Designing Interactive Systems I

Introduction, Fitts' Law, The CMN Model

Prof. Dr. Jan Borchers
Media Computing Group
RWTH Aachen University

Winter term 20/21

http:s//hci.rwth-aachen.de/dis

Video Conferencing Etiquette

- We would like to have an interactive class
  - Please **turn on your video** so we can see each other
  - Your video will **not** be in the lecture recording
- Please **ask questions** (only your voice will be in the recording)
  - Use Zoom's **'Raise Hand' function** so we don't talk over each other
  - Otherwise, please **Mute** yourself to avoid echos
    (we may do this for you if you forget)
  - In Audio settings, turn on the option to press **Space** to temporarily unmute
- Turn on your **lights** so you don't look like a zombie :)

Who am I?

Studied CS at Karlsruhe (& Imperial)

- Human-Computer Interaction

PhD CS, TU Darmstadt (& Linz, Ulm)

- Interaction with multimedia
- HCI design patterns

Assistant professor at Stanford & ETH Zurich

- Interactive rooms
- UbiComp user interfaces

Full professor at RWTH since Oct. 2003

- Interaction with audio & video
- Wearable & Tangible UIs, Personal Fabrication, IDEs,…

Our Team

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Marcel Lahaye, M. Sc.
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They answer all your questions!

Please use the forum on Moodle to ask about the course's content & organization.
Otherwise, please, add this subject line to your mail: **"[DIS1]"**

Human–Computer Interaction?


Source: https://ux.stackexchange.com/questions/15471/any-actual-reason-for-complicated-uis/15479
Fac
Order#
0
99004234
0
New
99031927
Report Selection
Prin
Vie
Fax
EMai
OCB
SSF View
Dupe Load
View Invent
Routing Sheet
Print Bill
Call Log
CUST
Caller JOE
Quote
0
Phn [redacted]
Unknown Shipper:
Terms
Prepaid
Collect
3rd Party
STD
Cust: Hi Fo Holdings, Ltd.
HIFO
Inv: Hi Fo Holdings, Ltd.
HIFO
PICK-UP
At: Hi Fo Holdings, Ltd.
HIFO
Add: 1125 [redacted] STREET SUITE 1200
CSPC VANCOUVER BC V6Z2K8
Ph: [redacted]
Fax:
Cont:
Est P/U:
Appointment: D: 06-10-02 F: T:
CONSIGNEE
Cons: CANADIAN HARDWARE & H
Add: [redacted] AVENUE SUITE 101
CSPC SCARBOROUGH ON M1B5M4
Ph: [redacted] x
Fax: (41 [redacted] 2
Cont:
VM:
Appointment: D: F: T:
COD $0.00
Fee $0.00
Fee Collect
Driver Collect
Mode
From SC
To SC
Air
ADT
ADT
Tariff CAXR9-00-01
Service 2D D 194
From YVR
To YYZ
Deliver By 06-12-02 17:00
Clock Stop
Miles 0
P/U Miles 0
Del Miles 0
Broker / Customs Agent
Broker:
Value: 0.00
In: USD
Notified:
Verbal Pod
Notify on POD
Hazmat
Find CAX#
CAX#: 100670861
Shpr Ref:
B/L:
PO#:
GBL Num:
Cons Ref:
Billing Ref:
Ref 5:
MasterID: 0
MAWB:
Statement: 0
Hold P/U:
Non-Freight:
Manifest Hold:
Print Hold
Rate
SAVED
Charges: 761.50
Discount: 0%
SubTotal: 761.50
Accessorial: 40.00
DV: 0 0.00
FSC: CAX 2.50% 38.08
Total: 839.58
Balance: 839.58
Addend
Closed
Post
SPEC DISP
CUST NOTE
INV
Units
Type
H Description
Stated
ActWT
Dimensions
ChgWt
Rate
Charges

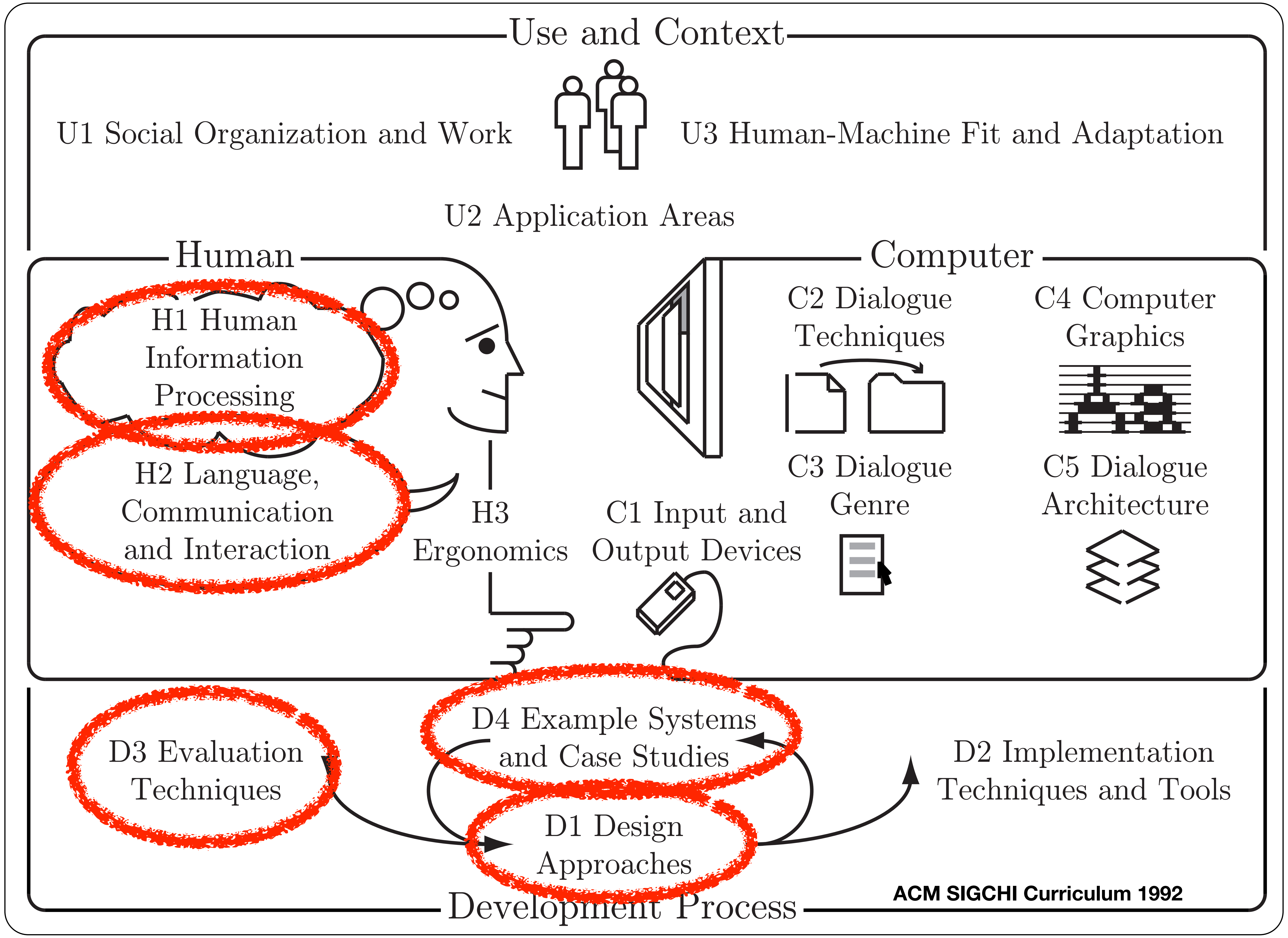
Source: https://www.pexels.com/de-de/foto/mann-hande-laptop-macbook-3777572/

Source: Yovko Lambrev - commons.wikimedia.org

Source: https://www.ktnv.com/news/investigations/shopper-claims-emergency-door-would-not-open-during-ross-store-shooting

Usability Sells!

What is HCI?


Use and Context
U1 Social Organization and Work
U3 Human-Machine Fit and Adaptation
U2 Application Areas
Human
Computer
H1 Human Information Processing
H2 Language, Communication and Interaction
H3 Ergonomics
C1 Input and Output Devices
C2 Dialogue Techniques
C3 Dialogue Genre
C4 Computer Graphics
C5 Dialogue Architecture
D3 Evaluation Techniques
D4 Example Systems and Case Studies
D1 Design Approaches
D2 Implementation Techniques and Tools
Development Process
ACM SIGCHI Curriculum 1992

Class Topics

Human

- Performance
- Models of interaction
  - Affordances
  - Mappings
  - Constraints
  - Types of knowledge
  - Errors
- Design principles

Case Studies

- History of HCI
- Visions
- Phases of Technology

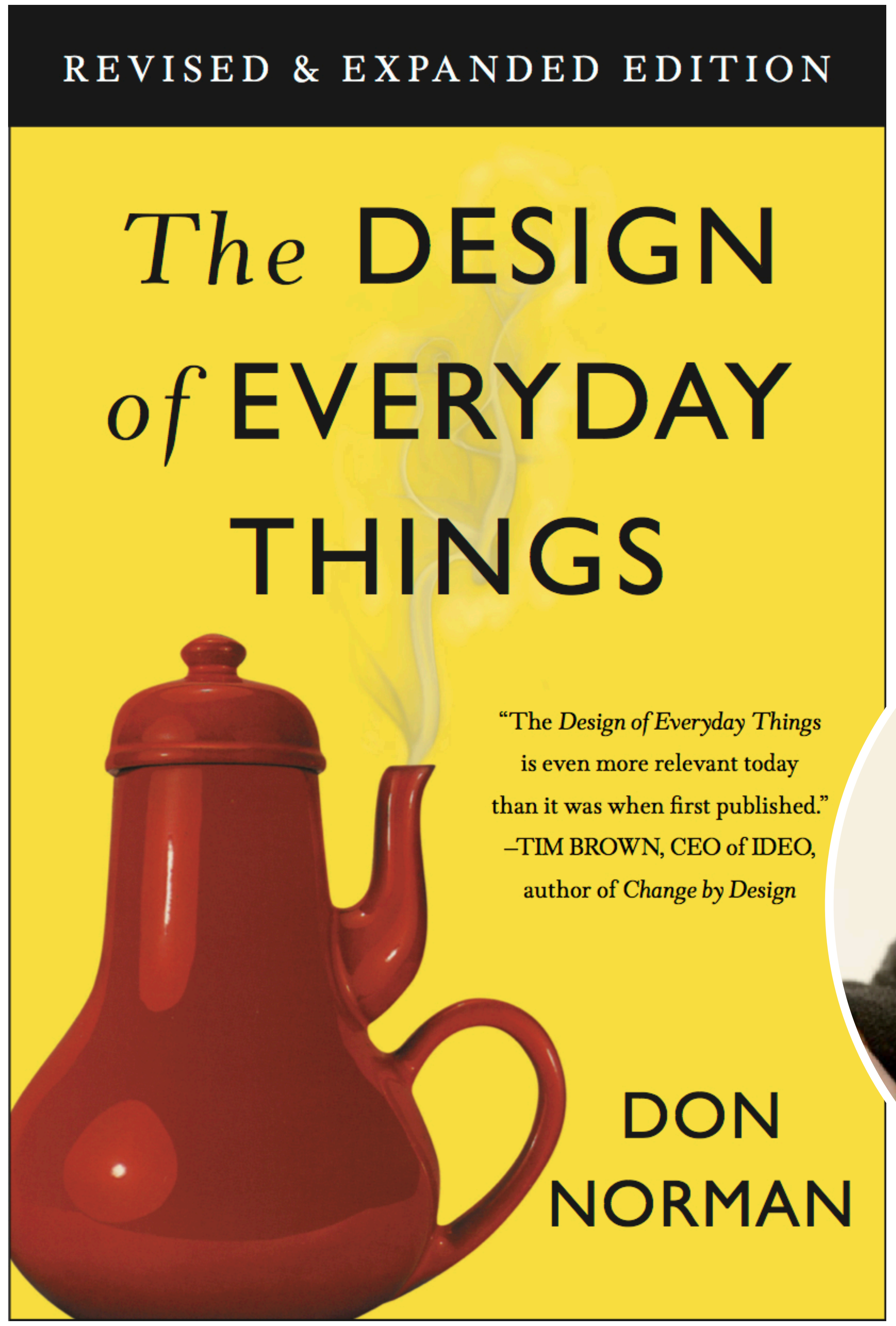
Development Process

- Iterative design
- User observation
- Ideation
- Prototyping
- User studies and evaluation
- Interaction design notation

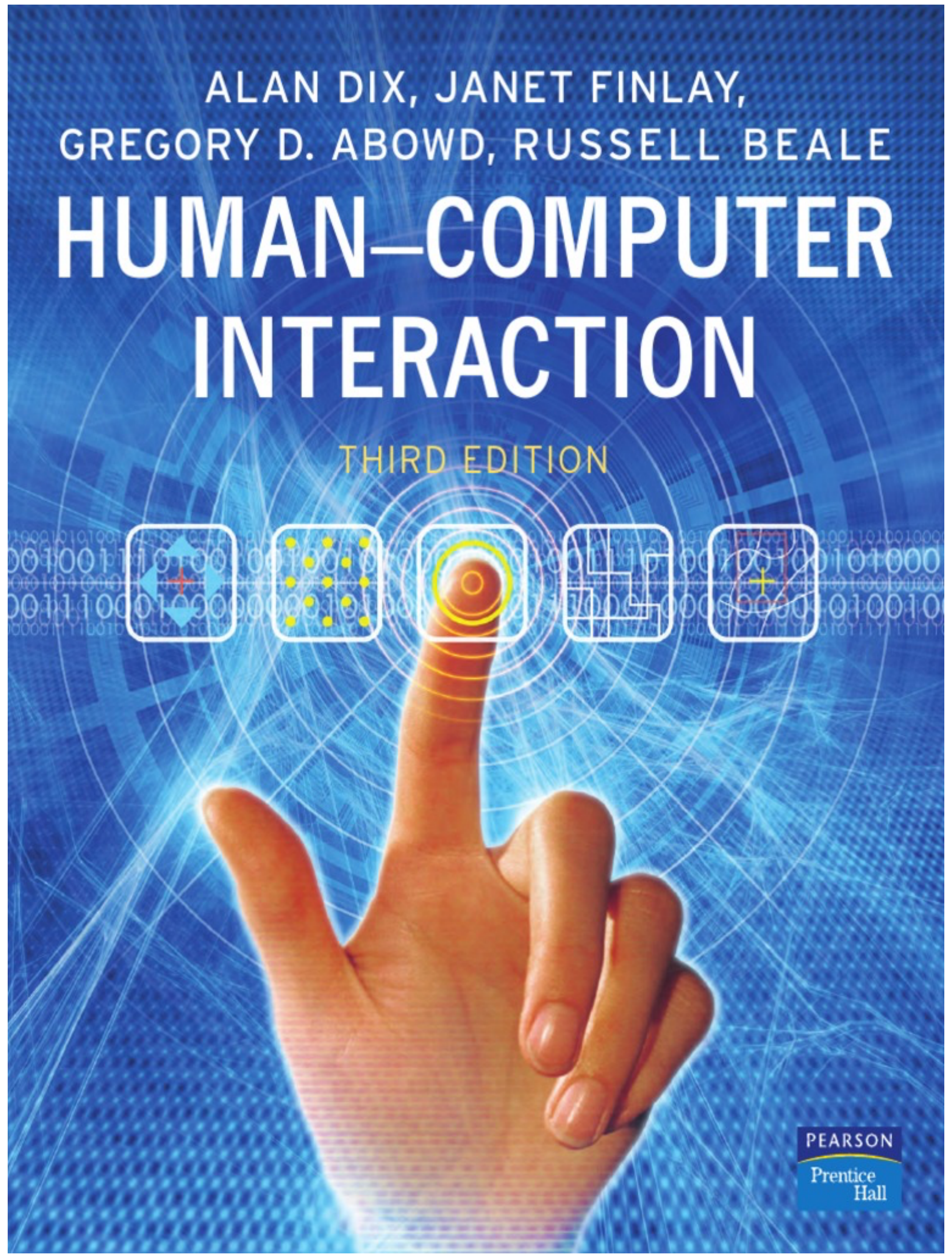
For more detailes, see www.hci.rwth-aachen.de/dis#syllabus.

Textbooks

Required Read



Recommended Read



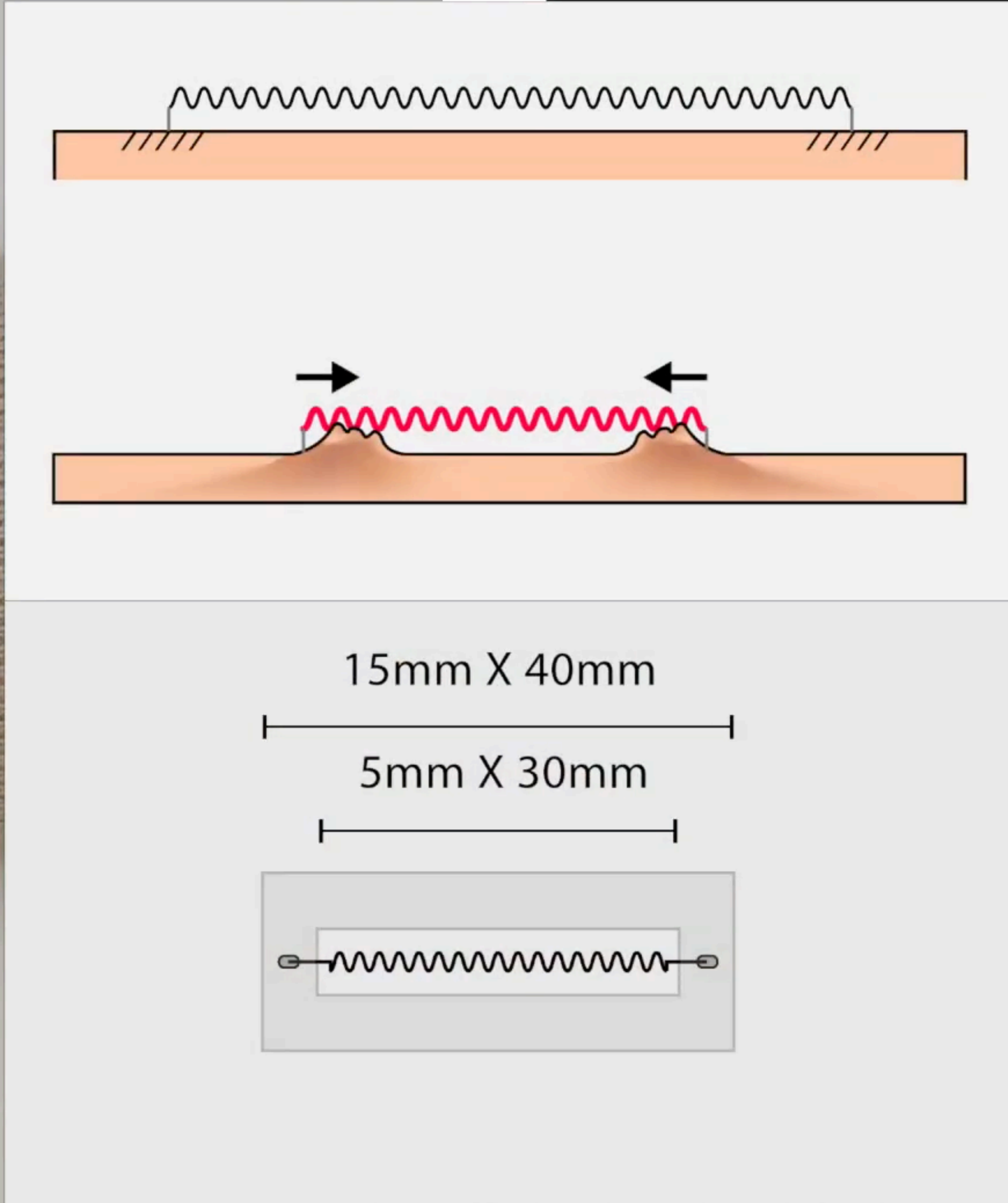
Media Computing Group

Our Classes

When?	Type	Credits (ECTS)	Name
SS, WS	**P**	**7**	**The Media Computing Project**
WS, SS	**S**	**4**	**Post-Desktop User Interfaces**
SS	V/Ü	6	Current Topics in HCI
WS	**V/Ü**	**6**	**iOS Application Development**
SS	V/Ü	6	Designing Interactive Systems II
WS	**V/Ü**	**6**	**Designing Interactive Systems I**
		Only for B.Sc. students	
SS	PS	4	Human-Computer Interaction
SS	SW-Pr	7	M3: Multimodal Media Madness


ARPen
https://hci.rwth-aachen.de/arpen

Springlets



https://hci.rwth-aachen.de/springlets

Student project “Safe” from M3, SS 2019

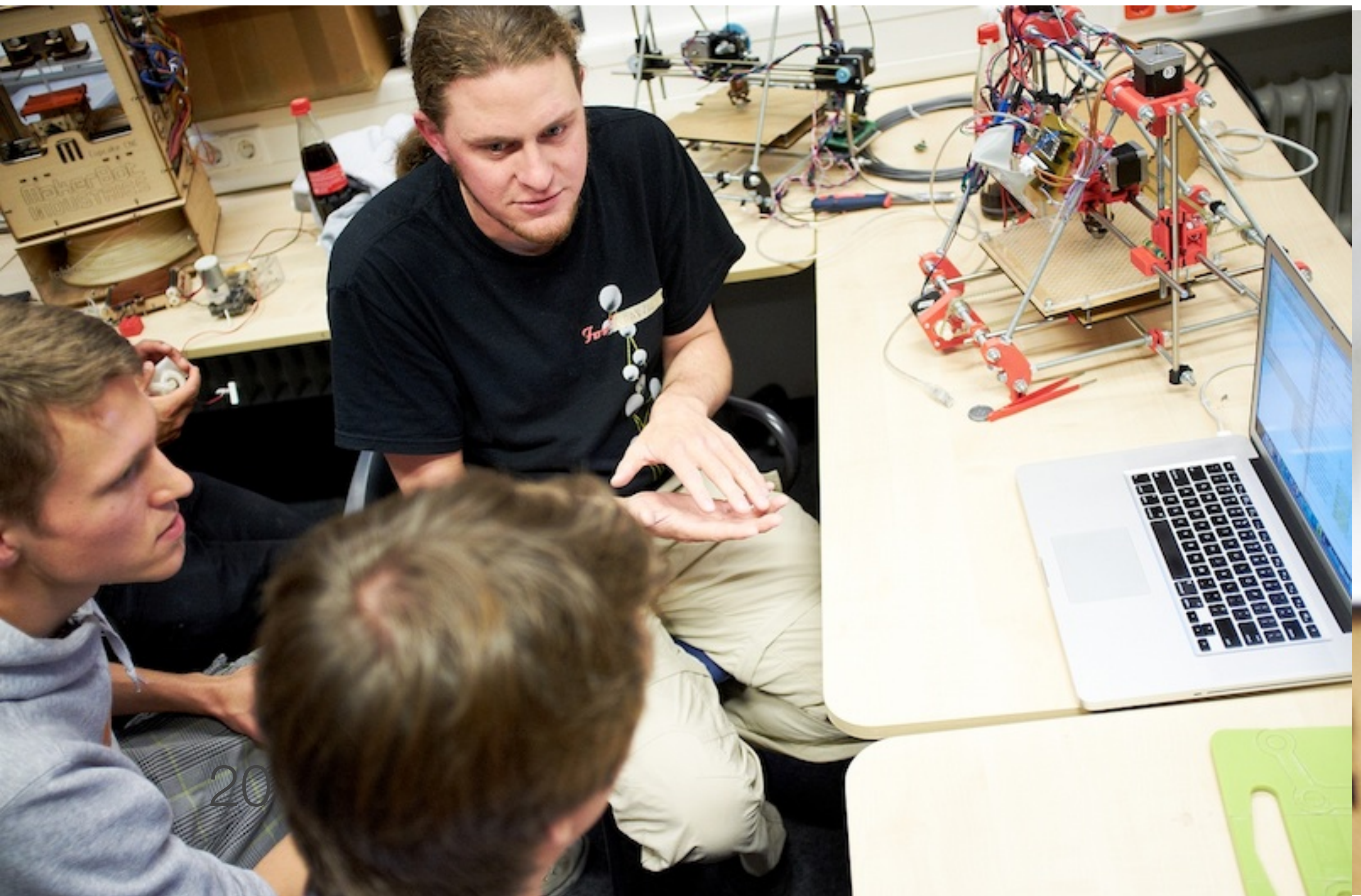
https://hci.rwth-aachen.de/m3

Headbang

https://hci.rwth-aachen.de/headbang

Aachen Maker Meetup

- People doing strange things with electricity in Aachen
- 3rd Wednesday every month (currently suspended due to COVID-19)
- Sign up here: https://www.meetup.com/Aachen-Maker-Meetup/




CocoaHeads Aachen

- CocoaHeads: International meet-ups about Apple’s Cocoa Framework for macOS and iOS
- Last Thursday every month
  Next event: **Oct. 29, 19:00**
- Sign up here: https://www.meetup.com/cocoaheads_ac/

Class Structure

Credits and Grading

- Group-oriented, project-centered
- **6 ECTS Credits**

Normal semester (this holds for now!):

- 20% assignments
- 20% project
- 25% midterm exam
- 35% final exam

Planned (not confirmed yet!):

- 30% assignments
- 20% project
- 50% final exam

- Cumulated grades are calculated from the weighted sum of **grades (not points!)**
- Exam date: **Feb. 13, 11:30-12:30 (preliminary date)**
- To pass the course, you need to pass the final exam (at least 4.0), **and**
  - overall, you need an average grade of at least 4.0
- Further details in the lab starting next **Monday, Nov. 02 at 14:30**

Registering for this Class

- Limited to **120 seats** (already 200+ registrations)
  - Register via RWTHonline **until end of Thursday**
  - We will announce who we have selected on Friday
  - Students for whom DIS 1 is mandatory (e.g., TK students) will be prioritized; others will be selected randomly
- M.Sc. SSE, Erasmus students, and others who cannot register via RWTHonline: Email **the supervisors** your matriculation number and full name from your official @rwth-aachen.de email-address
  - **Email subject: [DIS] Registration <your name>**

Exam Registration

Deadline to register: **Wednesday, Jan. 15, 23:55** (for both final exams)

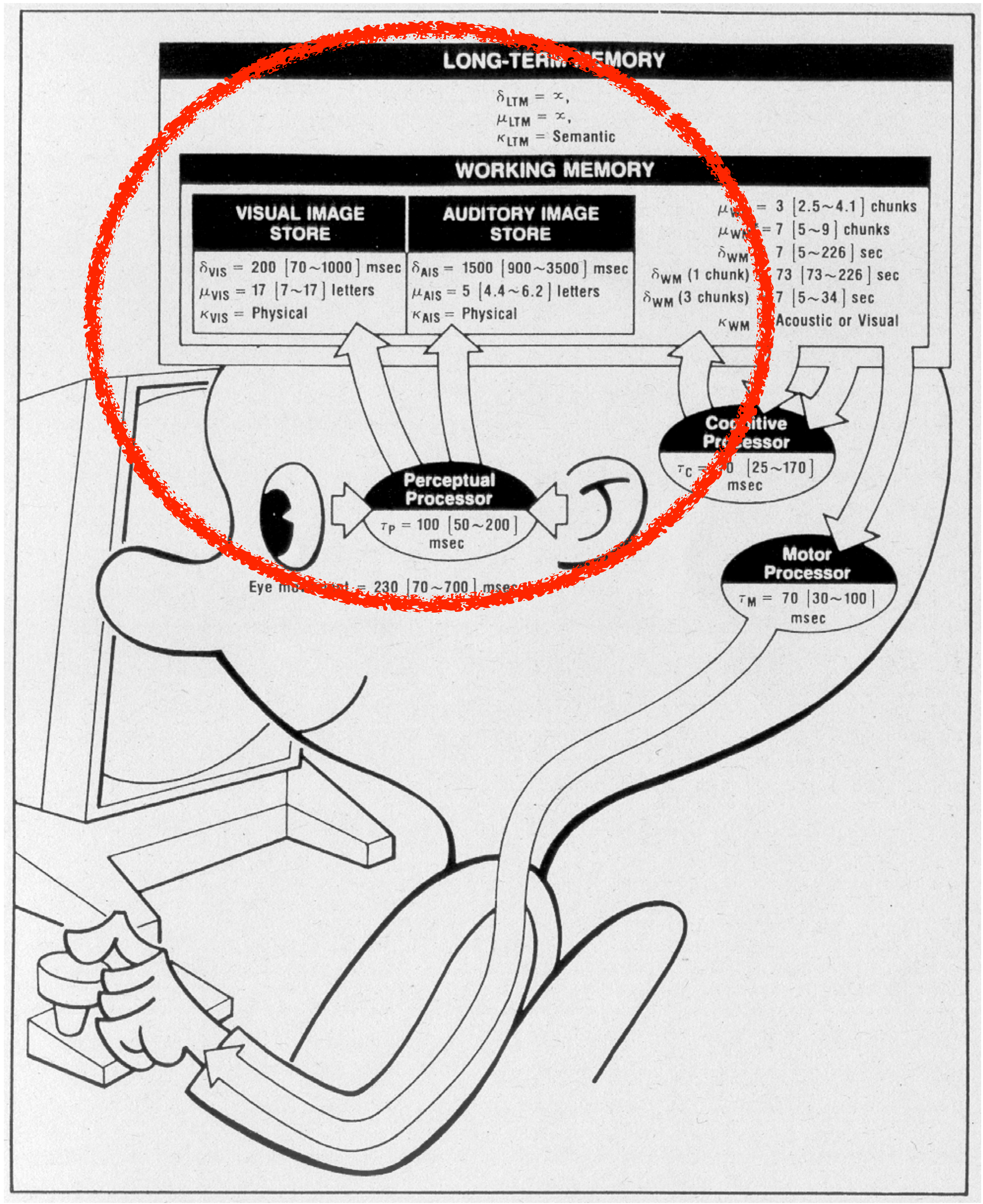
- If you fail the first final exam, there will be a short period to register for the second chance
- B.Sc. students: you won't be registered for the second final exam automatically!
- Do not register just for the second chance final directly (possible, but not recommended)

The Human

Model Human Processor

Model Human Processor

- 3 processors with associated memory
- Slow, middle, fast performers



Experiment 1

- Work in pairs of 2 (we will create breakout rooms)
  - Move near to the camera
  - Open the experiment sheet in a fullscreen window
  - Have your partner observe your eye movements while you're reading the text for "Experiment 1"

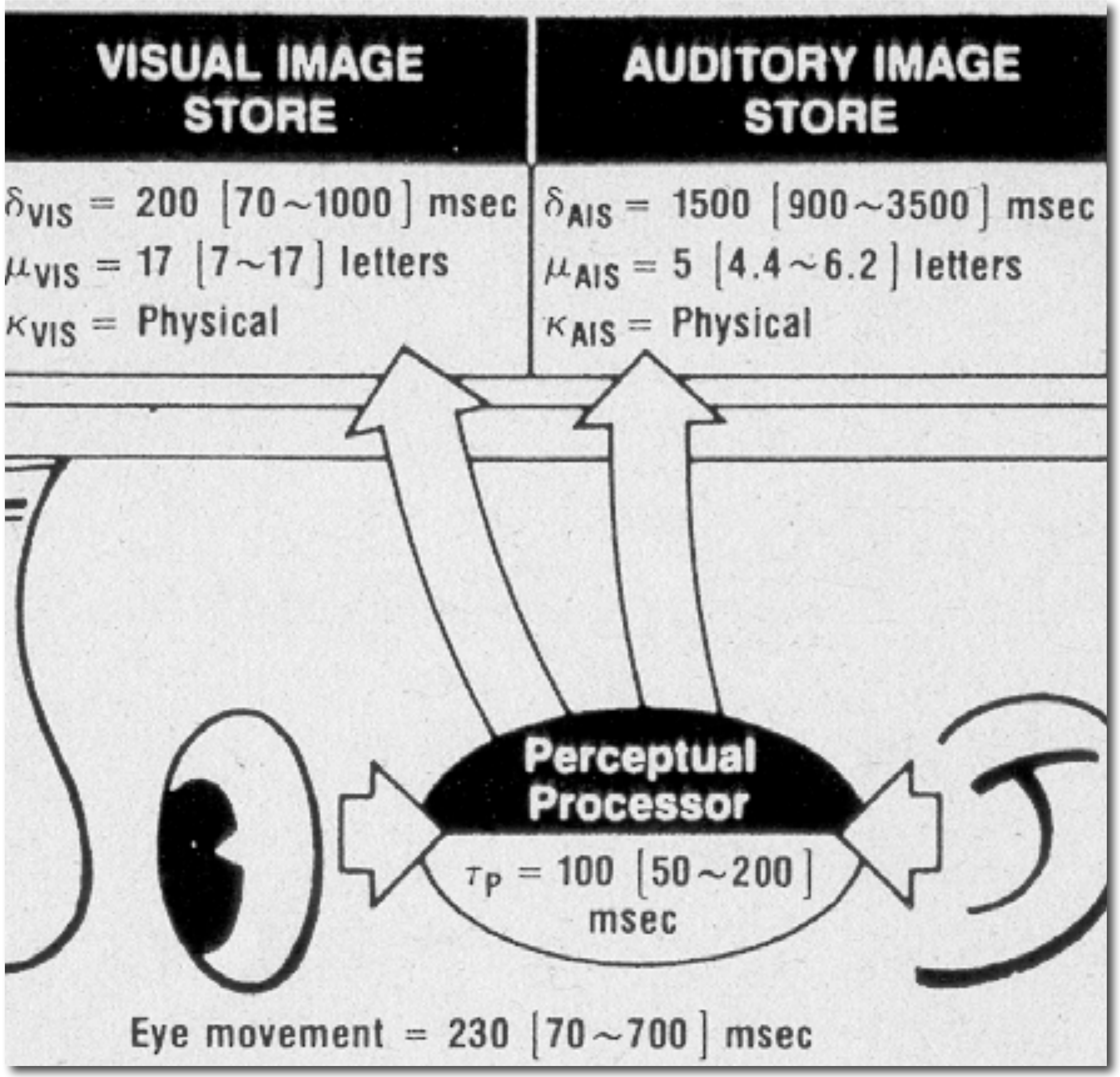
Tobii TX300

http://www.youtube.com/watch?v=VBTZNydUh0w

How do your eyes move when you are reading?

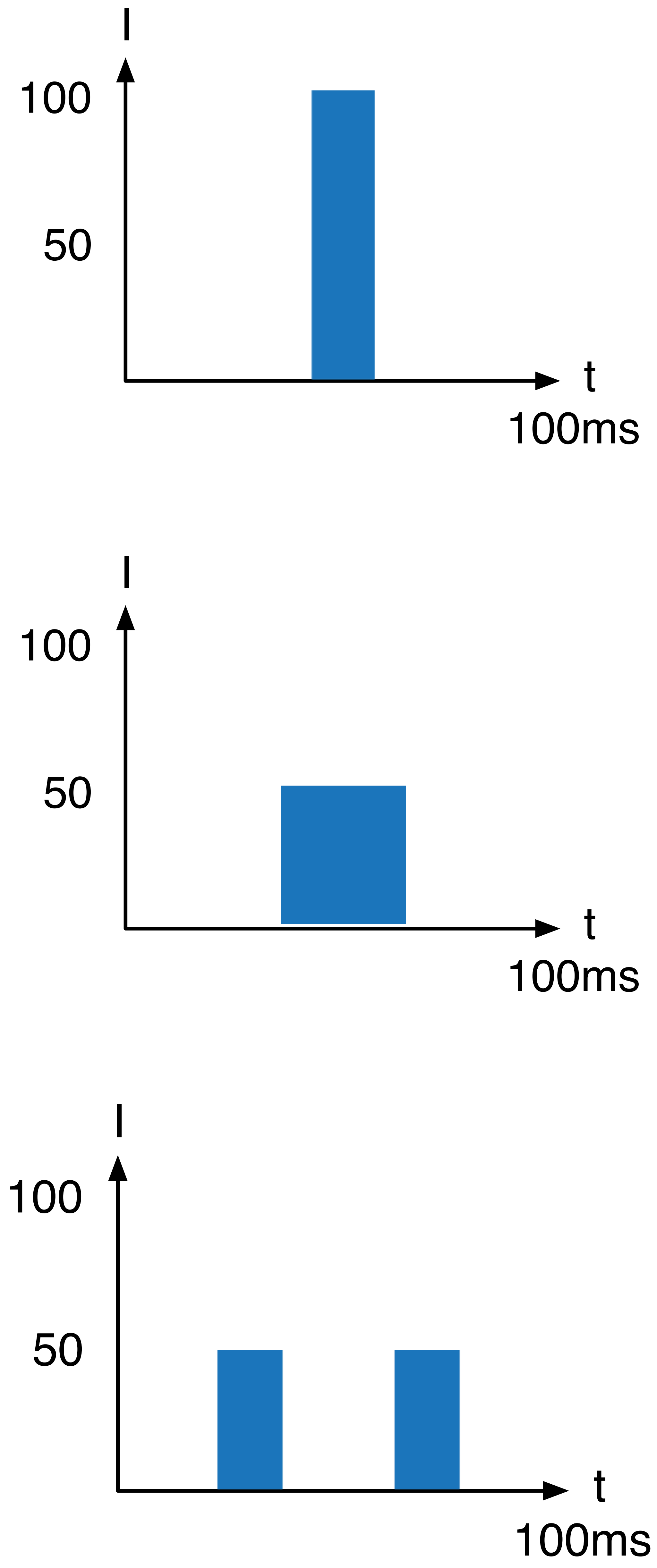
Perception

- Eye saccades: 230 ms
- Explains reading rates
  - Maximum:13 characters/saccade
    ⇒ 652 words/minute



Perceptual Processor

- Stores sensor signals in visual & auditory stores
- Perception time: $\tau_P \approx 100$ ms
  - Explains Bloch's Law
    - $R = I \times t$
    - R is response
    - I is intensity,
    - t is exposure time
  - Constant response for $t < 100$ms



In-Class Experiment: Bloch's Law

A

In-Class Experiment: Bloch's Law

B

In-Class Experiment: Bloch’s Law

C

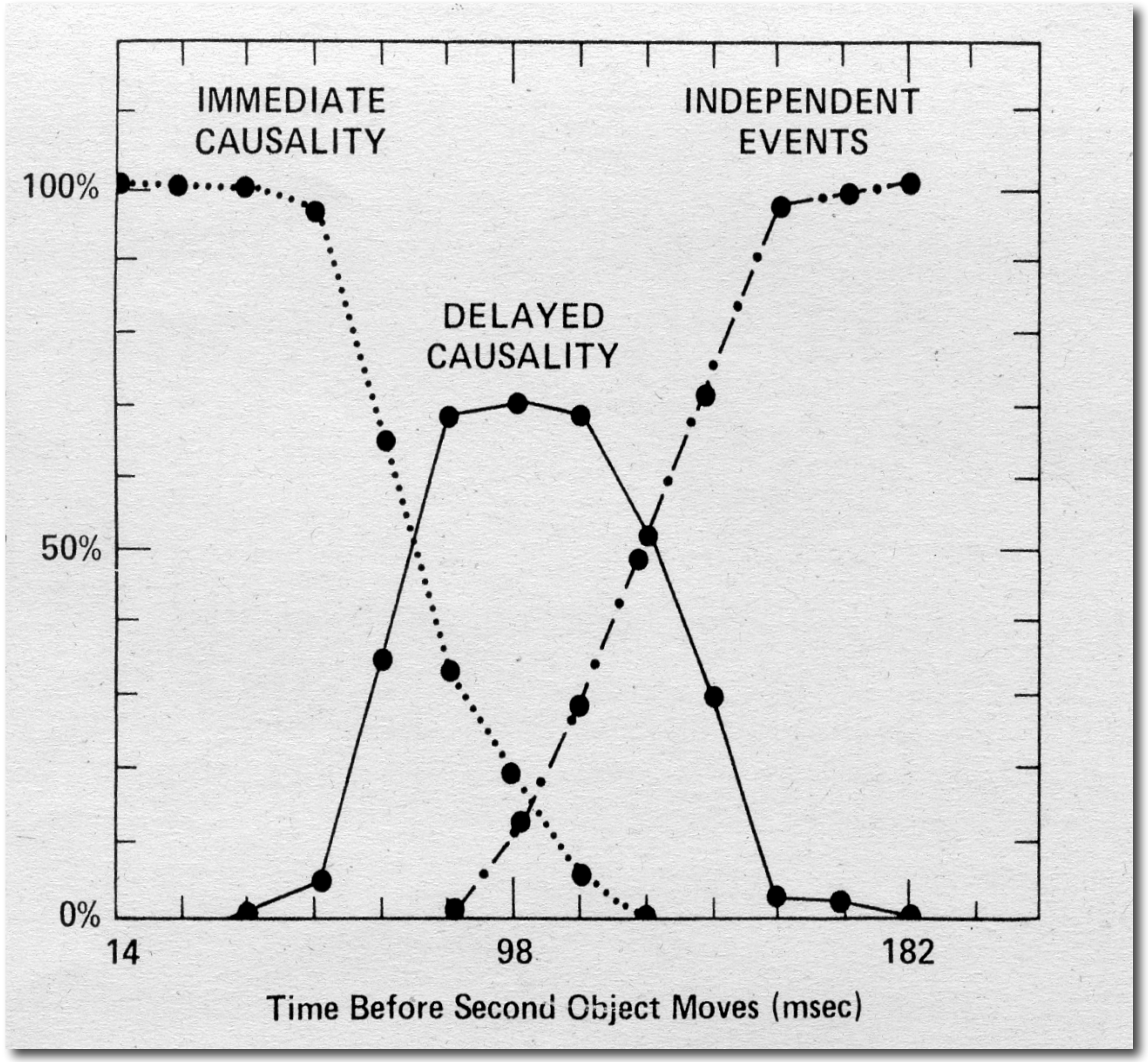
A: 0 ms delay

B: 50 ms delay

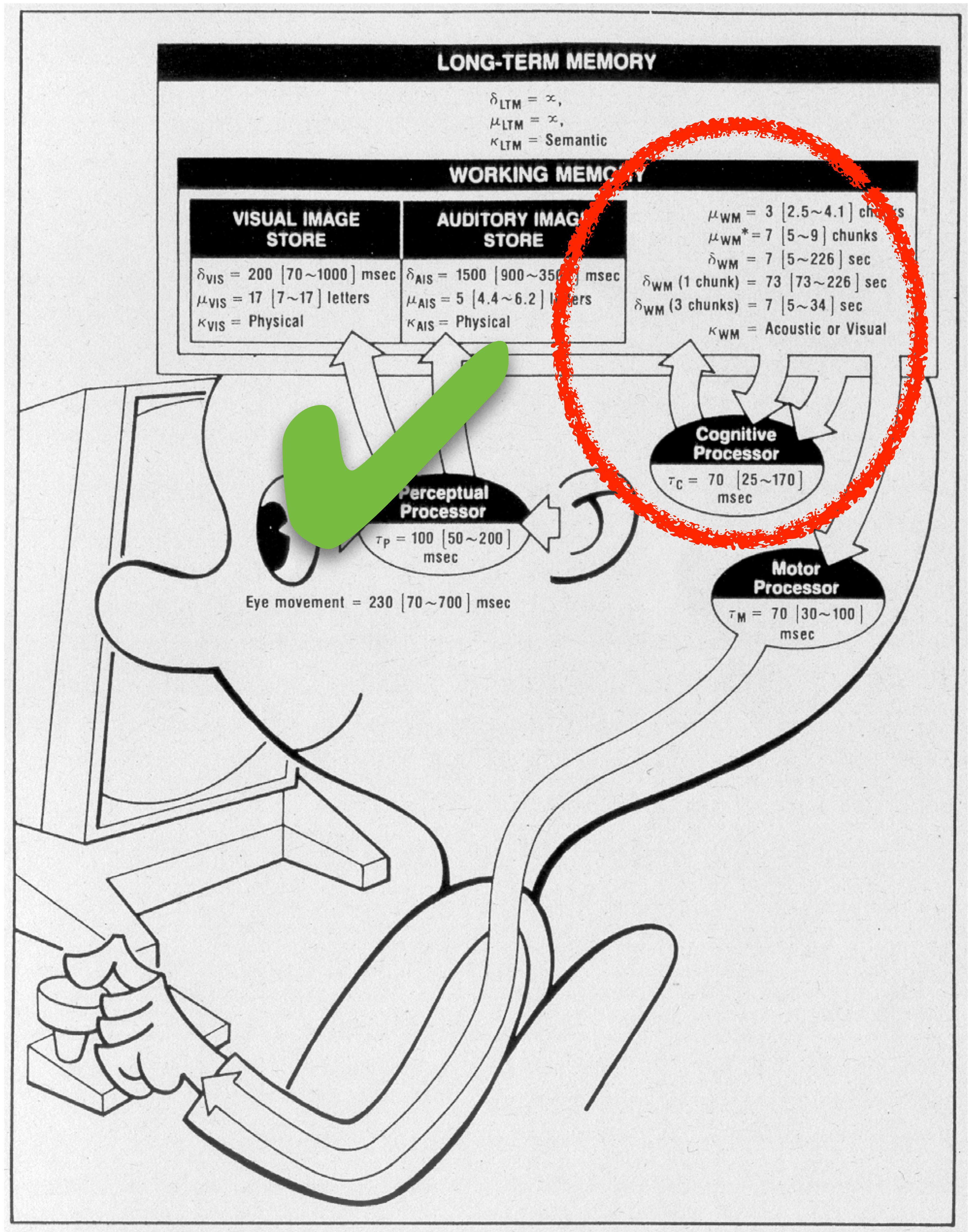
C: 100 ms delay

Perceptual Processor

- Perception time: $\tau_P \approx 100$ ms
  - Explains animation rates (10 fps for MiddleMan)
  - Explains max. delay before causality breaks down
  - Shortens with intensity



Model Human Processor

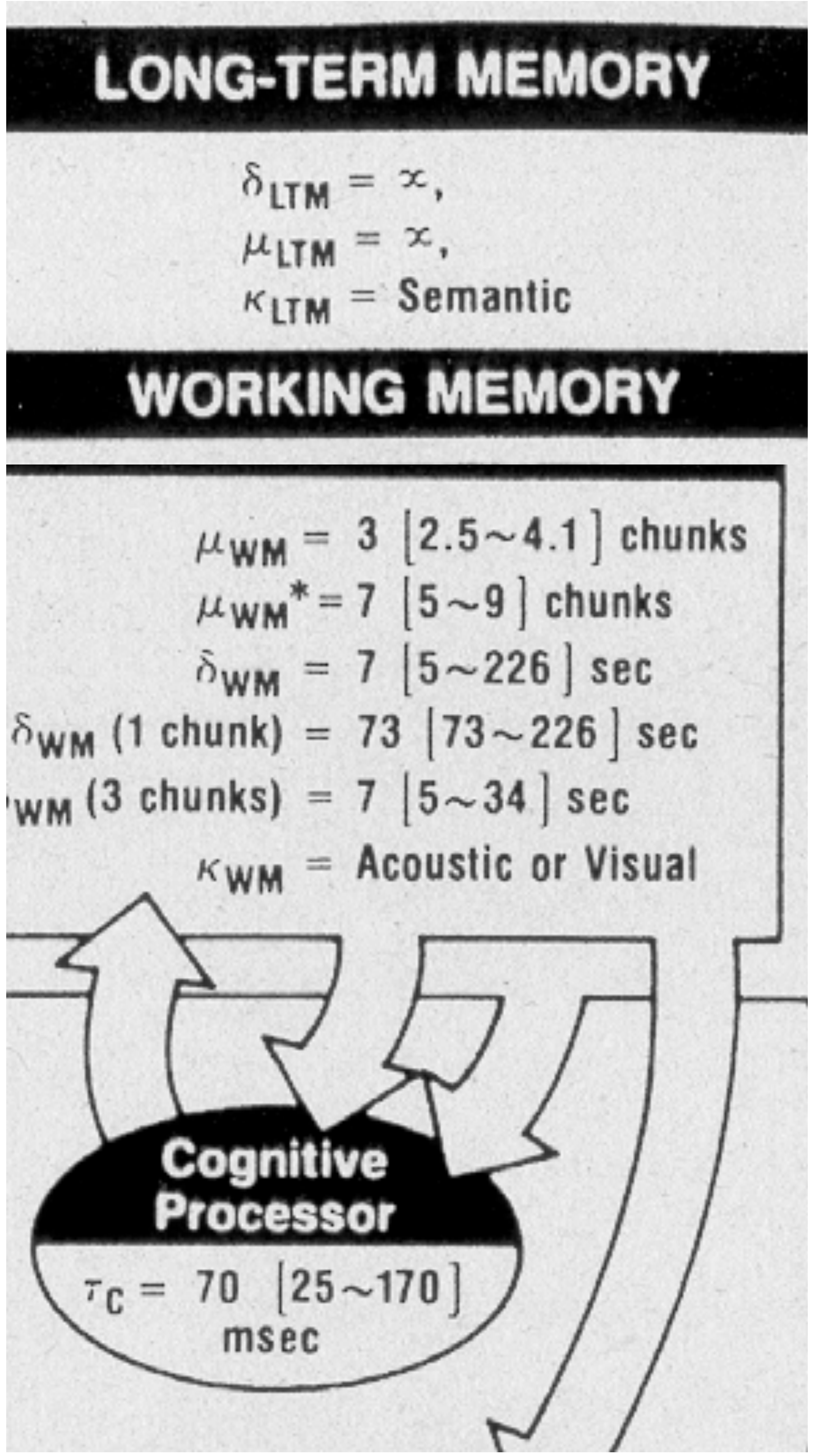


Experiment 2

- We will randomly create groups of two.
  - Choose 5 digits secretly from your sheet, then read them to your partner.
  - Have him count backwards aloud from 50.
  - Have him answer some other question (like what he had for dinner 3 days ago).
  - Does he still remember the entire 5-digit sequence correctly?
    Write down how many numbers he could remember.
- Switch roles, repeat with 9 digits.
- Finally, switching roles again, read the long sequence of numbers to your partner, stopping somewhere suddenly. See how many of the last numbers he can repeat immediately.

Cognitive System

- Chunks depend on user & task
- Working memory:
  - Capacity: μ_{WM} = 7 ± 2 chunks (Miller ’56)
  - Half life: $\delta_{1,WM}$ = 73 s (1 chunk)
    $\delta_{3,WM}$ = 7 s (3 chunk)
  - Visual/acoustic encoding

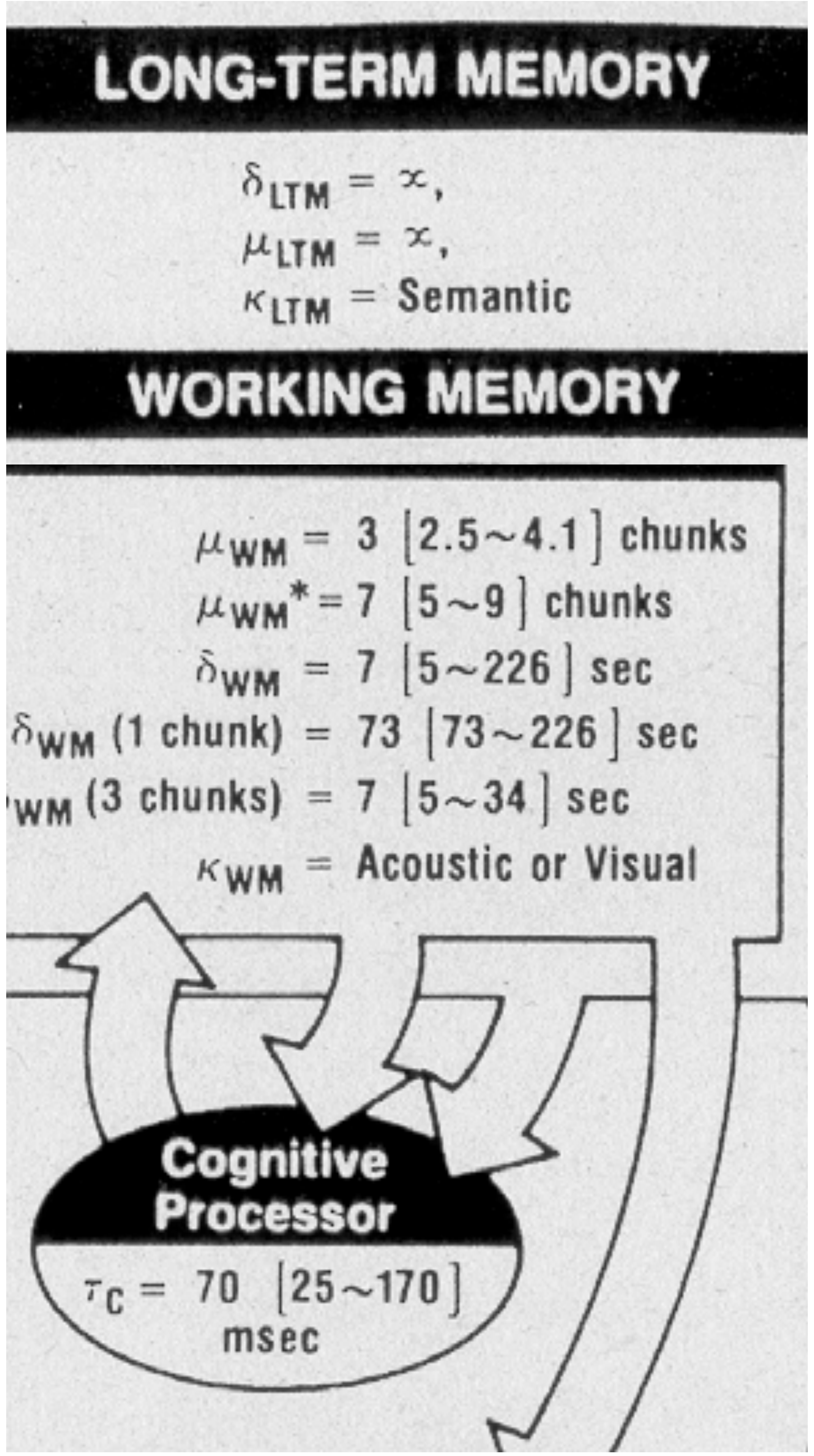


- In 2001, Nelson Cowen showed that this is actually 4±1 chunks.

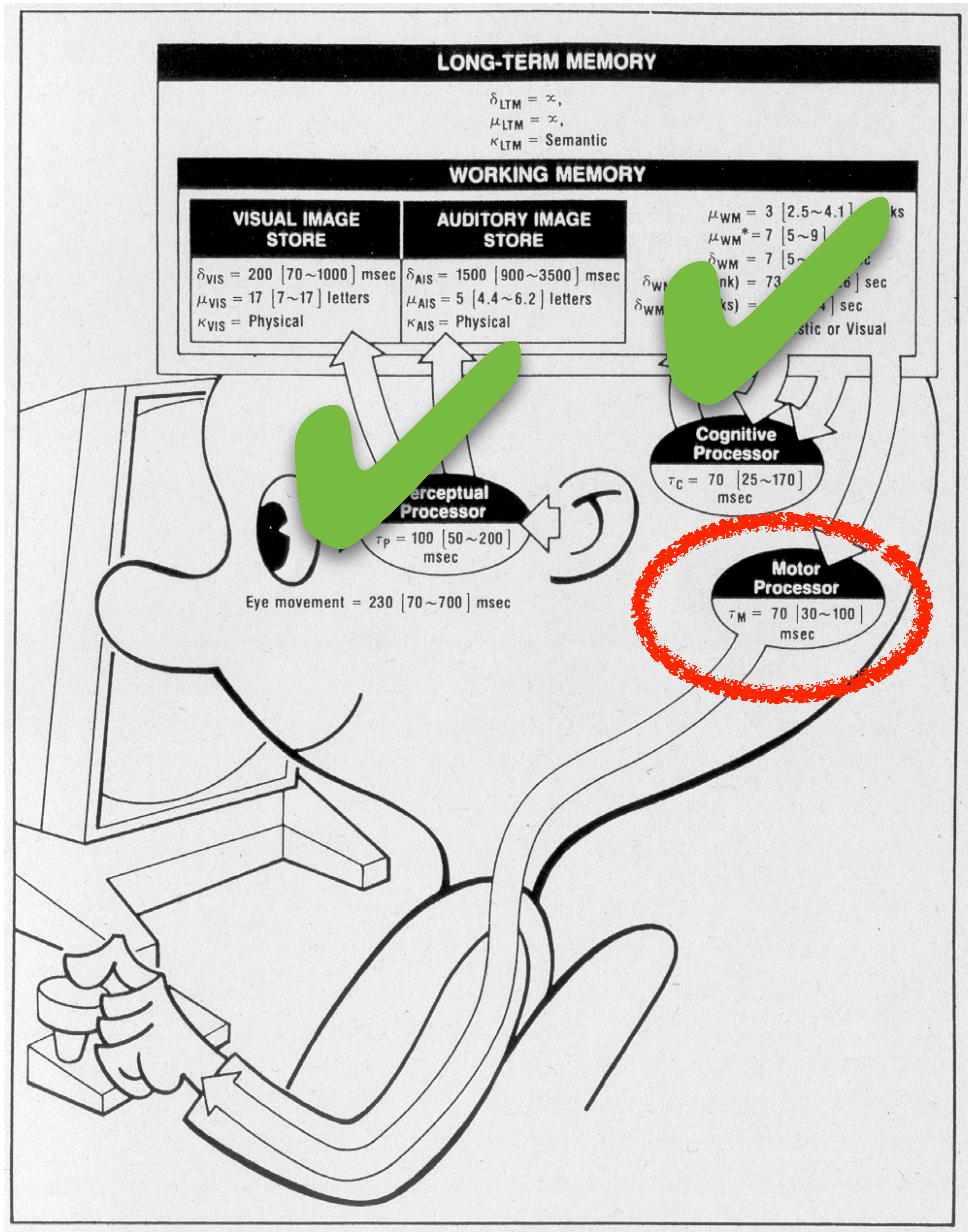
Cognitive System

- Cognitive processor:
  - Processing time $\tau_C = 70$ ms
- Long-term memory:
  - Infinite capacity and half life
  - Semantic encoding (associations)
  - Fast read, slow write

$\Rightarrow$ Remembering items maxes out at 7 s/chunk learning speed (1 pass)

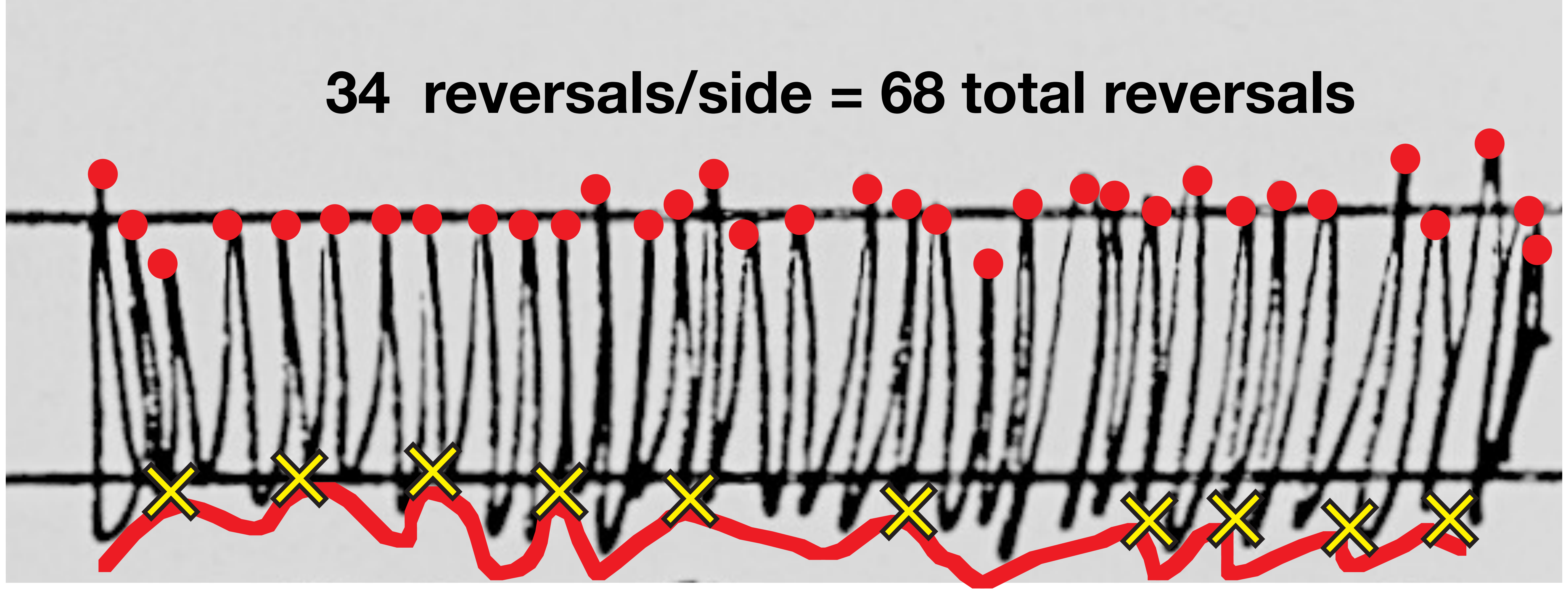


Model Human Processor



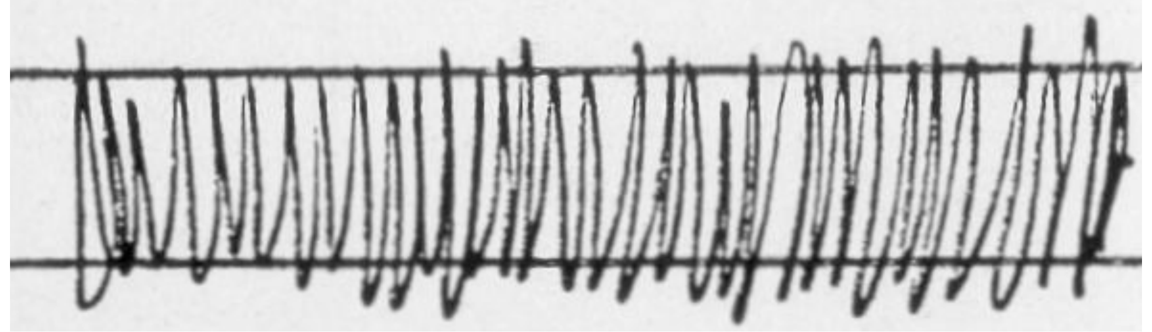
Experiment 3

- Experiment: draw strokes between lines for 5s. Try to reach both lines.
- Count number of reversals
  - How many milliseconds per reversal?
- Create a contour of stroke bottoms, count number of corrections
  - How many milliseconds per correction?



10 corrections/side = 20 total corrections

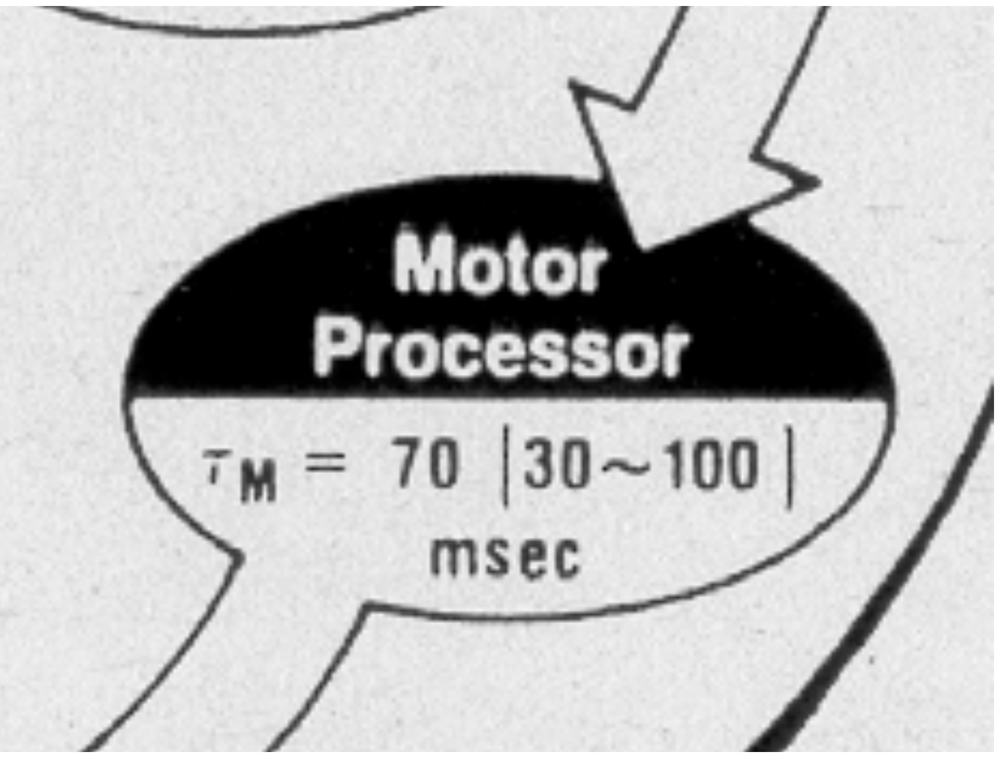
Motor System

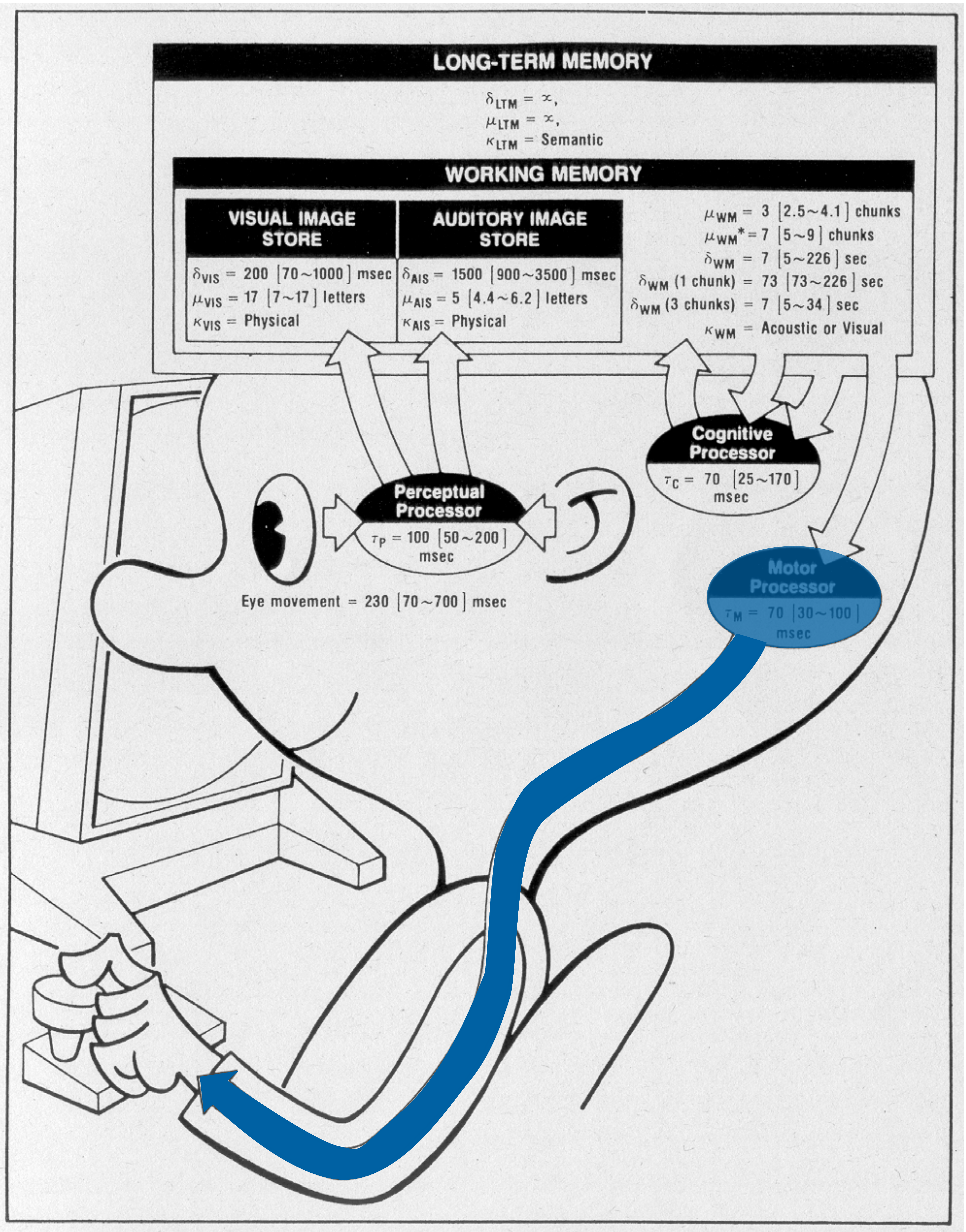


74 ms/reversal
250 ms/correction

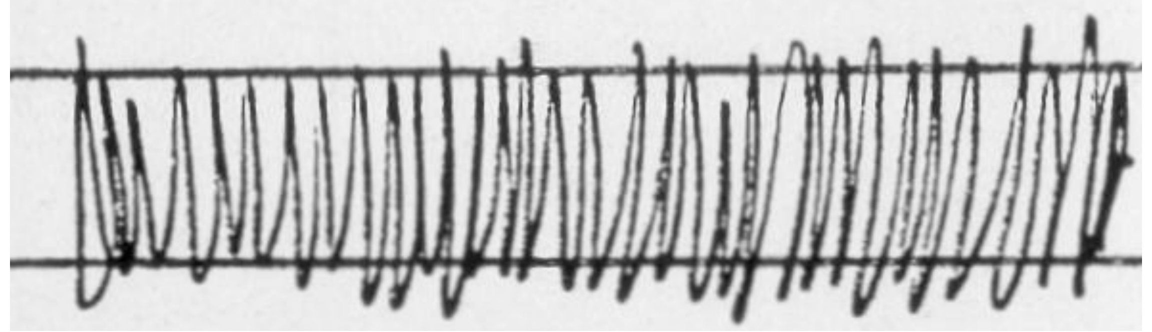
- Motor processor (open loop)
  - τ_M = 70 ms

$\Rightarrow$ Average time between each reversal





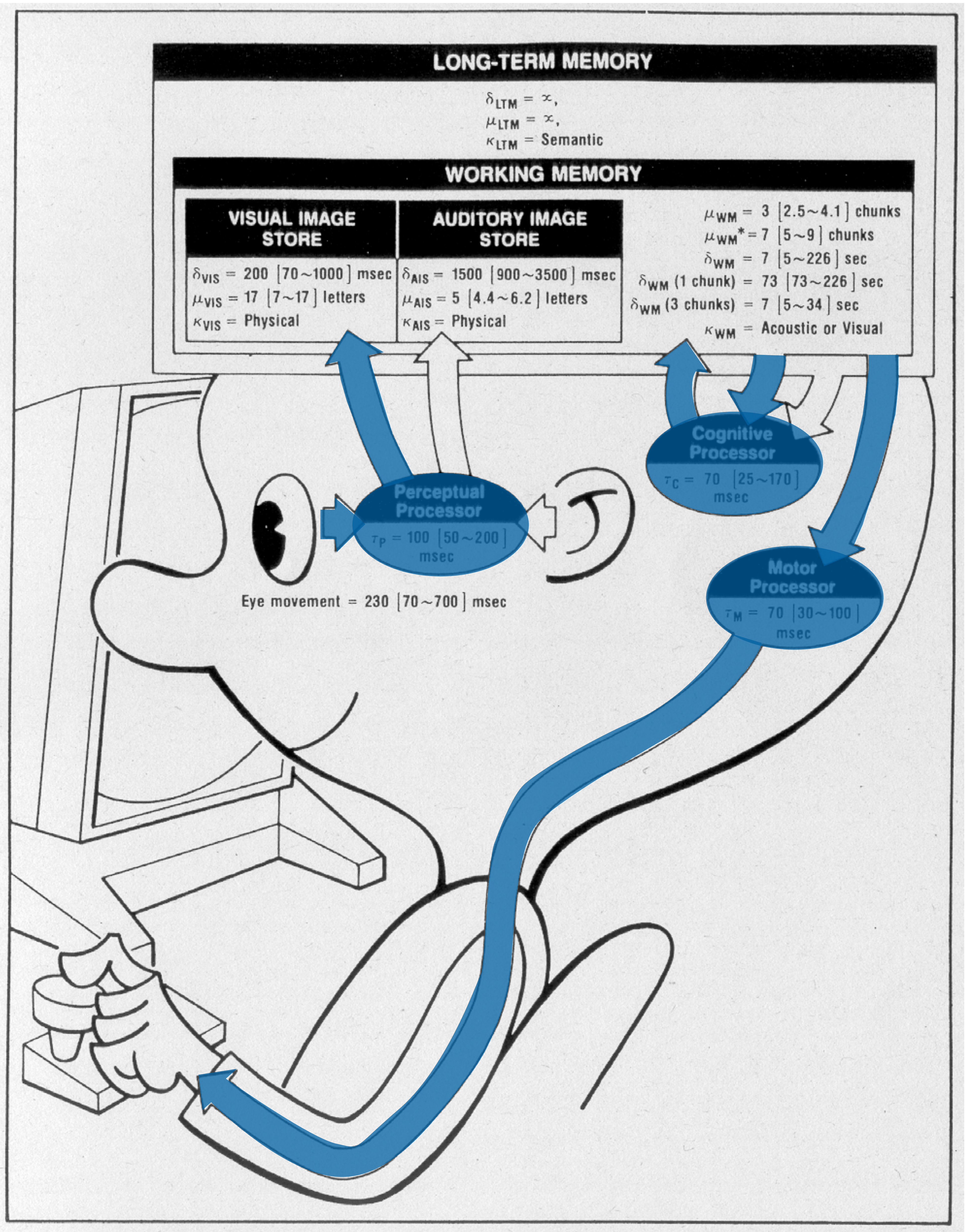
Motor System



74 ms/reversal
250 ms/correction

- Closed loop:
  - $\tau_P + \tau_C + \tau_M = 240$ ms

$\Rightarrow$ Average time between each correction



Fitts' Law

In-Class Experiment 4: Fitts' Law

1cm

4cm

Same for 0.5 cm and 2 cm wide strips

Tap for 10 s, count taps afterwards

8cm

16cm

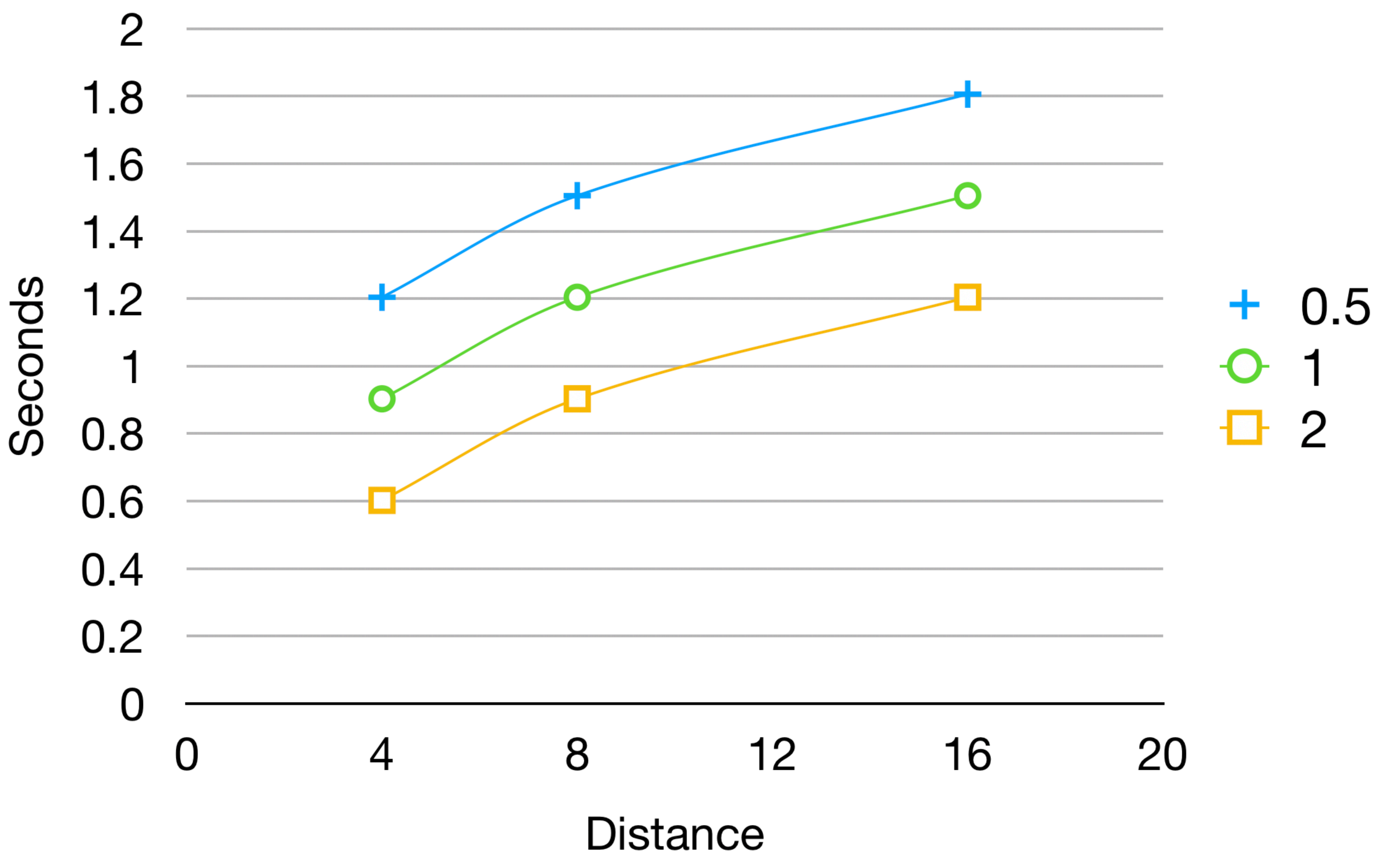
Tapping Task Results

- Doubling the distance adds roughly a constant to execution time

  ⇒ indicates logarithmic nature

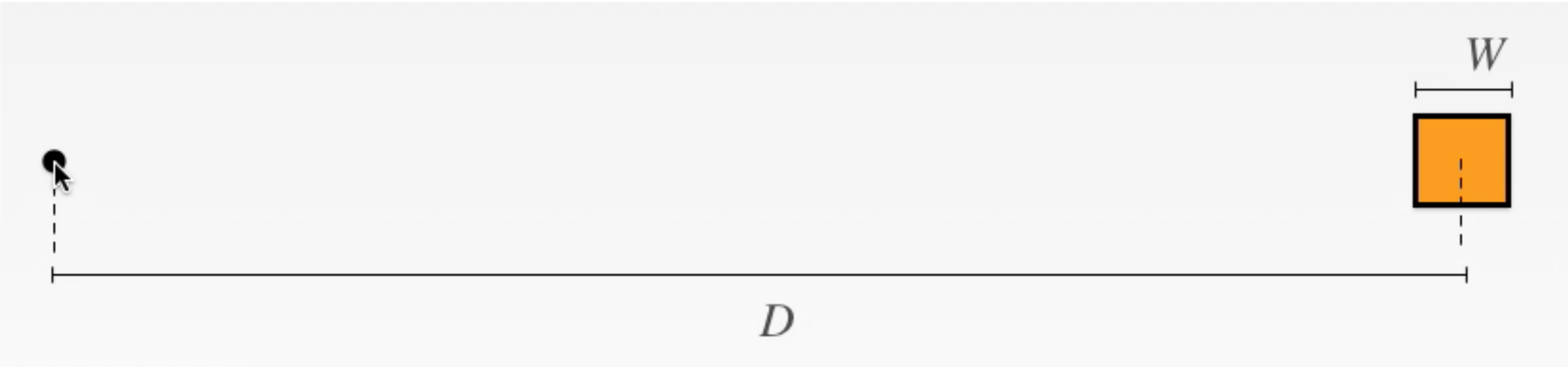
- Doubling the target width (W) gives about same results as halving the distance (D)

  ⇒ indicates connection of D/W in formula



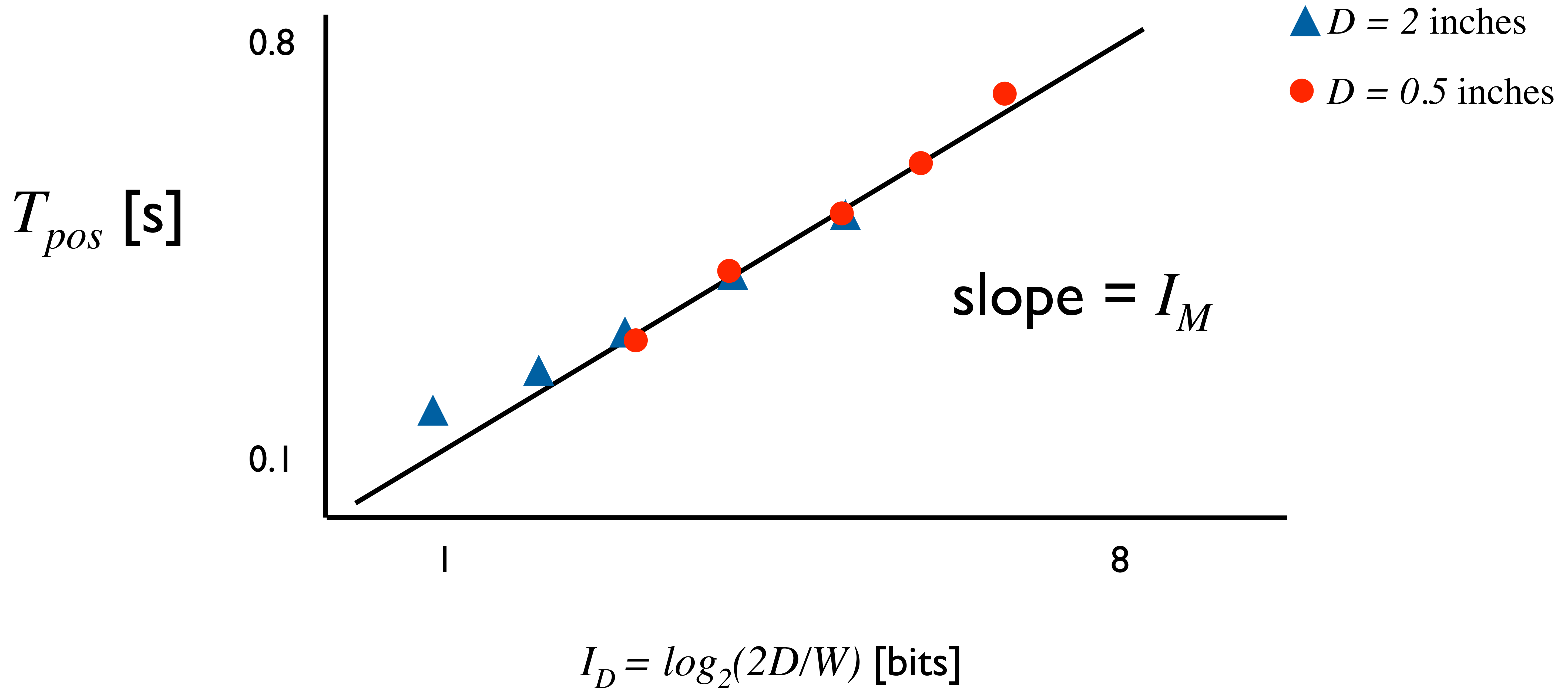
Motor System: Fitts' Law

- Goal: Predict time to press buttons (physical or on-screen) as function of distance and size
- Result (Fitts, 1954): $T_{pos} = I_M \times I_D$
  - T_{pos} time to reach button
  - I_M =100 ms/bit index of movement, constant
  - $I_D = \log_2(2D / W)$ index of difficulty, in bits
- Fitts' law can be derived from CMN model

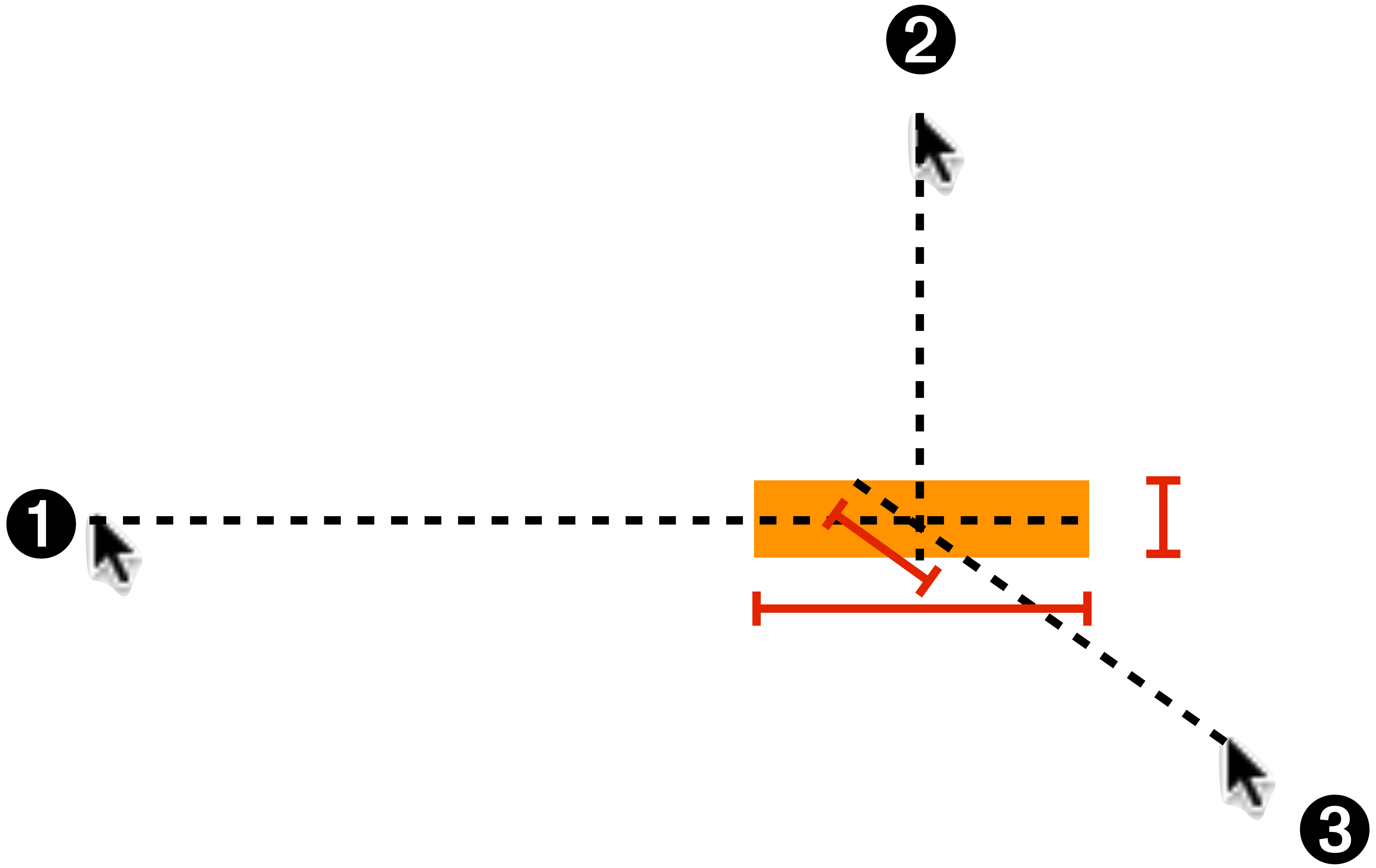


Visualizing Fitts' Law

Experiment: fixed distance D, varying width W



Target Width



- Alternative measures are compared by [MacKenzie & Buxton, CHI’92]

Windows 10

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macOS Catalina

Improvements

- Welford's Formulation, 1968:

$$T_{pos} = I_M \cdot \log_2\left(\frac{D}{W} + \frac{1}{2}\right)$$

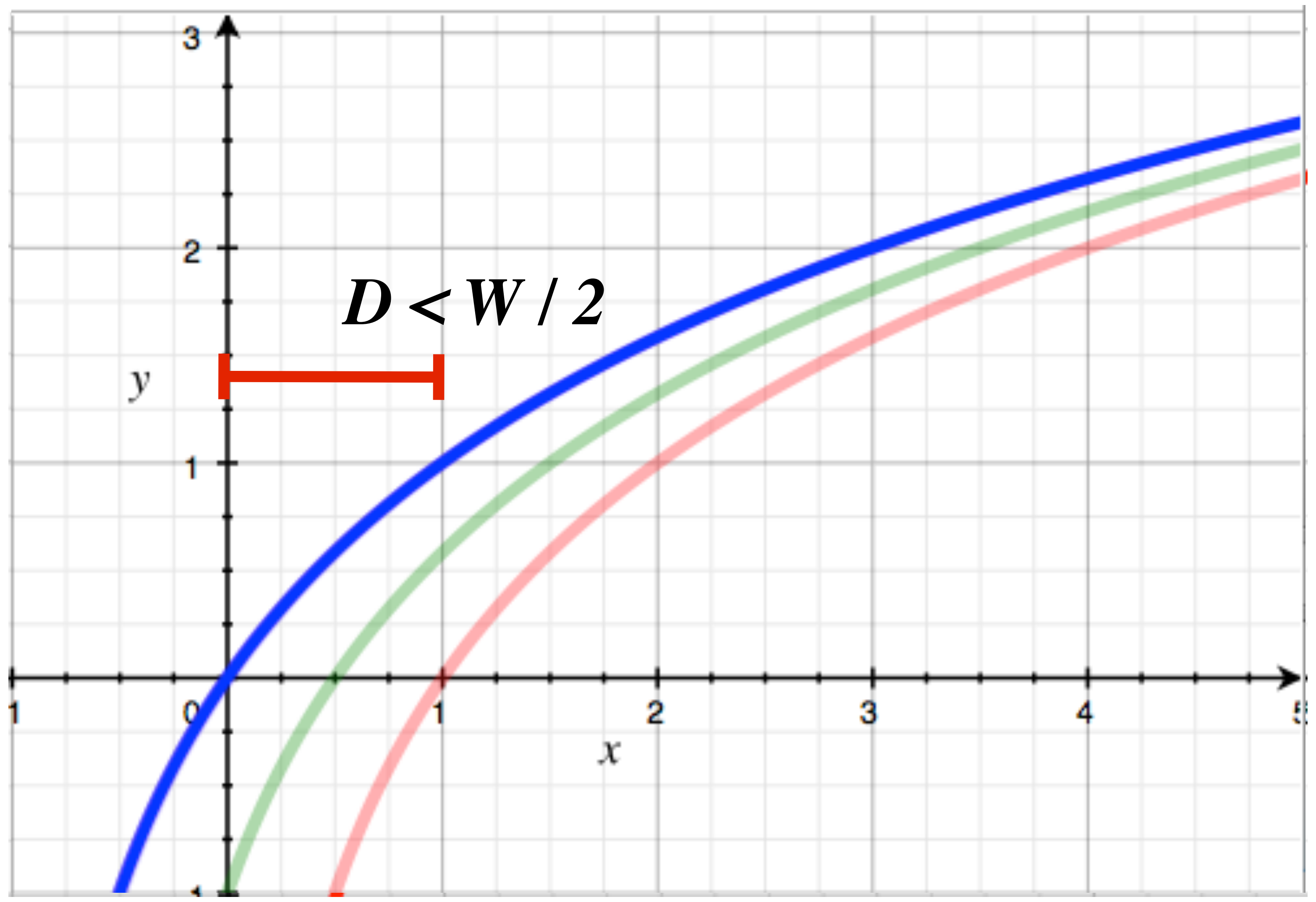
- Shannon's Formulation, ISO, 80's:

$$T_{pos} = a + b \cdot \log_2\left(\frac{D}{W} + 1\right)$$

  - *a, b* depend on device, determine experimentally

Use *a = 0 ms, b =* I_M *= 100 ms* for quick and dirty estimates

Improved curve fit, no negative times for infinite-size targets



$$T_{pos} = I_M \cdot \log_2\left(\frac{2D}{W}\right)$$

$$T_{pos} = I_M \cdot \log_2\left(\frac{D}{W} + \frac{1}{2}\right)$$

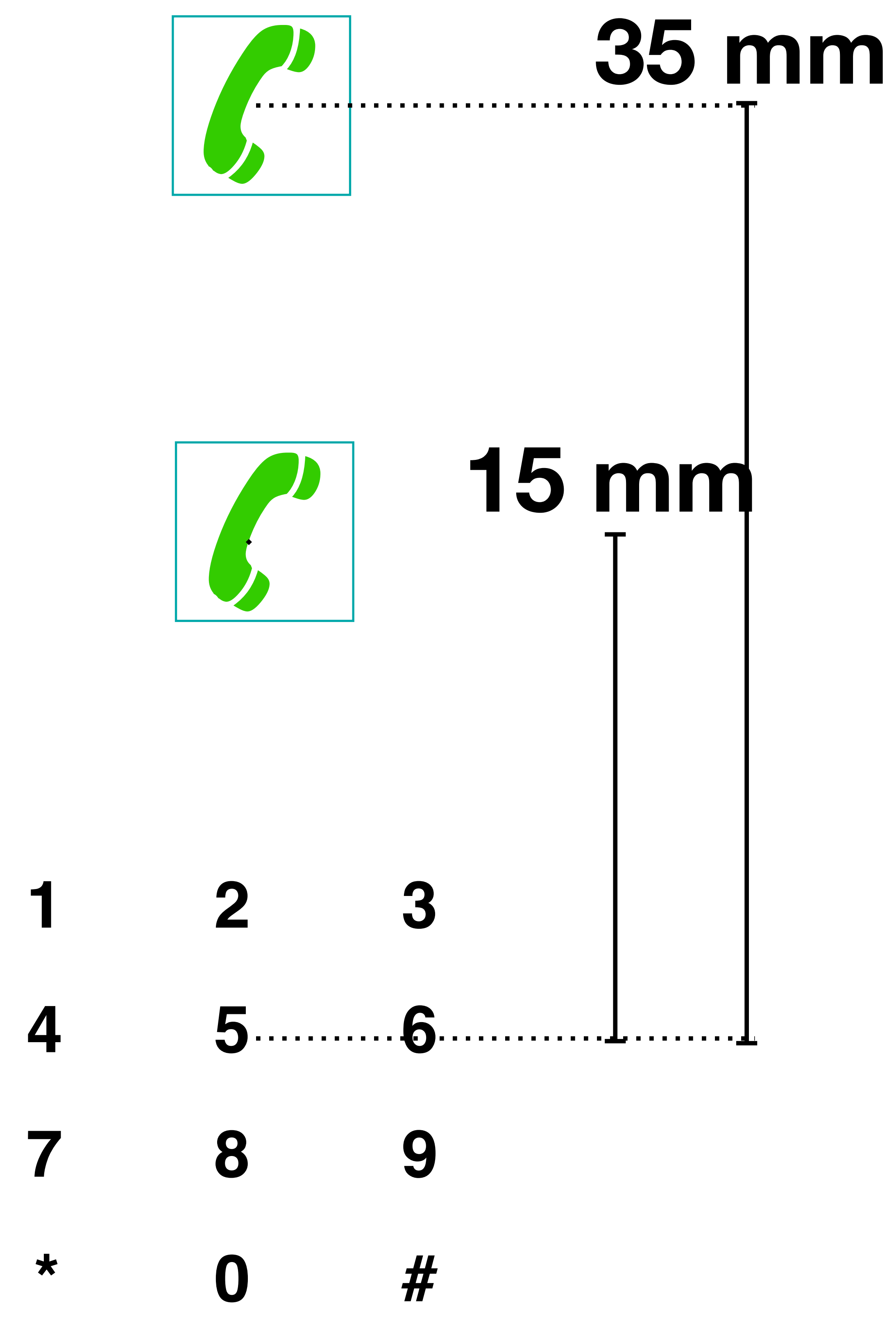
$$T_{pos} = a + b \cdot \log_2\left(\frac{D}{W} + 1\right)$$

Exercise: Mobile Phone

- How much faster does calling become by moving the “call” button from 35 mm distance to 15 mm distance, measured from the middle of the keypad? The size of the call button is 10 x 10 mm

- Welford’s Law: $T_{pos} = I_M \cdot \log_2(\frac{D}{W} + \frac{1}{2})$

- Use I_M =100 ms/bit



Solution

⇒ Moving the call button speeds up each call by an average of about 100ms.

$$
\begin{aligned}
T_{pos1} &= I_M \cdot \log_2\left(\frac{D_1}{W} + \frac{1}{2}\right) \\
T_{pos2} &= I_M \cdot \log_2\left(\frac{D_2}{W} + \frac{1}{2}\right)
\end{aligned}
$$

$$
\begin{aligned}
T_{pos1} - T_{pos2} &= I_M \cdot \left(\log_2\left(\frac{D_1}{W} + \frac{1}{2}\right) - \log_2\left(\frac{D_2}{W} + \frac{1}{2}\right)\right) \\
&= 100\,\frac{\text{ms}}{\text{bit}} \cdot \left(\log_2\left(\frac{35}{10} + \frac{1}{2}\right) - \log_2\left(\frac{15}{10} + \frac{1}{2}\right)\right)\ \text{bit} \\
&= 100\,\text{ms} \cdot (\log_2 4 - \log_2 2) \\
&= 100\,\text{ms} \cdot (2 - 1) \\
&= 100\,\text{ms}
\end{aligned}
$$

Summary

- The Media Computing Group does cool stuff
- HCI is about humans, computers, the design process, and the social context
- The CMN model allows estimating reaction times and memory performance
- Fitts' Law allows estimating times for typing, pointing, and similar tasks
- **Assignment**:
  Read "*Human-Computer Interaction*" (Dix, et al.) chapter "*The Human*" (pp. 11-59)
- Buy and start reading "*The Design of Everyday Things*", by Donald Norman