Human-Computer Interaction

COMS30029

aka **#HCI_Theory**

Oussama Metatla and Dan Bennett

Week 2: First Wave

Chunk 1: Introduction

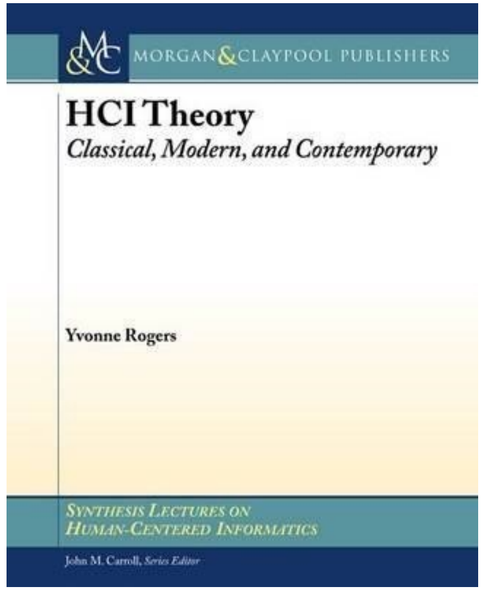
Week 2: First Wave

Chunk 1: Introduction

How did people think in the early days of HCI?

Reading

Chapter 4:



Rogers, Y. (2012). HCI theory: classical, modern, and contemporary. *Synthesis lectures on human-centered informatics*, *5*(2), 1-129.

PLUS: Choose at least one of…

A more in-depth look at Fitts' Law

A nice interactive explanation of Fitts' Law and why it matters

https://timmarco.com/fitts/

Meta theory: discussion of theory use in design

Beck & Stolterman: *Examining Practical, Everyday Theory Use in Design Research (2016) – in the reading folder*

Seminal account of why HCI should move past purely "hard" science perspectives (tougher read)

Carroll & Campbell: *Softening Up Hard Science: reply to Newell and Card (1986) – in the reading folder*

First wave of HCI

- 1980s-1990s
- HCI as an **applied science**, grounded in **lab research**
- An **information processing** perspective, from cognitive psychology
- **Still influential today** (though often using more advanced models)

Broad theoretical approaches in the first era

Paradigm: Scientific, grounded in lab based cognitive psychology. Computational, centralized, symbol processing view

Goal: How do *individuals* make use of computational technologies, and
how can technologies be designed to be more usable, and useful.

Main Approaches to Theory:

1. Using Isolated Ideas from basic science disciplines

2. Applying theories from basic science disciplines

3. Developing new HCI-specific theory, grounded in lab science disciplines

1. Using Isolated Ideas from basic science research

THE MAGICAL NUMBER SEVEN, PLUS-OR-MINUS TWO
or
SOME LIMITS ON OUR CAPACITY FOR PROCESSING INFORMATION

George A. Miller

My problem, ladies and gentlemen, is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data and has assaulted me from the pages of our most public journals. This number assumes a variety of disguises, being sometimes a little larger

- 5-9 top level menu items?
- 5-9 function types?
- 5-9 colours on screen?

- **Easy to remember**
- **Lacks detail and discrimination**
- **Not clear how to develop further**

1. Using Isolated Ideas from basic science disciplines

2. Applying theories from basic science disciplines

Paired associate theory used understand how to select command names:

Command names should be **familiar** and have some **natural link** with the invoked process

The approach is specific and allows us to refine our approach by reference to the theory

2. Applying theories from basic science disciplines

Paired associate theory

Command names should be **familiar** and have some **natural link** with the invoked process

Many experiments later

Various factors may affect memorability of command names in different contexts

Neat, generalisable rule for design


The Effect of Humour and Mood on Memory Recall ☆

Tunku Saraa-Zawyah Tunku Badli, Mariam Adawiah Dzulkifli

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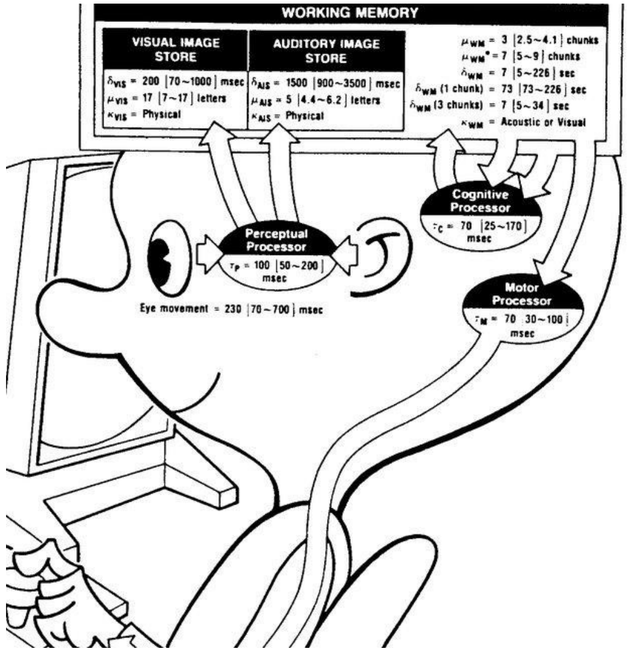
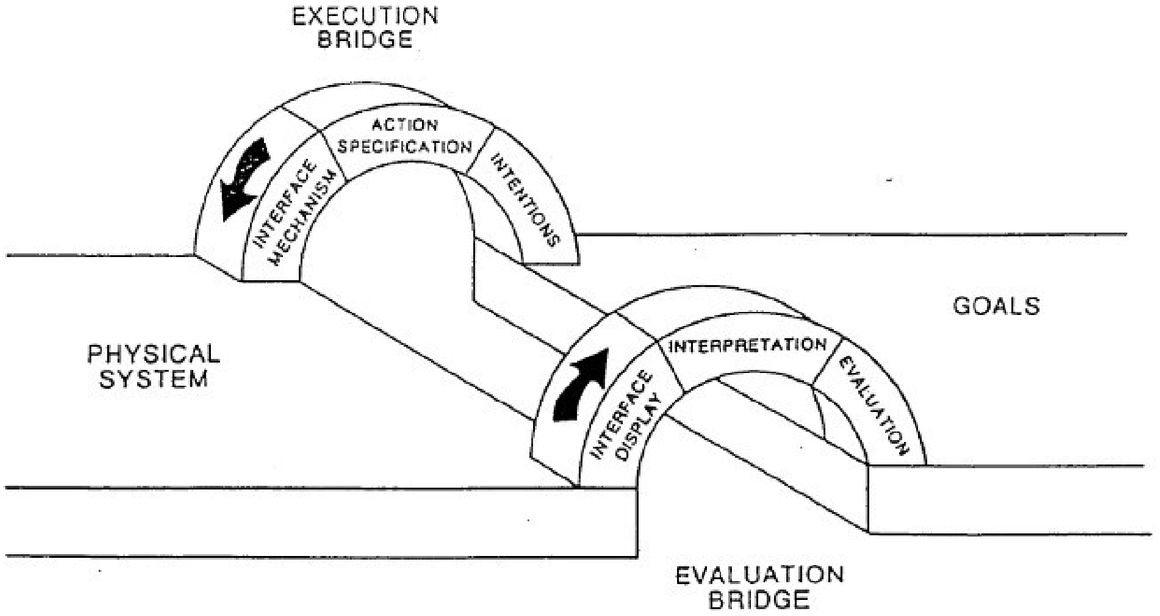
Complex, specific data which is hard to apply

3. Developing new HCI-specific theory, grounded in lab science disciplines

Cognitive modelling of interaction scenarios



GOMS



Gulfs of Execution and Evaluation

Week 2: First Wave

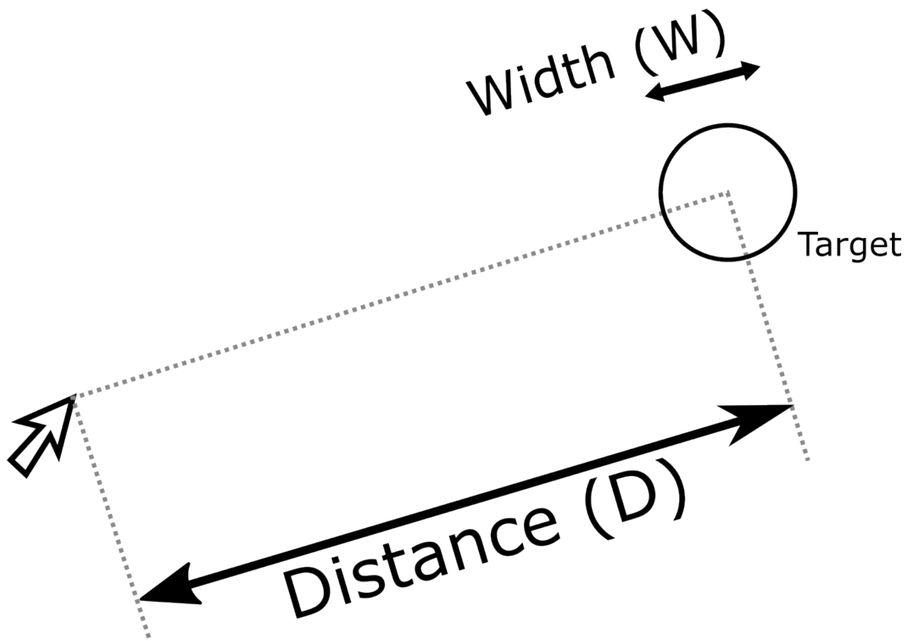
Chunk 2: GOMS and Fitts' Law

Mathematical models of user behaviour

GOMS and Fitts' Law

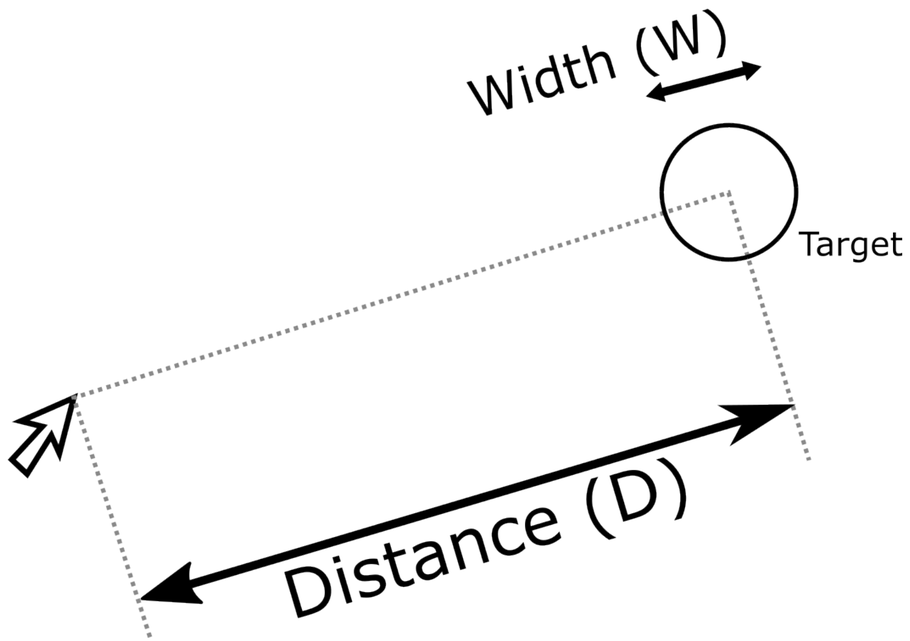
- **Fitt's Law:** predicting performance on mouse tasks
- **GOMS**: predicting performance on a range of input tasks (**G**oals, **O**perators, **M**ethods and **S**election rules)
- Both grounded in **cognitive psychology**
- Both **expanded and developed in HCI**
- **Narrow, and precise**, and focused on particular phenomena

Fitts’ Law:



- Originally developed to understand pointing with a finger
- HCI adopted and extended to understand mouse, touchscreen use, and other examples of cursor control
- Posits a speed-accuracy trade-off in movement towards a target, and quantifies this

Fitts' Law:

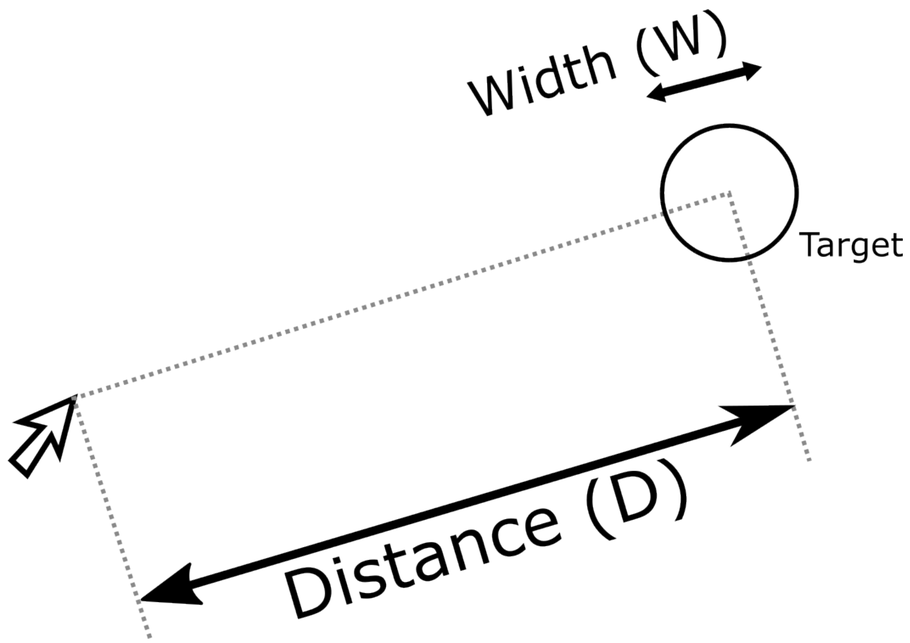


time Index of difficulty

$$T = a + b \log_2(2D / W)$$

"delay" "acceleration"

Fitts' Law:



time Index of difficulty

$$T = a + b \log_2(2D / W)$$

"delay" "acceleration"

Three ways to use Fitt's Law

1. High Level **qualitative-quantitative** engagement

2. **Mathematical** Engagement with the model

3. Further **Theory Building**

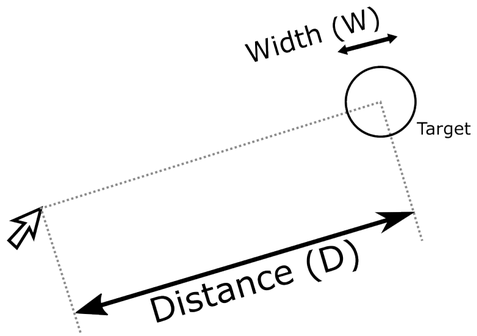
Fitts' Law:

1. High Level **qualitative-quantitative** engagement

Further = harder / slower

So:

- Minimise length of mouse moves
- Control the user's mouse-path



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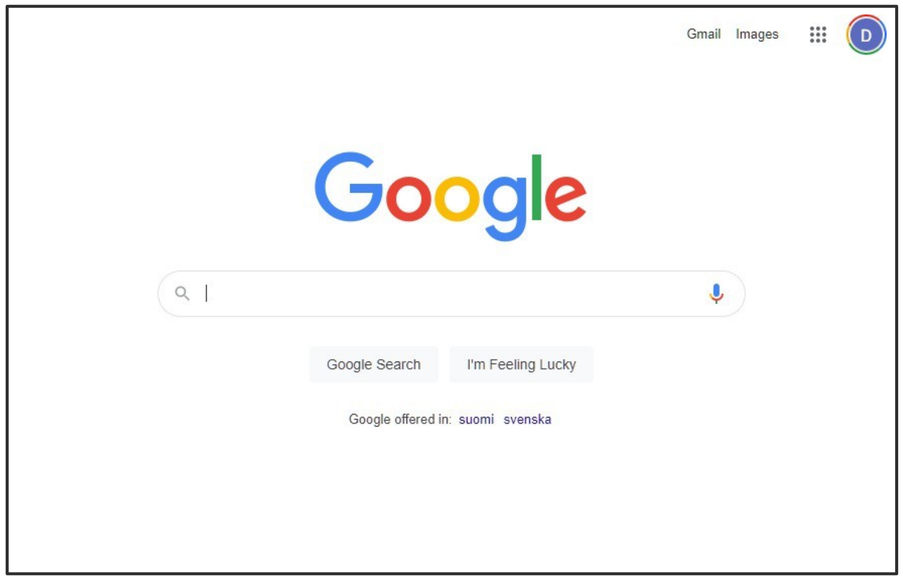


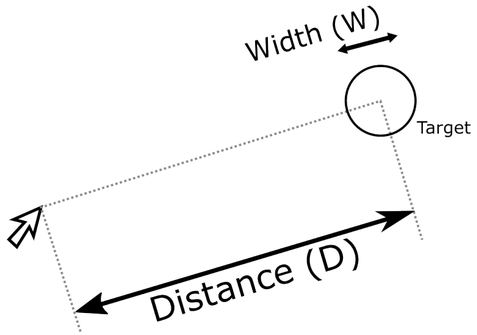
Fitts’ Law:

1. High Level **qualitative-quantitative** engagement

Further = harder / slower

So:

- Minimise length of mouse moves
- Control the user’s mouse-path
- Spawn controls close to mouse position



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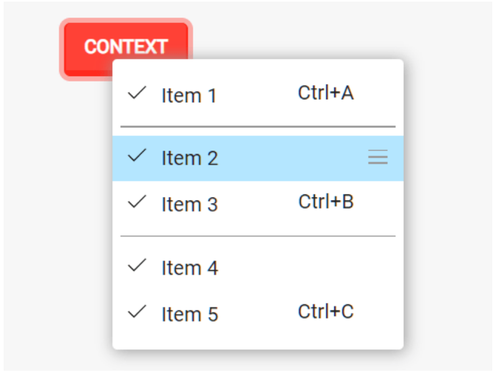
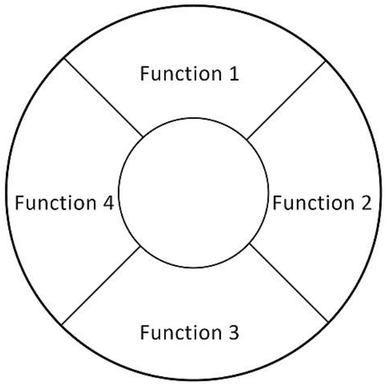




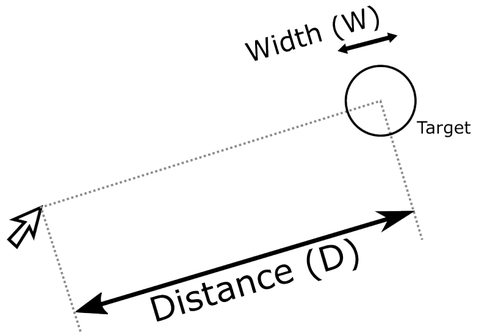
Fitts’ Law:

1. High Level **qualitative-quantitative** engagement

bigger = easier

So:

- Make UI elements bigger when time pressure, or risk of error are high



IMPORTANT BUTTON

time Index of difficulty

$$T = a + b \log_2(2D / W)$$

“delay” “acceleration”

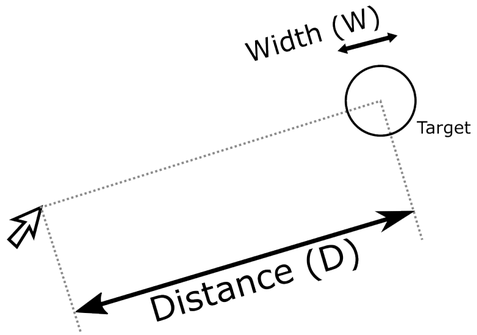
Fitts' Law:

1. High Level **qualitative-quantitative** engagement

Alerting the designer to high error rates

- Minimise cost of error

Edges and Corners Are Special: infinite width



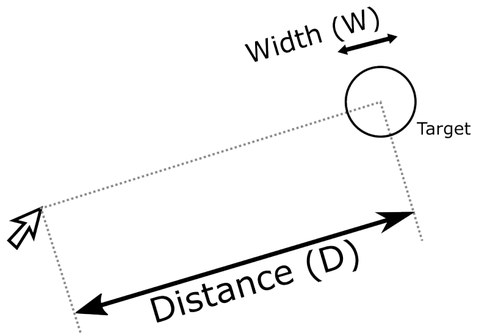
time Index of difficulty

$$T = a + b \log_2(2D / W)$$

"delay" "acceleration"

Fitts' Law:

2. Mathematical Engagement



time Index of difficulty

$$T = a + b \log_2(2D / W)$$

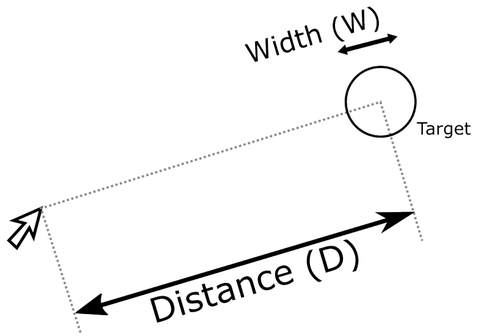
"delay" "acceleration"

- Build tools to analyse layouts and guide design
- Analyse use of nested vs flat menus
- Calculate times for paths through website
- Create adaptive interfaces?

Fitts' Law:

3. Further Theory Building

- Does mouse-path efficiency nudge behaviour?
  - Easier: encourage purchases?



time Index of difficulty

$$T = a + b \log_2(2D / W)$$

"delay" "acceleration"

A GREAT PRODUCT

BUY

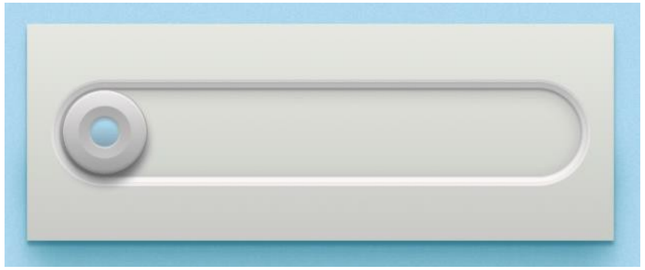
A GREAT PRODUCT

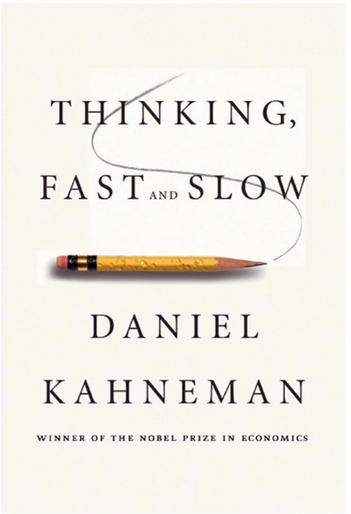
BUY

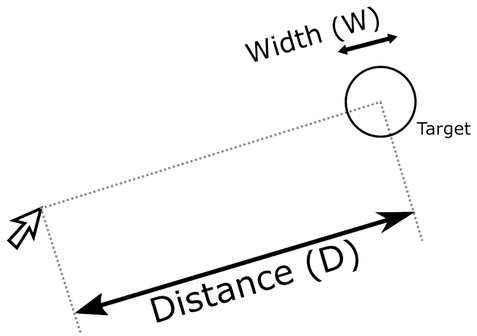
Fitts' Law:

3. Further Theory Building

- Does mouse-path efficiency nudge behaviour?
  - Easier: encourage purchases?
  - Harder: increase thoughtfulness?







- Extensions: 3d pointing in VR?

time Index of difficulty

$$T = a + b \log_2(2D / W)$$

"delay" "acceleration"

READING:

READING OPTION 1:

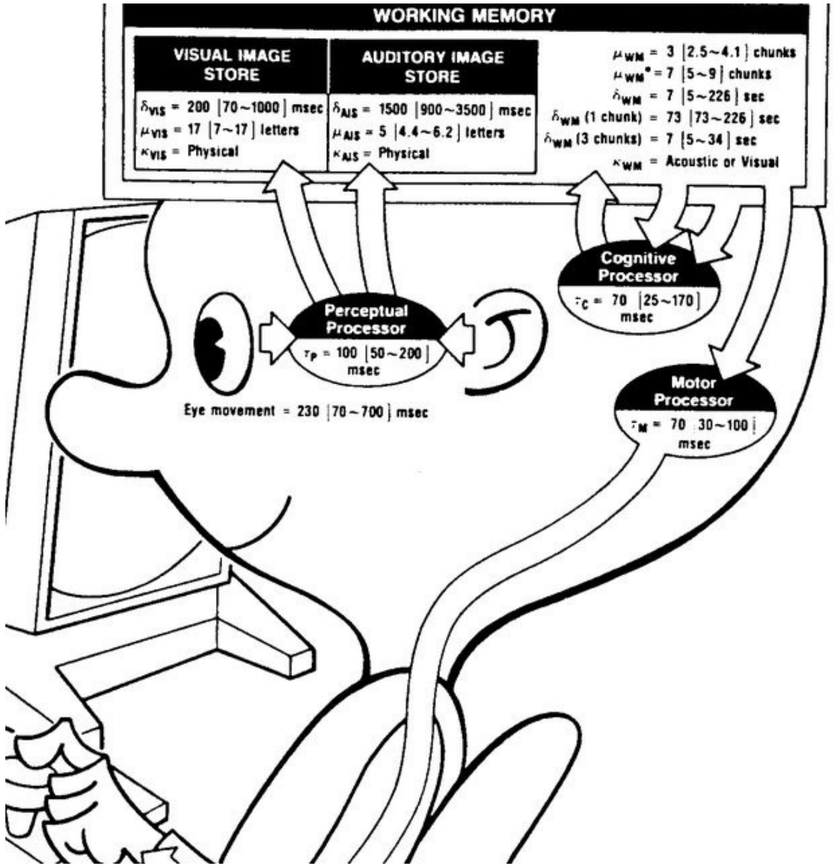
A Deep Dive Into Fitts' Law

https://timmarco.com/fitts/

NEXT:

GOMS: **G**oals **O**perators **M**ethods and **S**election rules

GOMS: Goals Operators Methods and Selection

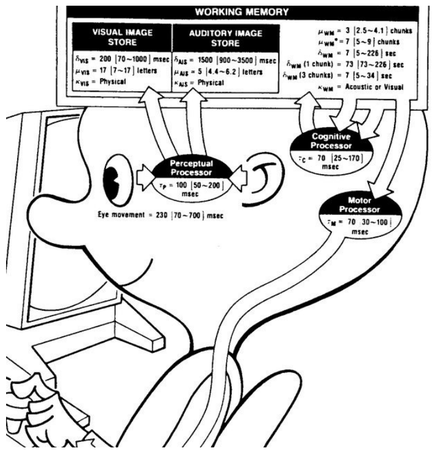


- Analyse times for input tasks for a **skilled user**
- Again, grounded in information processing models from cognitive psychology
- Aims to be easy for designers to apply

GOMS: Goals Operators Methods and Selection

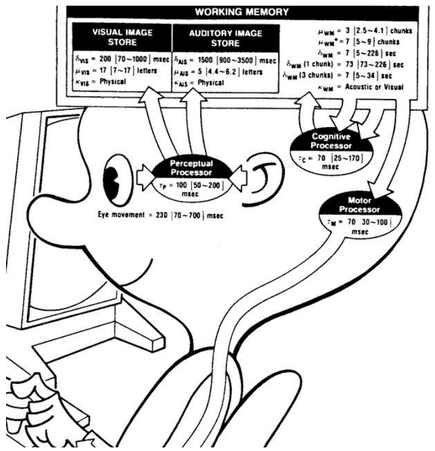
- Decomposes tasks into on atomic actions (operators) and assigns times

- Various versions of varying complexity
- Simple: KLM-GOMS
- Complex: CPM-GOMS



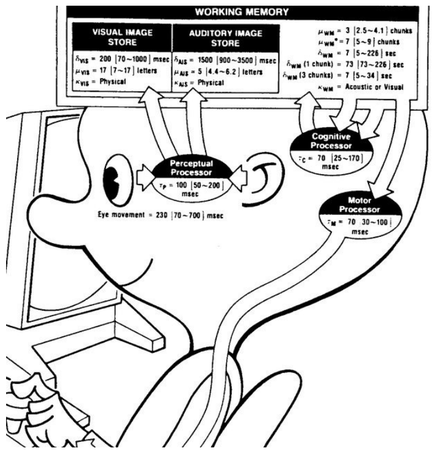
GOMS: Goals Operators Methods and Selection

- **GOALS**: what the user wants to do
- **OPERATORS**: individual actions
- **METHODS**: how to combine actions to achieve the goal
- **SELECTION RULES**: how to choose between potential METHODS of the task



GOMS: Goals Operators Methods and Selection

Applying GOMS



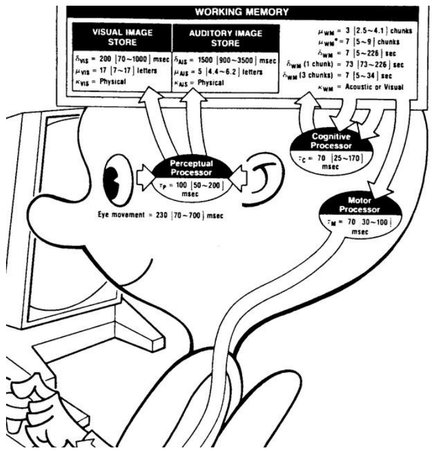
KLM OPERATORS:

- K - press a key
- P - point to location on screen with mouse
- H - move hands to home position on the keyboard
- M - mentally preparing to perform an action
- R - system response while the user waits for the system.

GOMS: Goals Operators Methods and Selection

GOMS Limitations?

- No Fatigue
- No Learning (expert users)
- No Errors (expert users)
- All tasks are goal-directed
- Goal is clear at start of the task (no problem solving)



Week 2: First Wave

Chunk 3: Heuristic models, and disagreements with the first wave

More general approaches in the First Wave, and why HCI started to investigate other approaches

GOMS and Fitts' Law

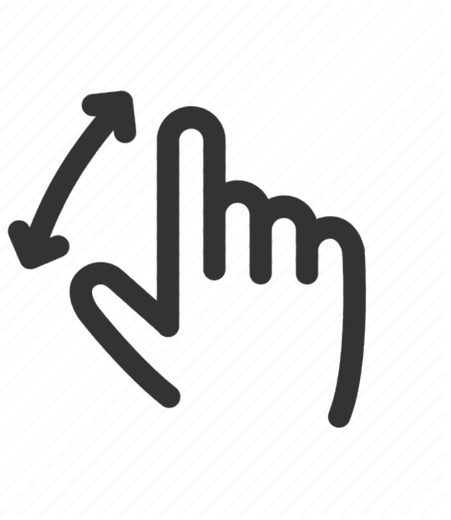
- Grounded in **cognitive psychology**
- **Narrow, precise**, and **predictive**

Next: More General, or Heuristic Models

- Grounded in **cognitive psychology**
- **Broader, generalising, prescriptive**

Reading Option 3: Carroll & Campbell: *Softening Up Hard Science (1986)*

a foundational GUI theory



a foundational GUI theory

The Effect of Humour and Mood on Memory Recall ☆

Tunku Saraa-Zawyah Tunku Badli, Mariam Adawiah Dzulkifli

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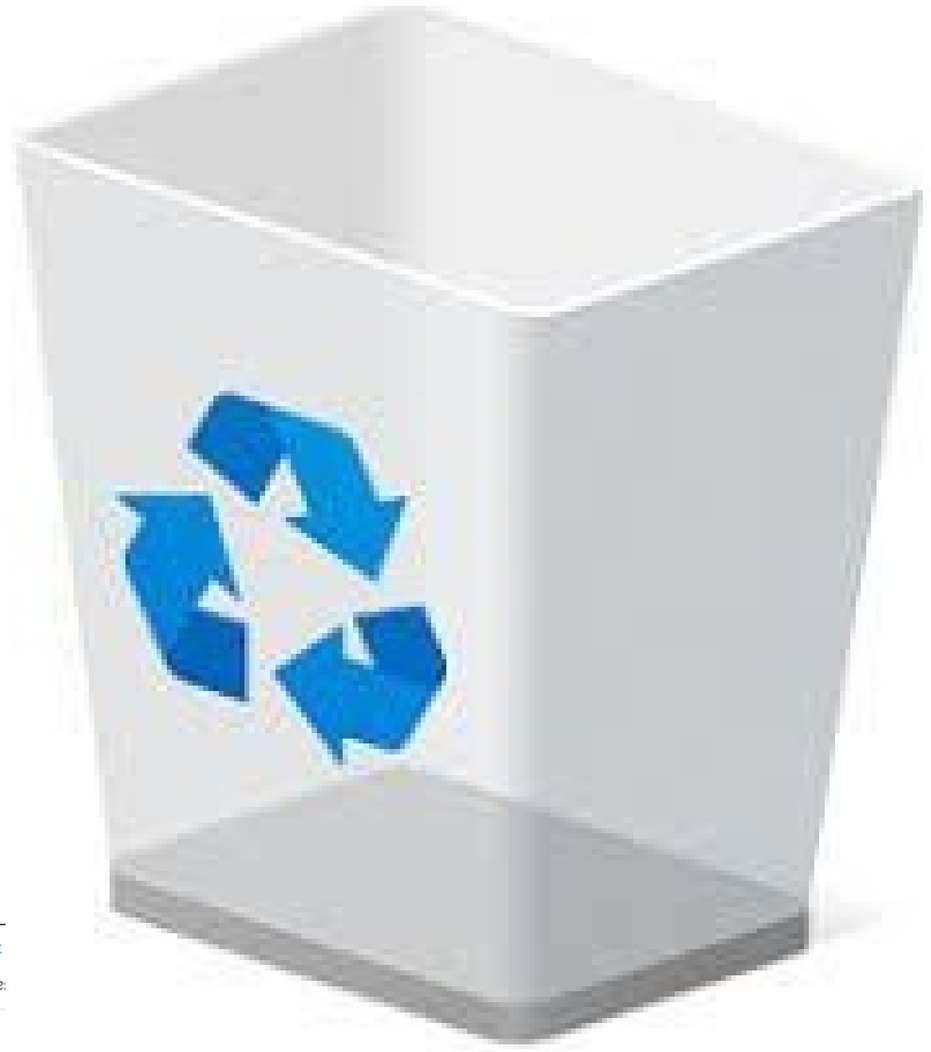
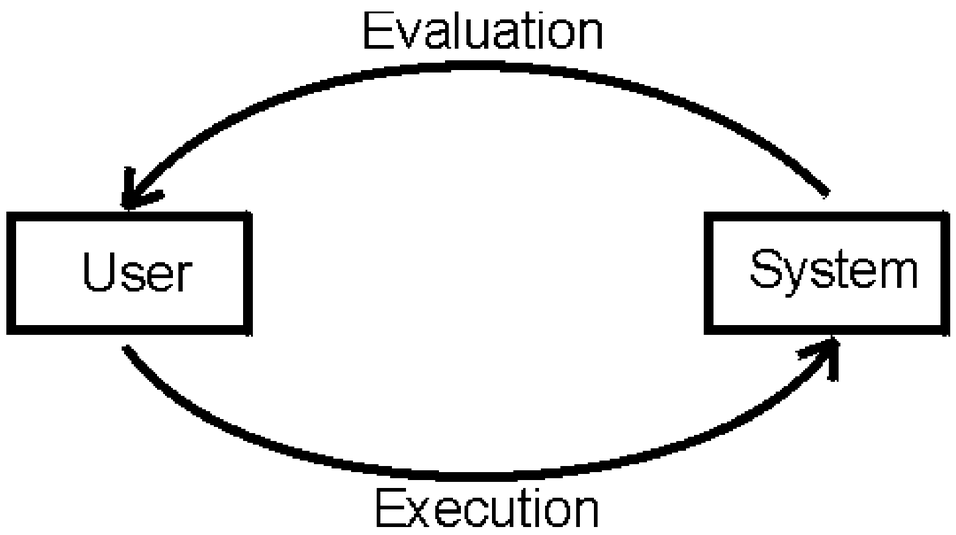
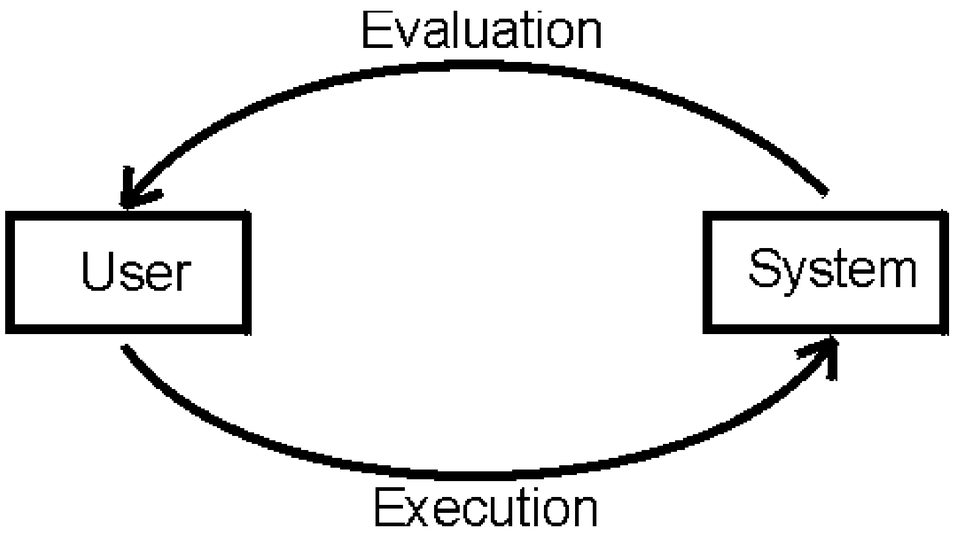


a foundational GUI theory

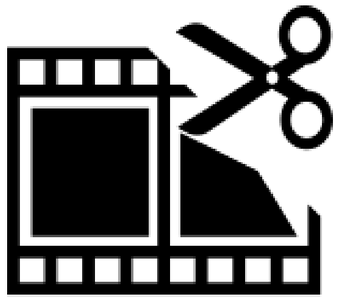


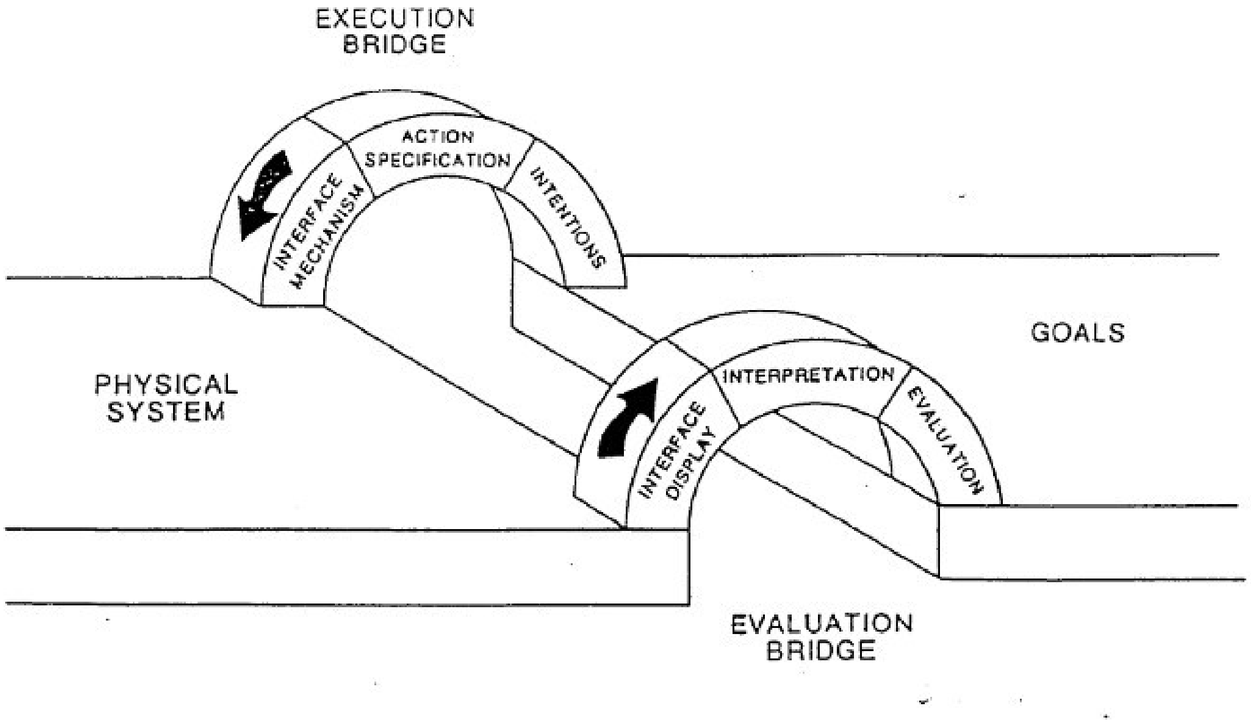
interaction problems and how to solve them



interaction problems and how to solve them

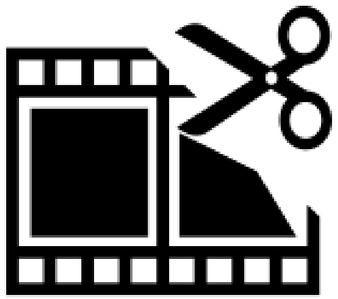
System
Capabilities

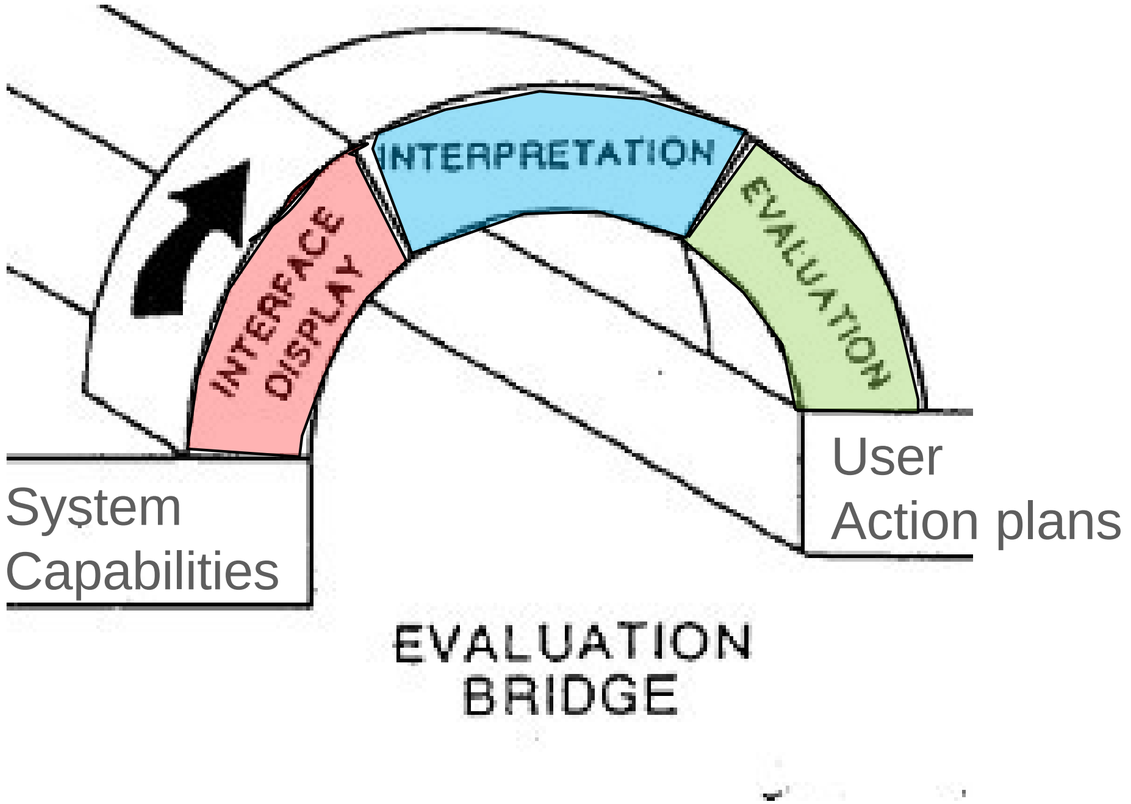




User
Action plans
(Adnan)

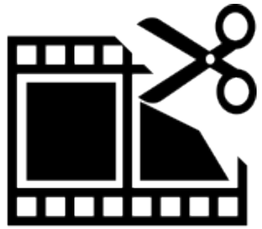
interaction problems and how to solve them

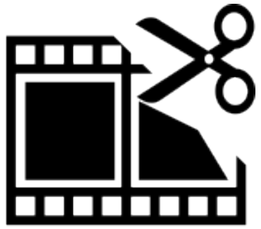




interaction problems and how to solve them

Editing a video: Gulf of Evaluation





Hyper VideoEdit 2097 is only £134 a month!

Evaluated System State

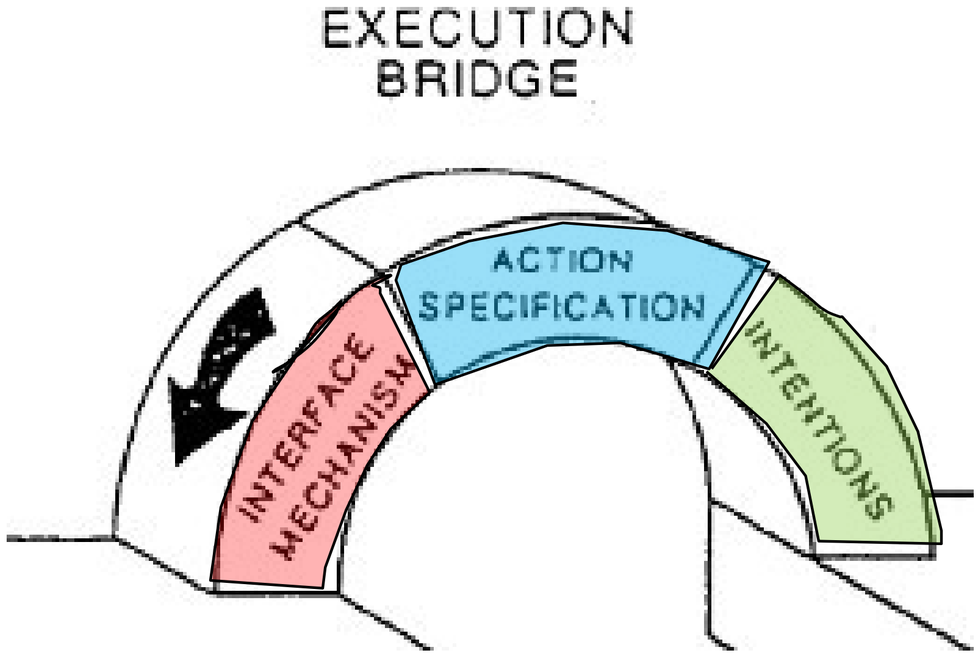
System has a video editor

Actual System State

Vendor wants to sell you a video editor

interaction problems and how to solve them

System
Capabilities



User
Action plans

interaction problems and how to solve them

Editing a video: Gulf of Execution

Expected Action Plan

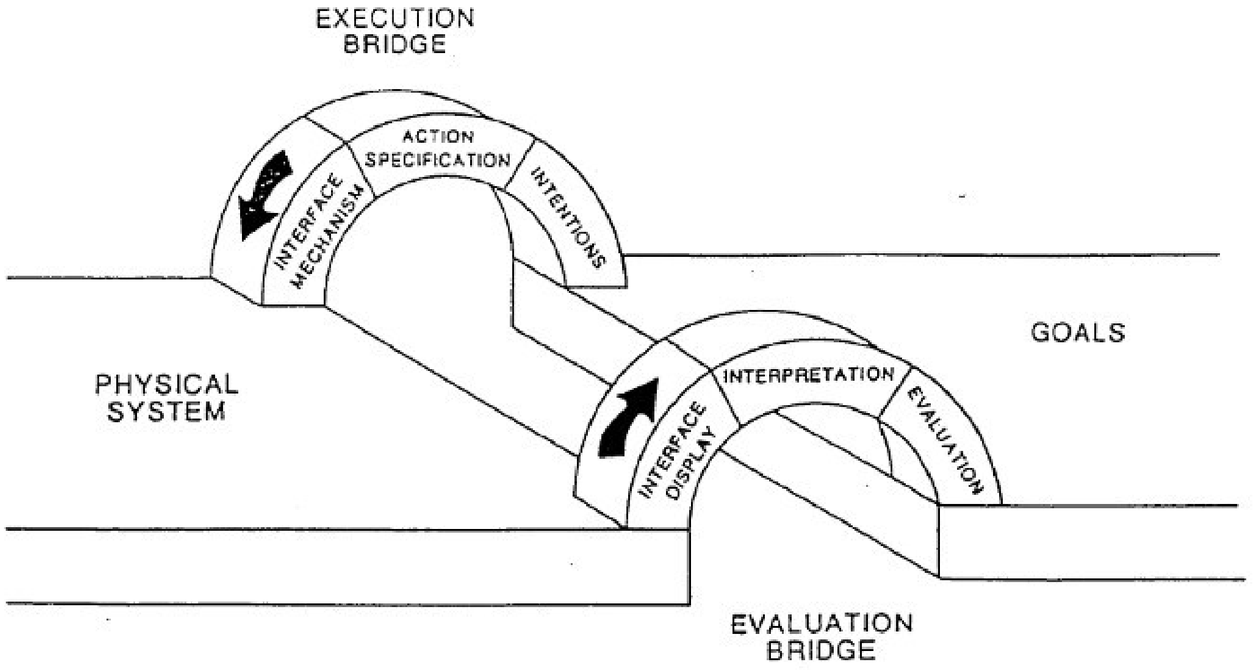
1. Run video editing app
2. load the video sections
3. Select each section of video I want, and put it onto a timeline

Required Action Plan

1. Install and pay for a video editing app
2. Install a video conversion program
3. Set the correct parameters for the conversion, looking them up on the internet
4. Run the video editing app
5. load the video sections into my app
6. Select each section of video I want, and put it onto a timeline

interaction problems and how to solve them

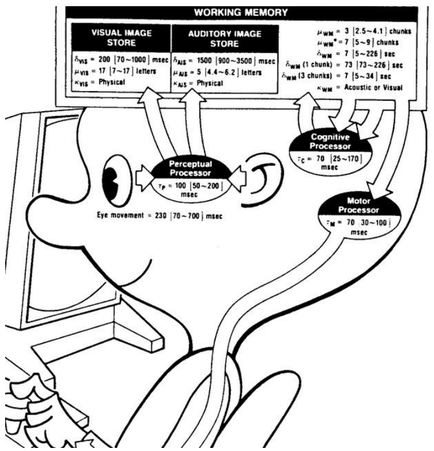
System
Capabilities



User
Action plans

Gulf of Execution:

Wrong **method** for the task, mismatch in steps (**operators)**



GOMS

- **GOALS**: what the user wants to do
- **OPERATORS**: individual actions
- **METHODS**: how to combine actions to achieve the goal
- **SELECTION RULES**: how to choose between potential MODELS of the task

Information processing theories in the First Wave:

- **ALL IN THE BRAIN:** all the important stuff is happening via symbol processing in the brain. The body is controlled by the brain without adding too much.

- **ATEMPORAL**: history and order considered minimally relevant, other temporal factors, synchronisation etc. are not considered

- **ACONTEXTUAL**: context is not modelled

- **COMPOSABLE**: Cognitive processes can be broken apart and sections modelled independently without too much loss of accuracy

- **SIGNAL + NOISE**: variability in the process can be treated as noise

- **ALL IN THE BRAIN:** all the important stuff is happening via symbol processing in the brain. The body is controlled by the brain without adding too much.

- **ATEMPORAL**: history and order considered minimally rele
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- **ACONTEXTUAL**: context is not mo

- **COMPOSABLE**: C ocesses can be broken apart and sections model
dently without too much loss of accuracy

- **SIGNAL + NOISE**: variability in the process can be treated as noise, distributed in a roughly Gaussian manner

Does any of this matter much to HCI?

What is the practical effect of these differences in theory? How to choose?

- **Better fit for phenomenon?** Does another theory give a better, more parsimonious account of the interaction we're observing? Does it explain it better?

- **Supports Collaboration?** helps us understand and be understood by colleagues in another discipline, or another team?

- **Easy to convert into design?** designers can understand and apply the theory to their own practice

- **Computable, formal?** Can we formalise the theory in a model or code, make quantitative predictions, can we use it to build adaptive computer systems?

- **Other properties? …**

Where after the First Wave?

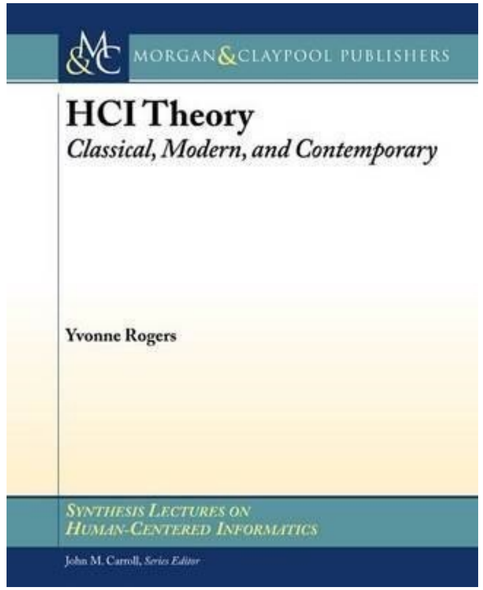
- Capturing real world behaviour?
- Accounts for interaction in real spaces?
- Accounts for social and cultural contexts, and constraints?
- Accessible to observation?

Next week…

Week 3: The Second Wave part 1: From cognition to the experiences of bodies

Reading

Chapter 4:



Rogers, Y. (2012). HCI theory: classical, modern, and contemporary. *Synthesis lectures on human-centered informatics*, *5*(2), 1-129.

PLUS: Choose at least one of…

A more in-depth look at Fitts' Law

A nice interactive explanation of Fitts' Law and why it matters

https://timmarco.com/fitts/

Meta theory: discussion of theory use in design

Beck & Stolterman: *Examining Practical, Everyday Theory Use in Design Research (2016) – in the reading folder*

Seminal account of why HCI should move past purely "hard" science perspectives (tougher read)

Carroll & Campbell: *Softening Up Hard Science: reply to Newell and Card (1986) – in the reading folder*

#HCI _Theory