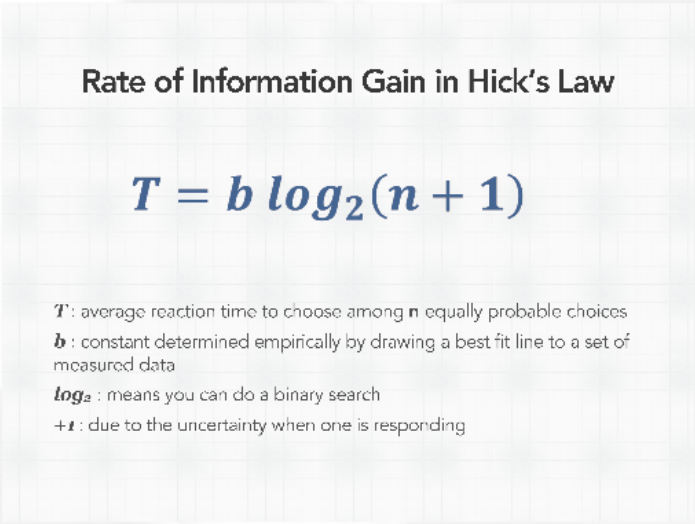
T : average reaction time to choose among **n** equally probable choices

b : constant determined empirically by drawing a best fit line to a set of measured data

$\log_2$: means you can do a binary search

$+1$: due to the uncertainty when one is responding

Hick-Hyman Law



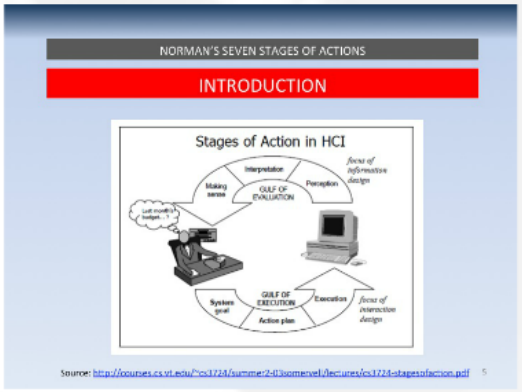
Like Fitts' law, psychologists wanted to create predictive models for dealing with choice (selectors in GOMS) (cf Shannon's work on Information Theory)

The key part of Hick's law is that it is logarithmic, that is, it's not linear.

Tangent: Often, choices have a different amount of entropy. Common choices have less information (entropy) and are thus faster to make. To make a choice that's rare takes more time.

- E.g., the response time for avoiding sudden obstacles on the road (a falling tree) is larger than avoiding more common moving obstacles (errant pedestrians).

Norman's Gulfs of Execution and Evaluation

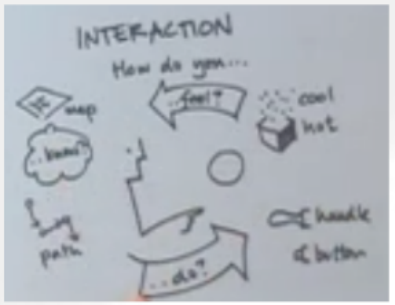


Gulf of Execution - The user does not know how to accomplish her task

Gulf of Evaluation - The user does not know how to check on the effects of her actions

These "gulfs" arise often because there's a mismatch in the mental models of the user and of the designer.

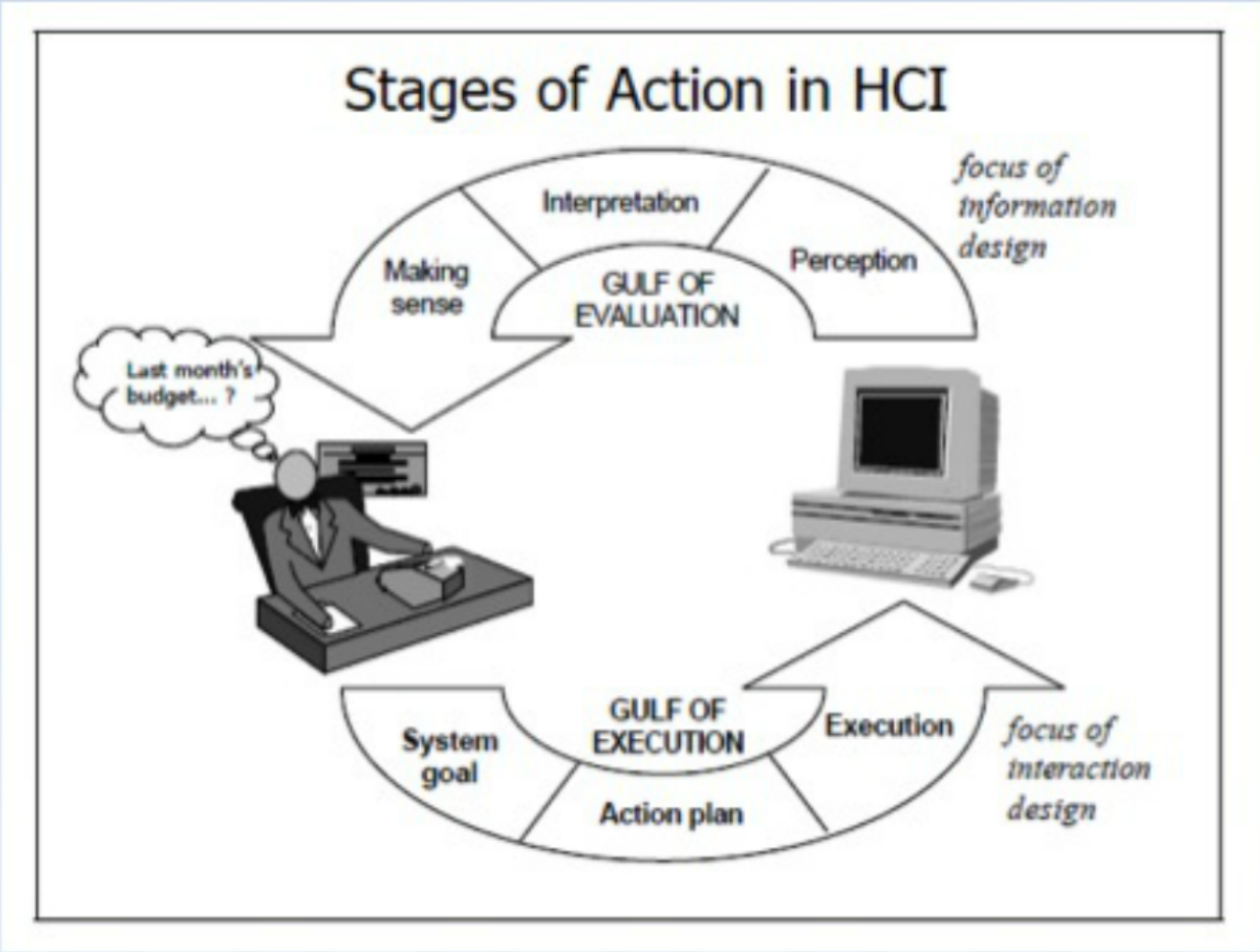
A good way to provide a mental model is to draw on the user's experience using a metaphor: "Think of swiping as opening a sliding window"



Quick Q: Can you find all three red terms in Bill Verplank's sketch?

NORMAN'S SEVEN STAGES OF ACTIONS

INTRODUCTION



Source: http://courses.cs.vt.edu/~cs3724/summer2-03somervell/lectures/cs3724-stagesofaction.pdf

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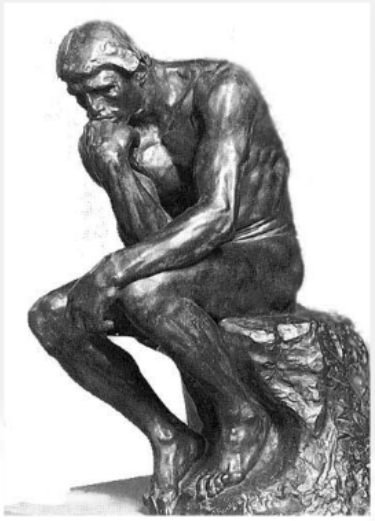

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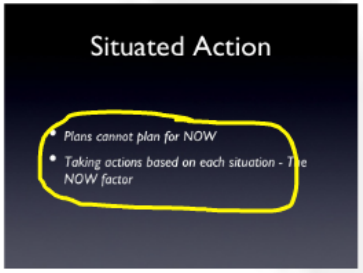
Situated Action



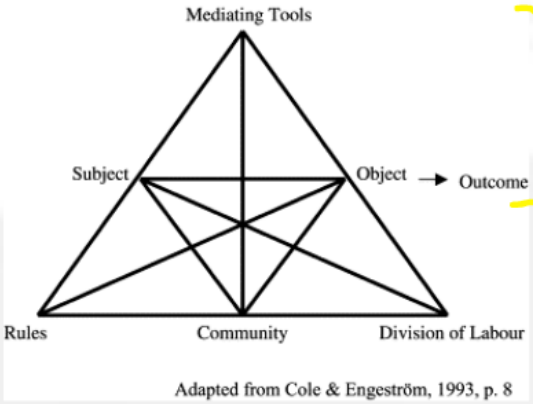
http://csalt.lancs.ac.uk/alt/lucy/

"Situated" in the contexts in which an activity occurs in. These include the organizational, social and technological contexts in which an activity occurs.

HCI is a collaboration between the users and the system designers (cf Norman's Gulfs)

A key point is that situated action states that much real human activity happens in the now, the immediate and personal context. This notion of immediacy is an opposing viewpoint to the regularity of scripts and plans. In certain situations, our actions are opportunistic, flexible, reactive and individualized.

Activity Theory



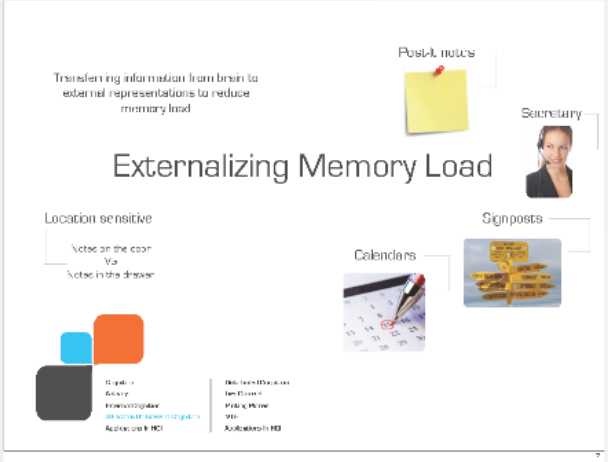
Adapted from Cole & Engeström, 1993, p. 8

An activity is the unit of analysis and is diagrammed to show the actors (subject), outcome (object), artifacts (tools).
In AT, the activity is the context.

In subsequent revisions, the activity schema evolved to encompass rules (working practices; scripts), community and division of labor.

Thinking about the parts of the schema can help identify mismatches (contradictions) when a part of the activity changes.

Distributed and External Cognition



The unit of analysis here is the system.

In a DC analysis, we look for the structure of how both people and artifacts interact. There can be many analyses for the different people and artifacts involved.

It is different from Activity Theory, which looks at these and other factors holistically as an activity.

Comparing Contextual Models

The 3 models have different foci, but all are valuable for specific analyses.

Persistent structures: Activity theory and distributed cognition are similar, but distributed cognition puts humans on parity with artifacts; AT keeps the actor as the focus. Situated action emphasizes temporary or improvisatory artifacts.

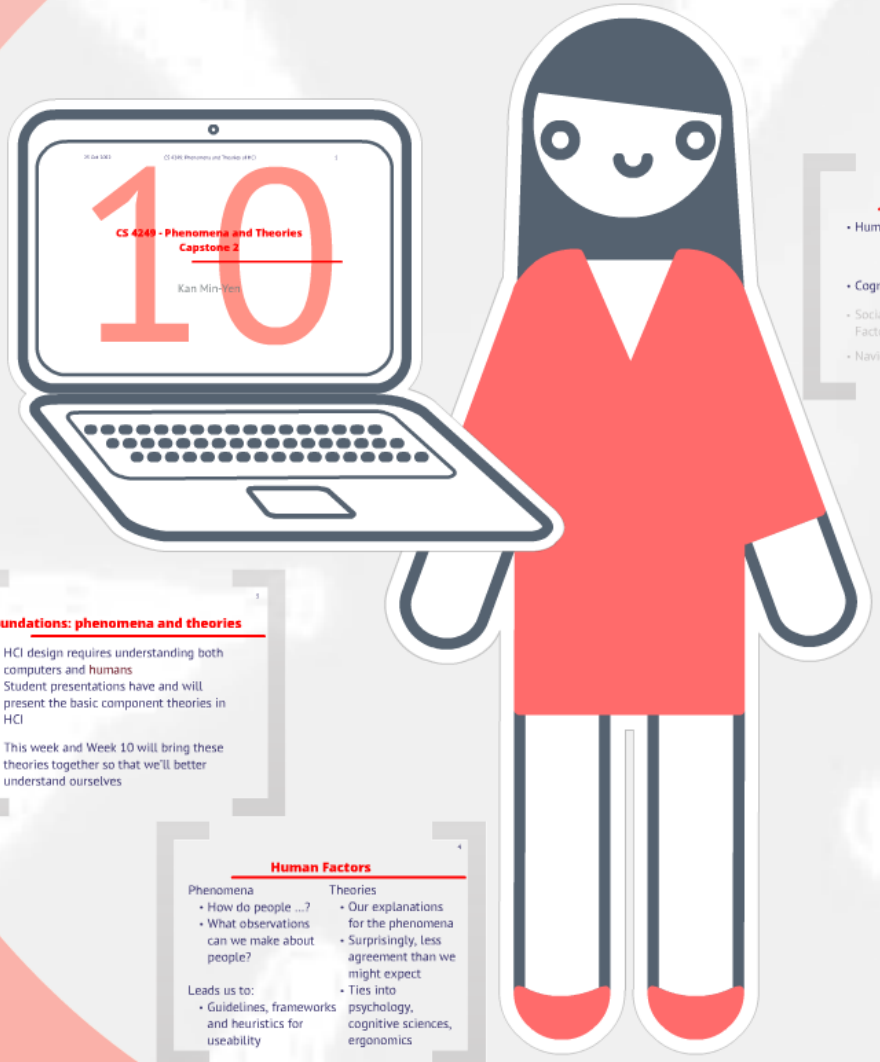
People vs. Artifacts AT is human-centric. Distributed cognition again puts both as equal parts of a whole. From one limited perspective, Situated Action describes people as reactive to their immediate environment.

Summary

Cognitive Models started as descriptive and explanatory models to help HCI understand how people make decisions.

1st generation: linear, isolated problem solving.

2nd generation: interaction in the environment, w/ others and artifacts, to ID problem areas within a system.



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Human Factors

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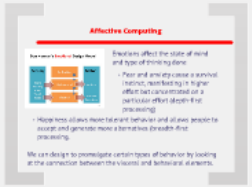
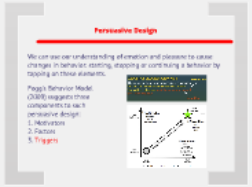
Emotion and Affective Models

How and why do affective models matter in HCI





Summary

Affective computing: employing an understanding of emotions to design systems better.

Affective theory gives designers more ways to analyze a system to look for potential conflicts.

Important longitudinal effects: emotion, moods and pleasure are changing and individualized.

Large changes on the horizon; plenty of opportunity for more development. cf gamification.

Affective Computing

Goals of Affective Computing

1. Recognizing Emotion
2. Synthesizing Emotion
3. Causing Emotional Responses

Outline:

Models of Emotions
Application to Persuasion and Gamification

Psychological Theories of Emotion

Ekman, Friesen and Ellsworth (1972) and Plutchik (1980): six to eight basic universal emotions.

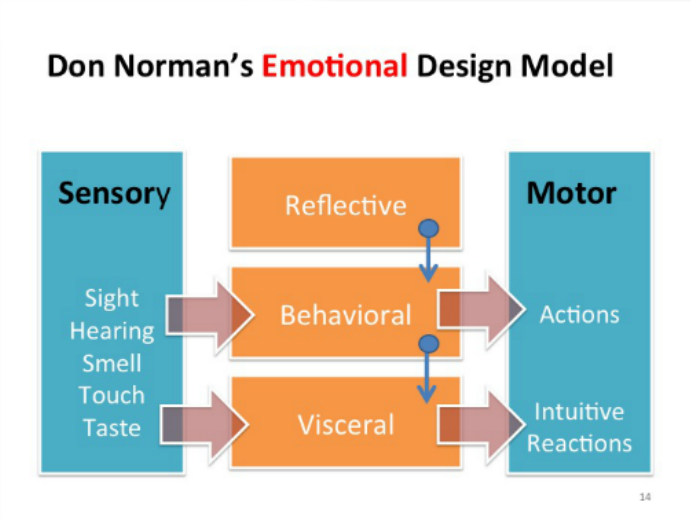
http://library.thinkquest.org/25500/index2.htm

Alternative models (Russell and Fernandez-Dols, 1997) distinguish only degrees on two dimensions: arousal and pleasure.

Generally agreed that there are 3 components:

1. The subjective experience of emotion
2. Accompanying physiological changes
3. Change in higher level behavior

Affective Computing



Emotions affect the state of mind and type of thinking done

- Fear and anxiety cause a survival instinct, manifesting in higher effort but concentrated on a particular effort (depth-first processing)
- Happiness allows more tolerant behavior and allows people to accept and generate more alternatives (breadth-first processing.

We can design to promulgate certain types of behavior by looking at the connection between the visceral and behavioral elements.

Detecting and Recognizing Emotions

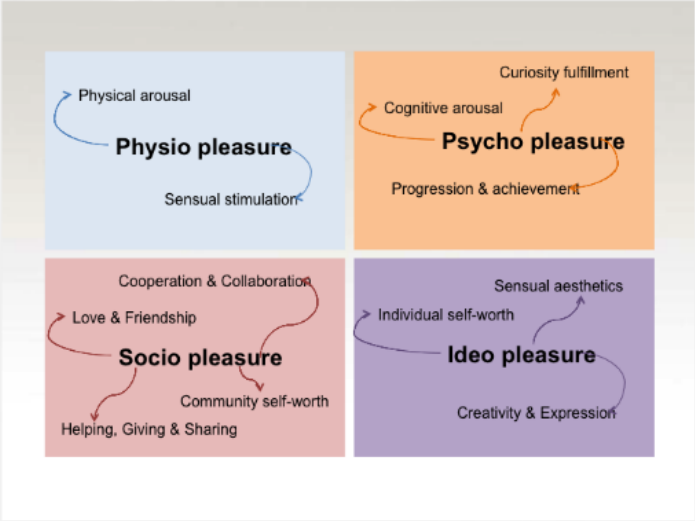
Overt input: facial expression, voice intonation, gesture, movement, posture and pupilary dialation

Intrusive input: respiration, skin conductance, pulse, blood pressure, perspiration and temperature.

Current A.I. technologies for emotion recognition are getting better (70-90% for different emotions), but using intrusive detection.

Tangent: Speech recognition technology and problems with hyperarticulation.

Pleasure Models



"Usability" is equated with psycho-pleasure - designing around human error and mitigating negative emotion

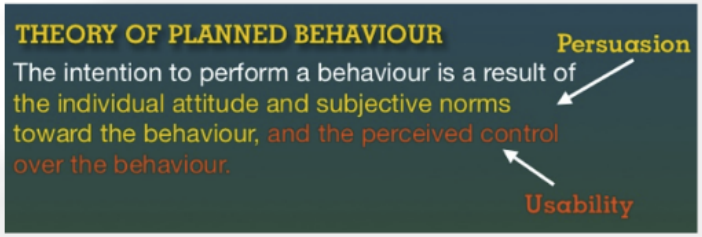
Keep this model in mind as we continue to think about what HCI really is about.

Persuasive Design

We can use our understanding of emotion and pleasure to cause changes in behavior: starting, stopping or continuing a behavior by tapping on these elements.

Fogg's Behavior Model (2009) suggests three components to such persuasive design:

1. Motivators
2. Factors
3. Triggers



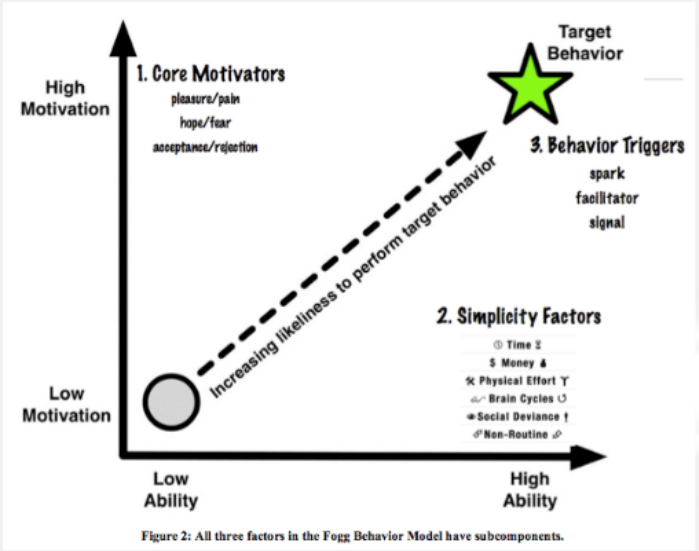


Figure 2: All three factors in the Fogg Behavior Model have subcomponents.

Towards Gamification

Suits' The Grasshopper argues that in a utopia where material needs are fulfilled, then game playing is left as the ultimate form of good.

Gamification: The use (not extension) of design (not technology or practices) elements (not whole) characteristic of games (not play) in non-game contexts.

Jane McGonigal: The game that can give you 10 extra years of life

Examine the connections between the pleasure model and the challenges that Jane asked her audience to play.

Study of gamification is not new: this subject used to be called funology or serious gaming.

We'll return to this notion in crowdsourcing at the very end of this course.

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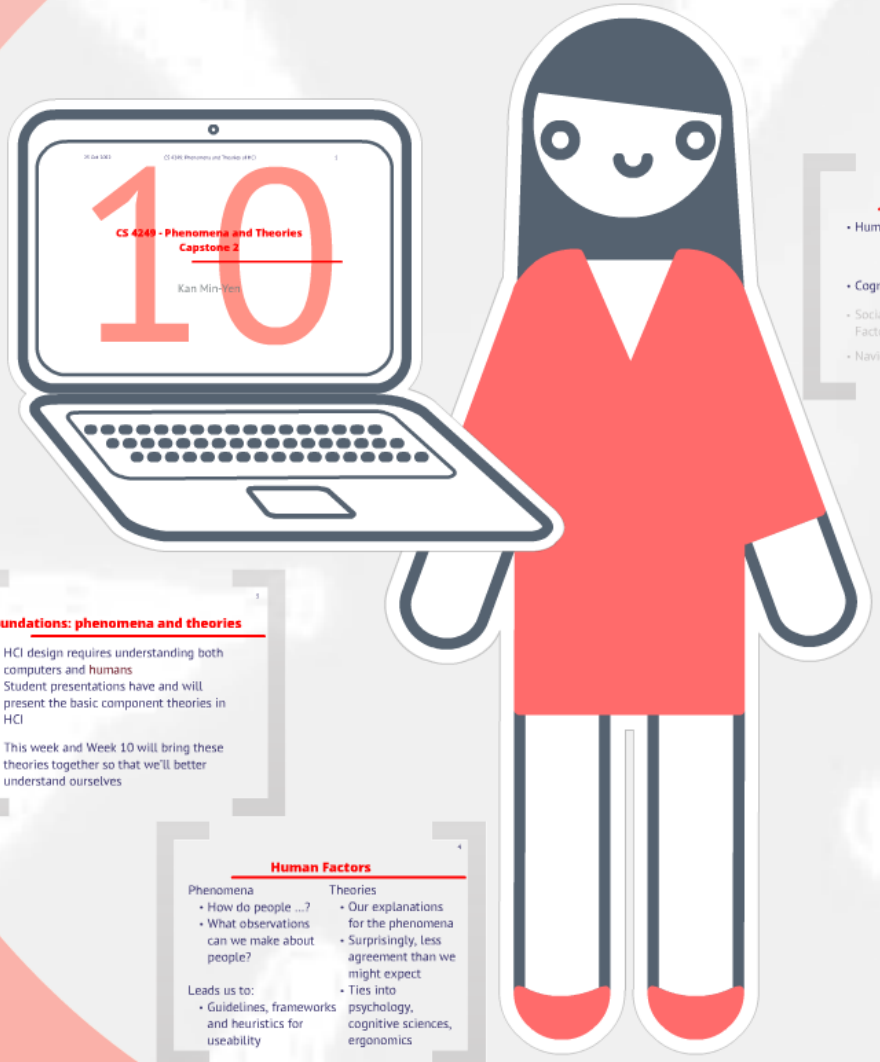

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