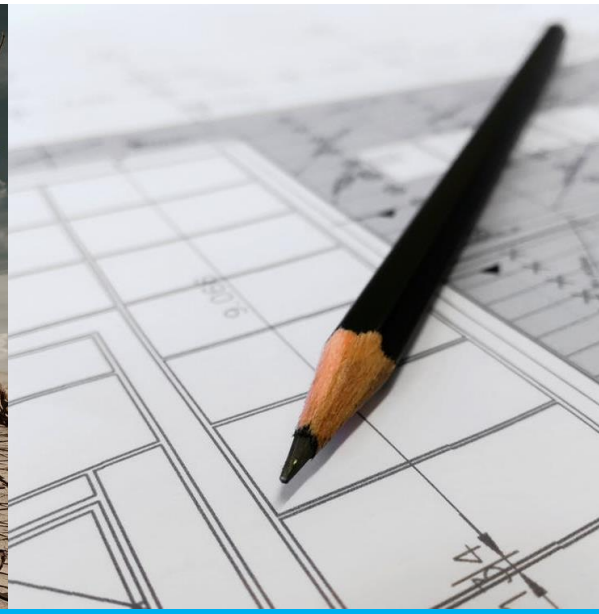


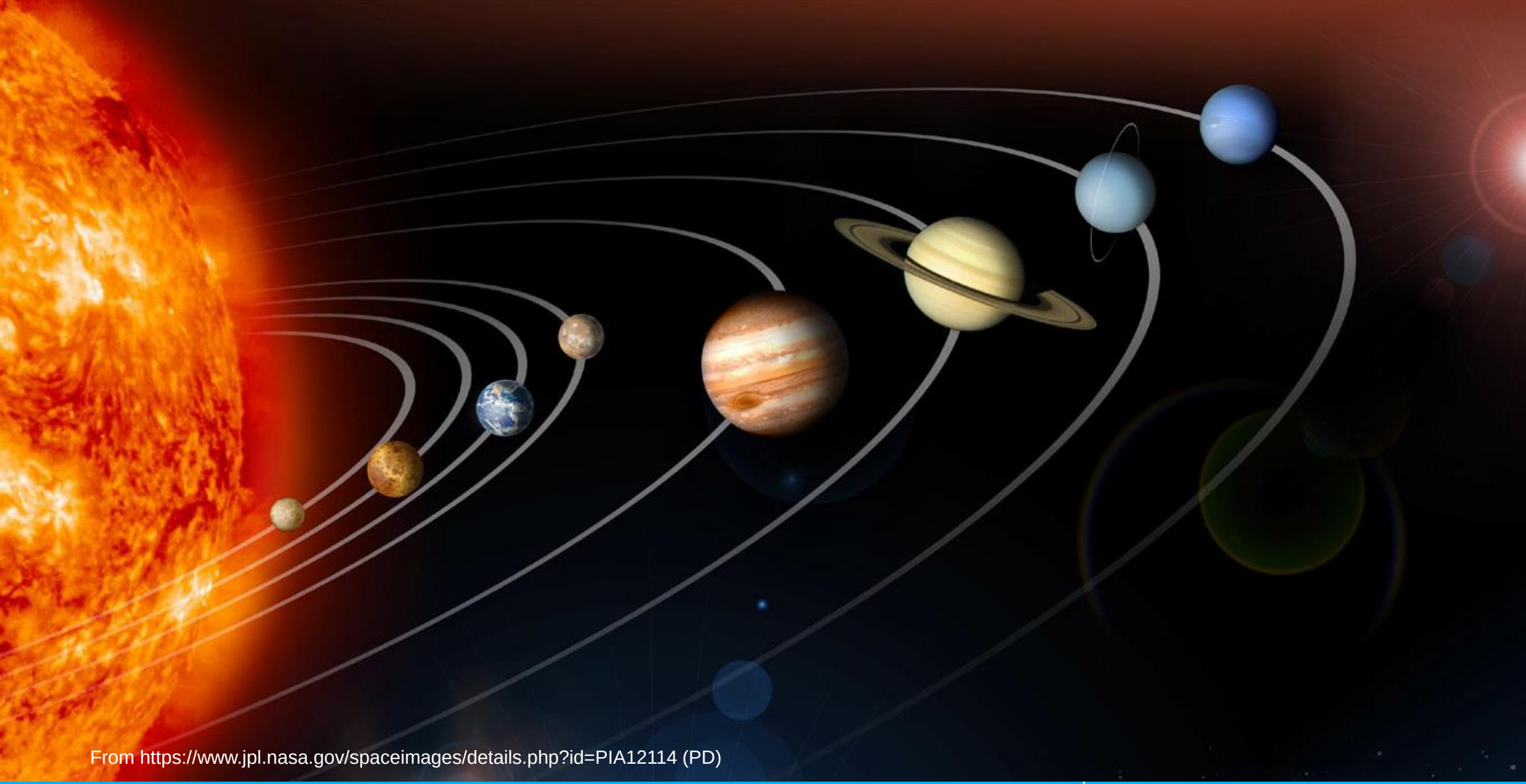
Introduction to Models

Niels Henze

Learning Goals

- Understand what models are and why they are useful
- Now about their limitations
- Have a rough overview of models in HCI

By Godisable Jacob from https://www.pexels.com/photo/woman-sitting-on-sofa-bed-wearing-sunglasses-965324/ (PD)



From https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA12114 (PD)

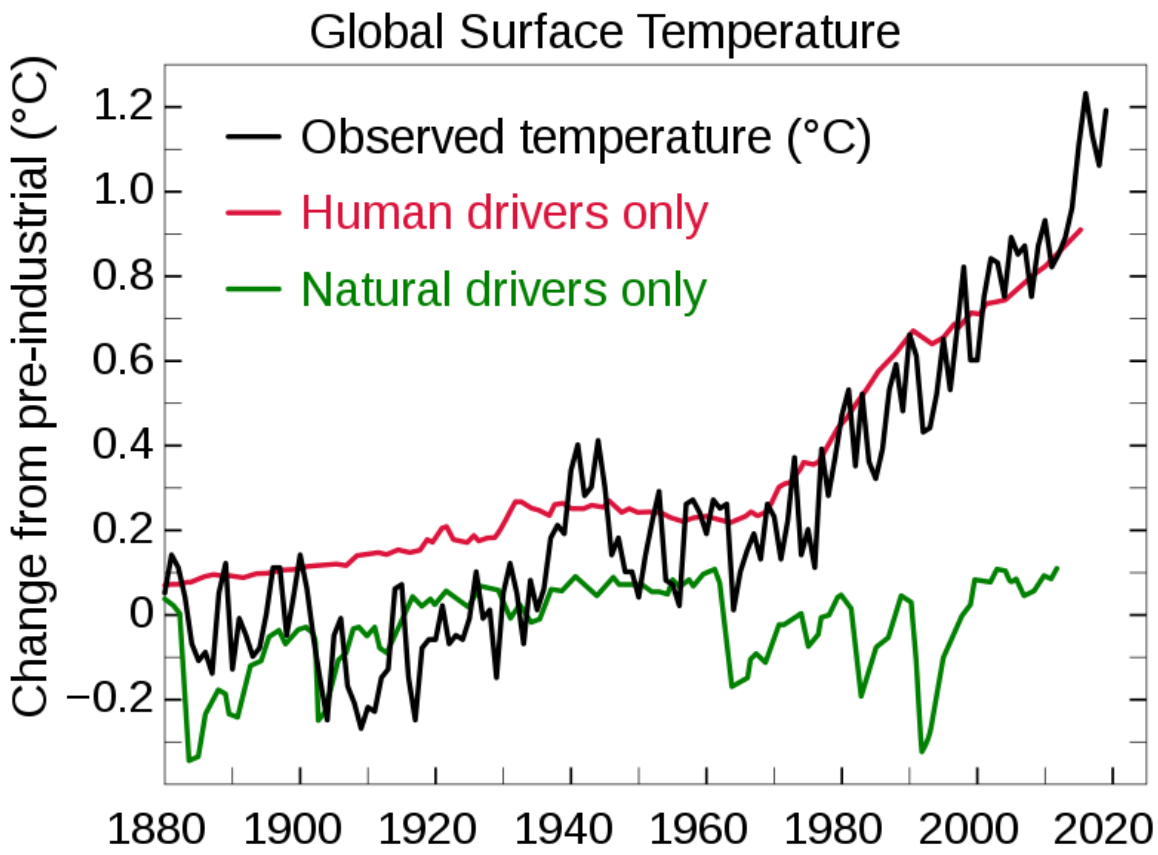


Image by Efbrazil from https://en.wikipedia.org/wiki/File:Global_Temperature_And_Forces.svg (CC BY-SA 4.0)

Models

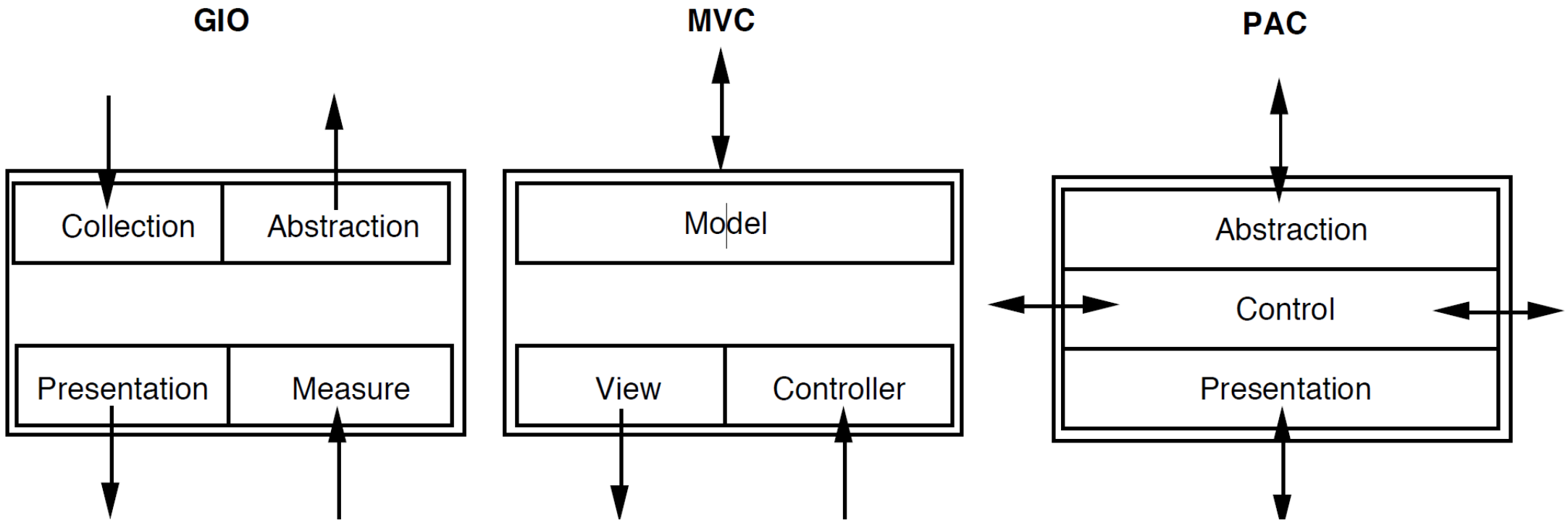
- Are representations of phenomena that help us to understand how something works or how it will work.
- Models are never perfects. There will always be one that is better for specific questions.
- A model is only useful for specific phenomena but not is not useful for most phenomena.

Models in Human-Computer Interaction

Can you think about phenomena that we could model in HCI?

- Prototypes are representations of systems and help us to understand how they will work.
- Perfectly valid models and used in HCI
- Covered in a dedicated block

From Le, H. V., Mayer, S., Bader, P., & Henze, N. (2017). A smartphone prototype for touch interaction on the whole device surface. MobileHCI.



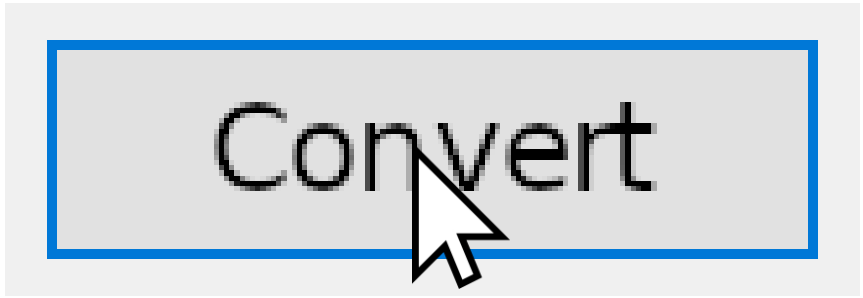
- Conceptual software architecture models are representations of our systems
- Similar to prototypes they help us to build better systems
- Yet another topic for another time

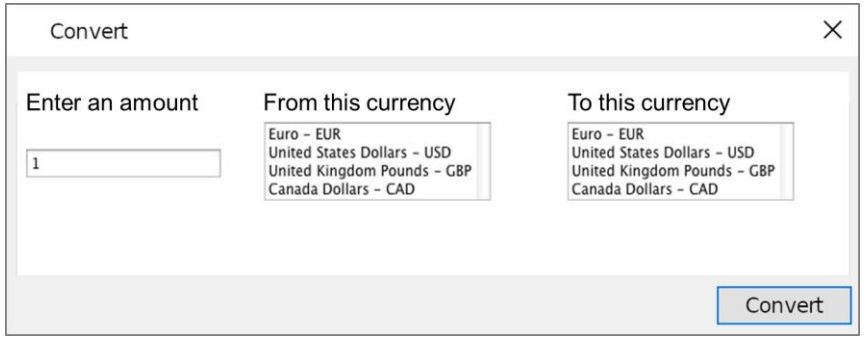
From Coutaz, J., Nigay, L., & Salber, D. (1993). Conceptual software architecture models for interactive system. ESPRIT BRA, 7040.

- Mental models are models users form about our systems
- While we want to influence them, we cannot develop them
- Also covered in another block

Image by Andrea Piacquadio from https://www.pexels.com/photo/photo-of-a-woman-thinking-941555/

task complexity





Bottom image by Andrea Piacquadio from https://www.pexels.com/photo/photo-of-woman-using-her-laptop-935756/

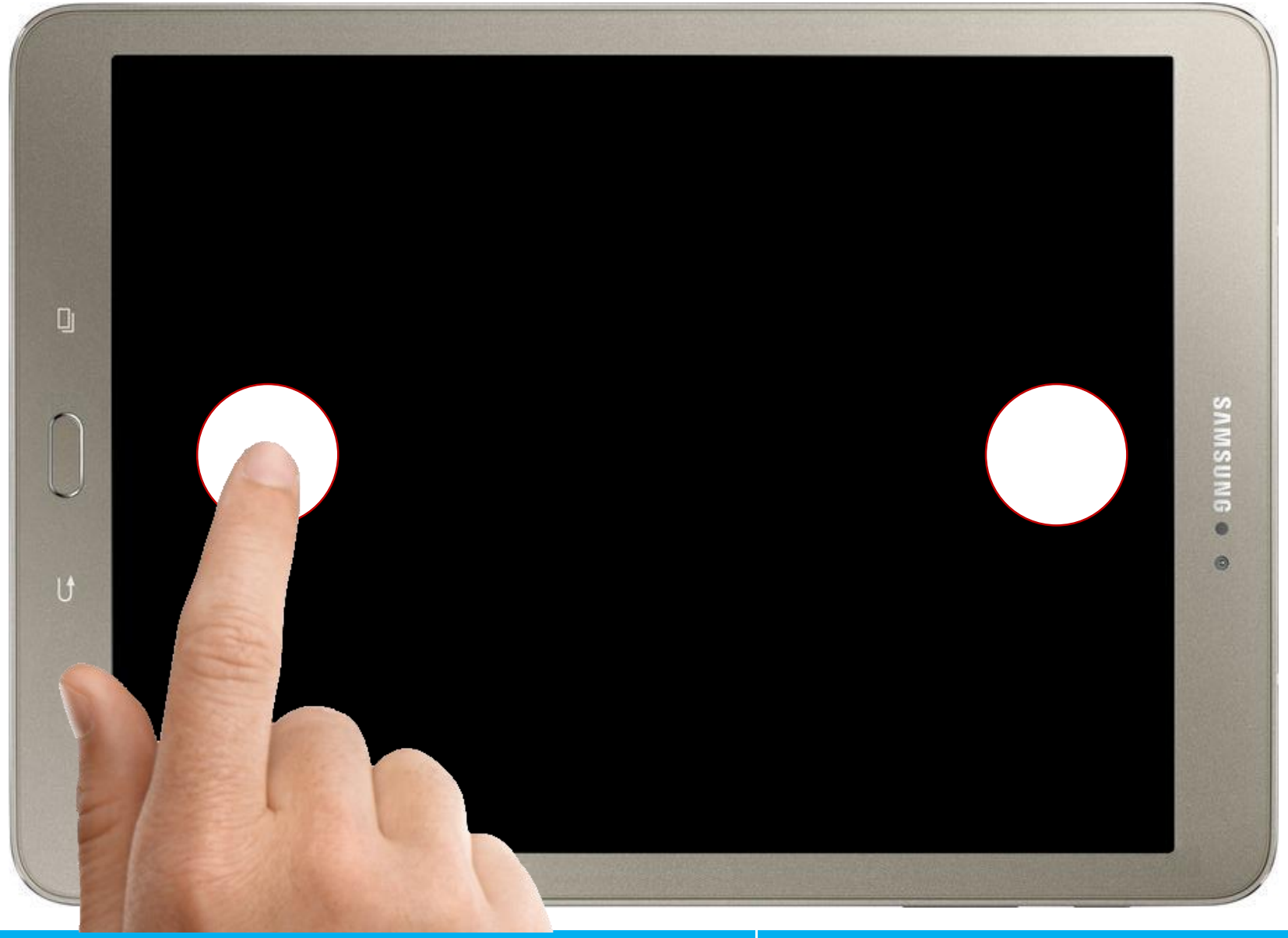
For more content see: https://hci-lecture.de

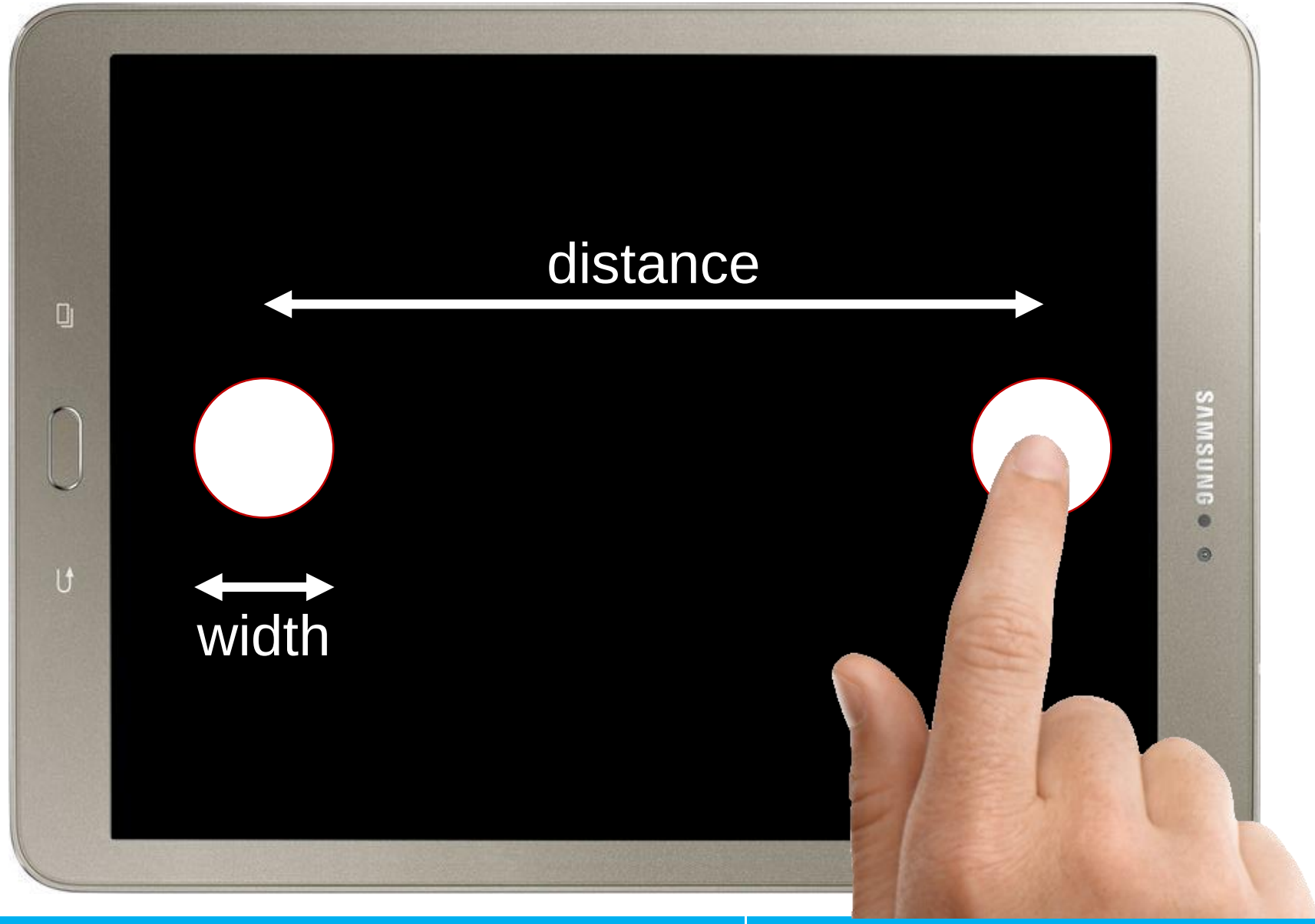
Basics of Fitts' Law

Schwind, V., Mayer, S., Comeau-Vermeersch, A., Schweigert, R., & Henze, N. (2018). Up to the Finger Tip: The Effect of Avatars on Mid-Air Pointing Accuracy in Virtual Reality. CHIPLAY.

Learning Goals

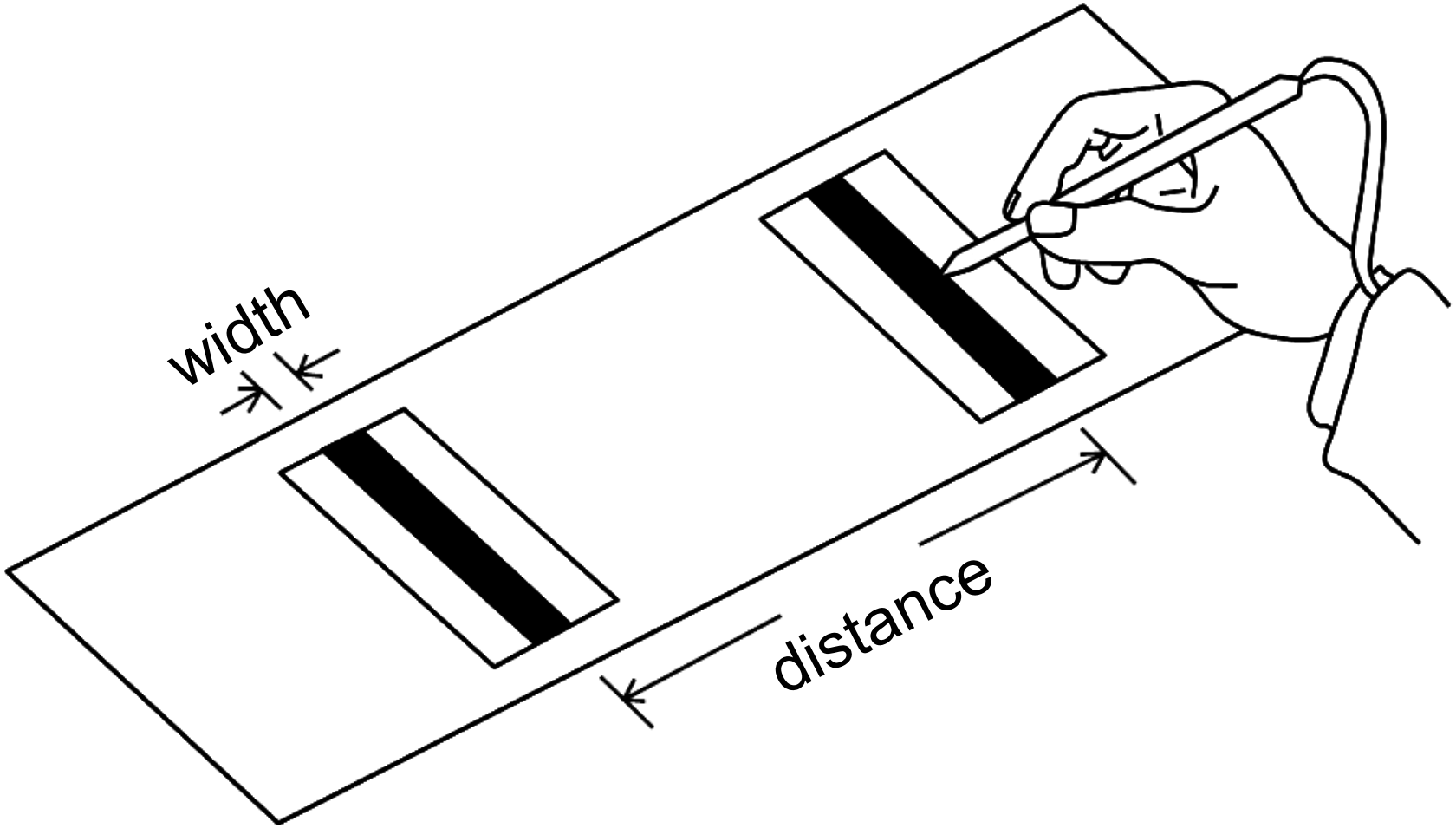
- Now the purpose of Fitts' Law
- Can determine the index of difficulty for pointing tasks
- Be able to determine the device-specific constants


SAMSUNG

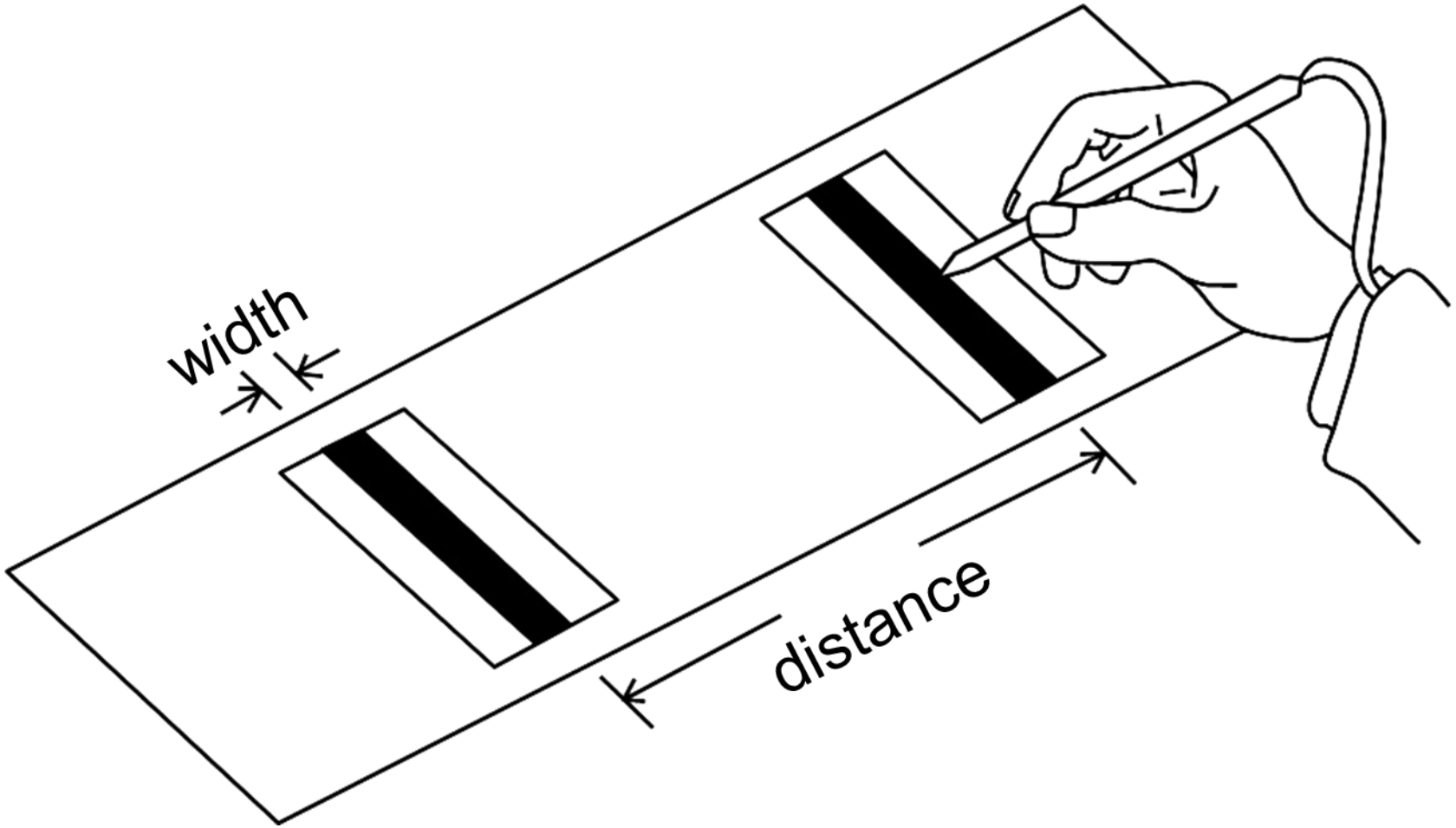

distance
width
SAMSUNG

From: U-M Library Digital Collections. Bentley Image Bank, Bentley Historical Library. Accessed: March 27, 2020. CC BY 4.0

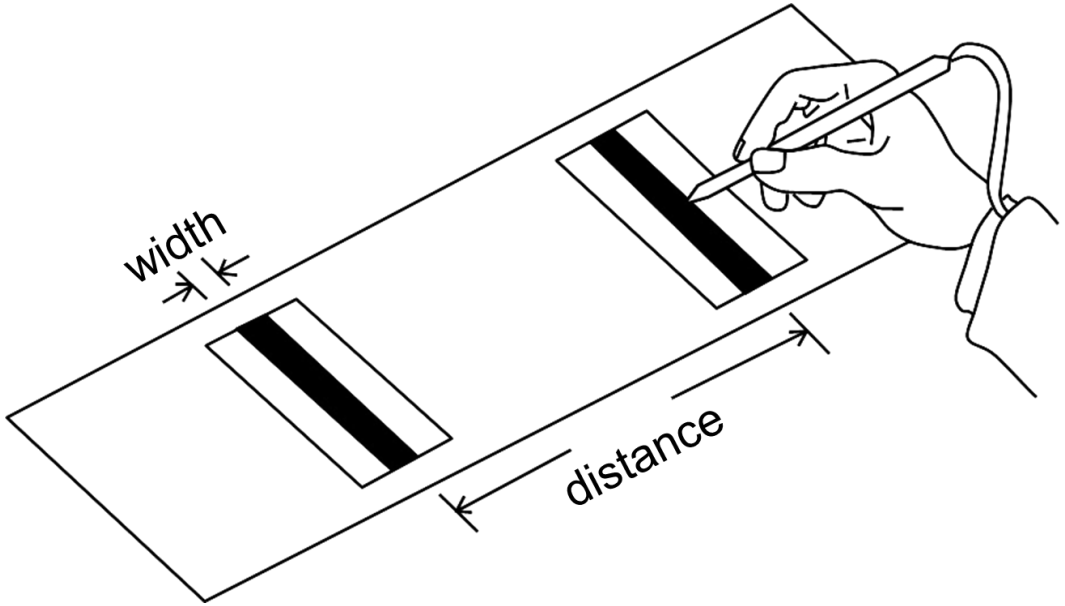
From: Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of experimental psychology, 47(6), 381.



From: Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of experimental psychology, 47(6), 381.



From: Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of experimental psychology, 47(6), 381.



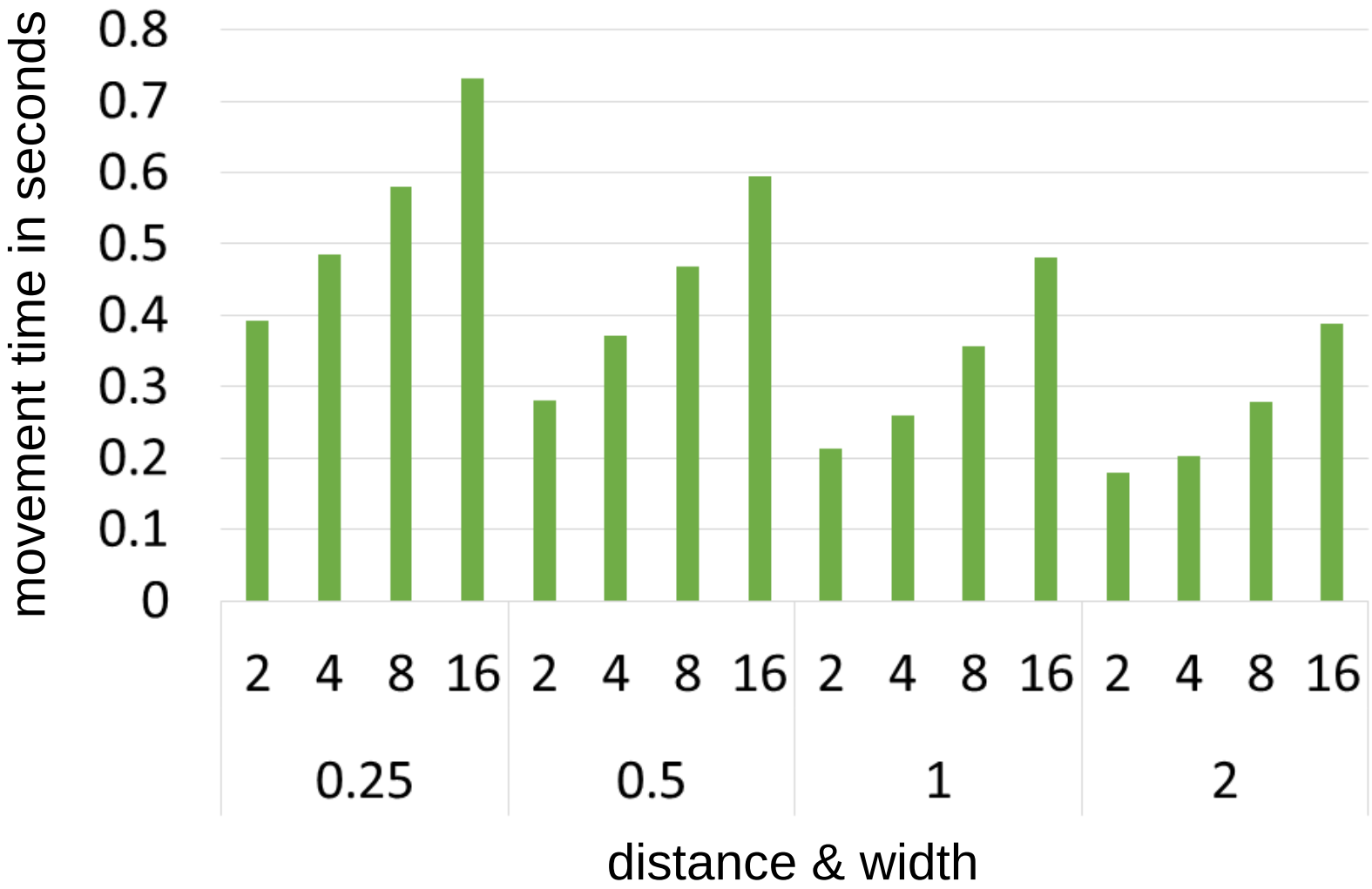
Four distances:

- 2, 4, 8, 16 inch

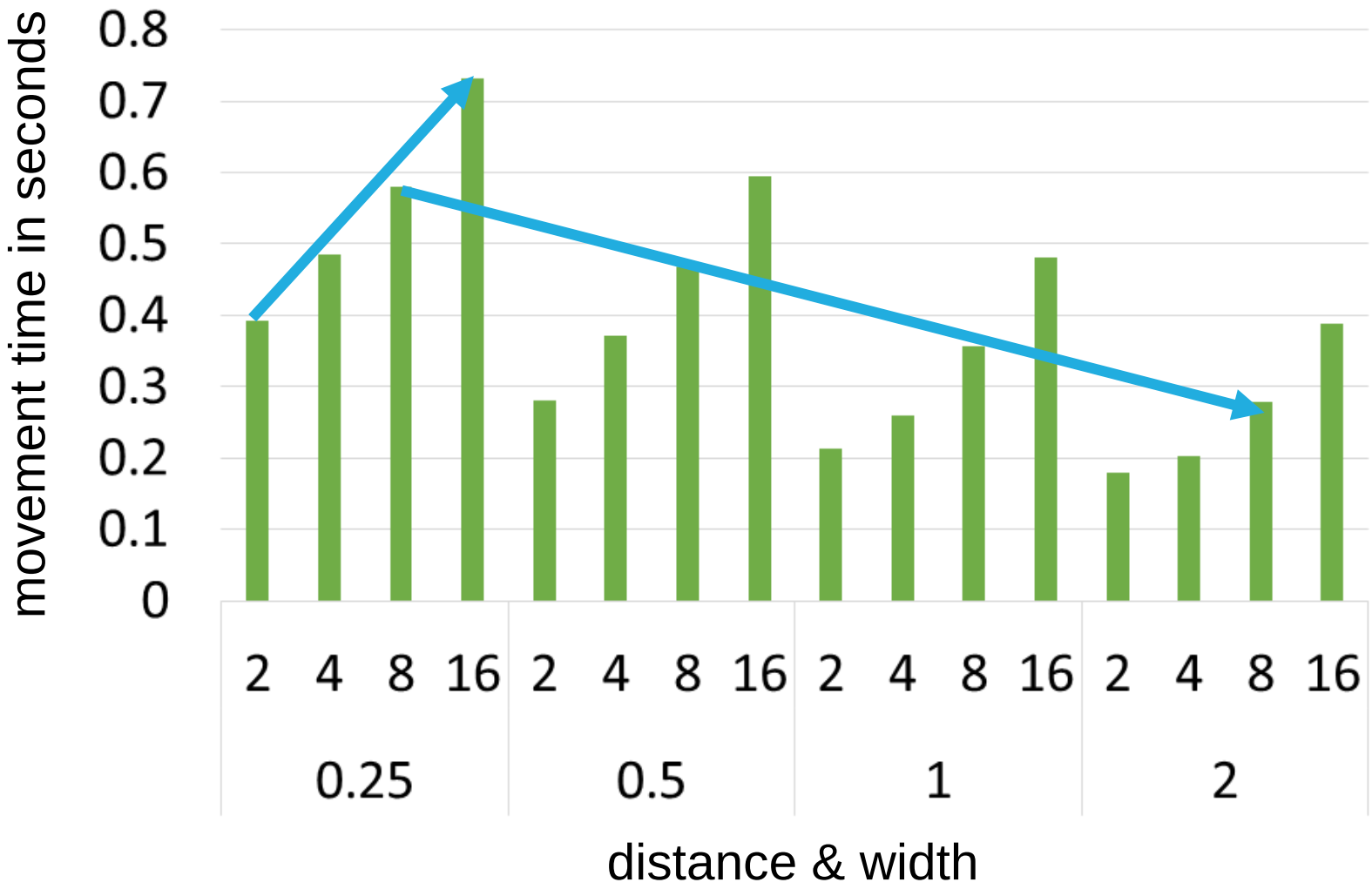
Four widths:

- 0.25, 0.5, 1.0, 2.0 inch

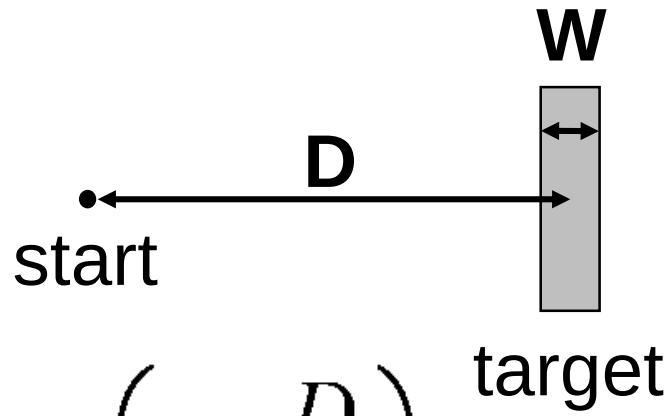
From: Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of experimental psychology, 47(6), 381.



From: Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of experimental psychology, 47(6), 381.



The movement time (MT) to select a target is a function of the target's width (W) and distance (D). It depends on the input device.



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

MT: movement time

a & b: input device-dependent constants

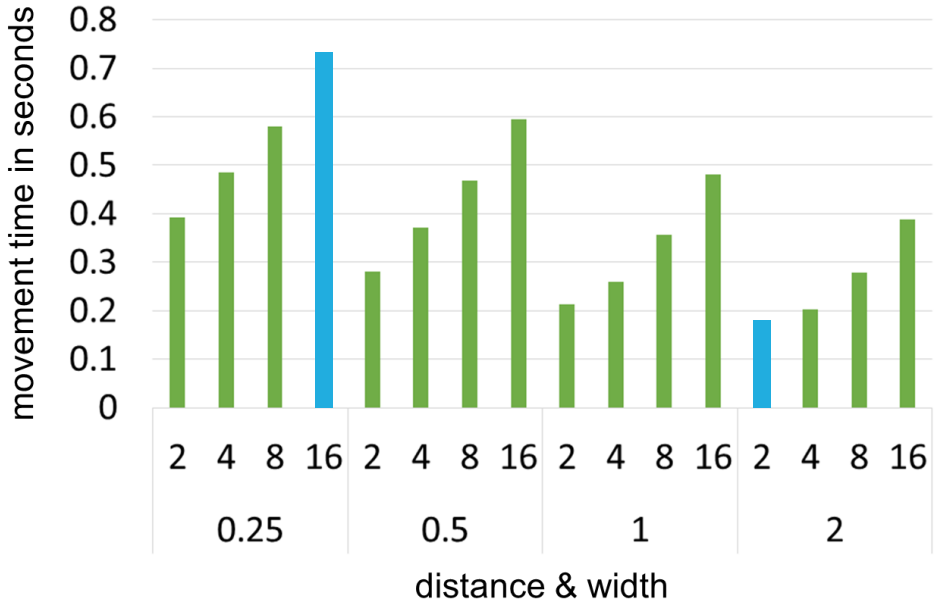
D: distance to the target

W: width of the target

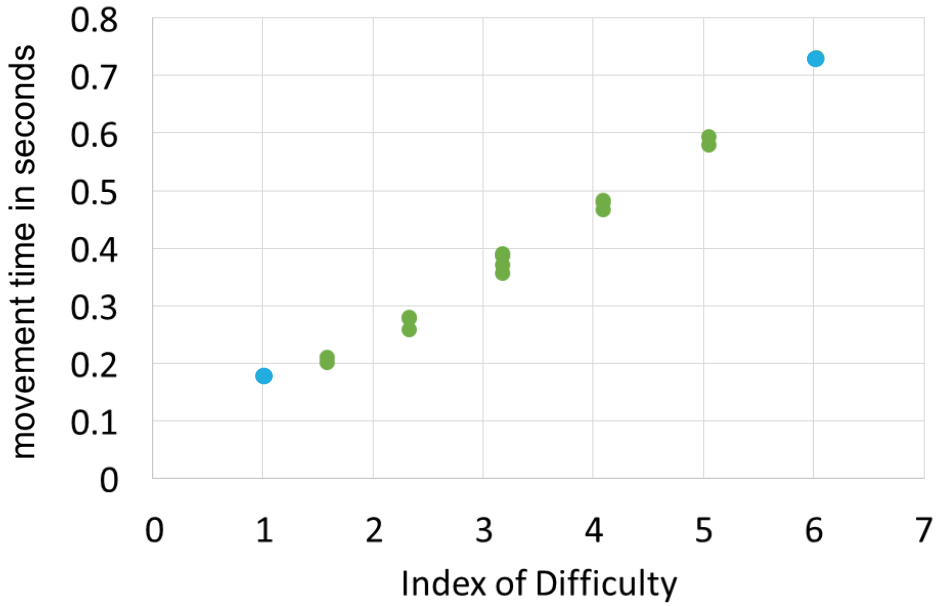
$$MT = a + b \underbrace{\log_2\left(1 + \frac{D}{W}\right)}$$

- Index of Difficulty, ID = $\log_2\left(1 + \frac{D}{W}\right)$
  - MT = a + b ·ID
  - ID how difficult a task is independent from the input device

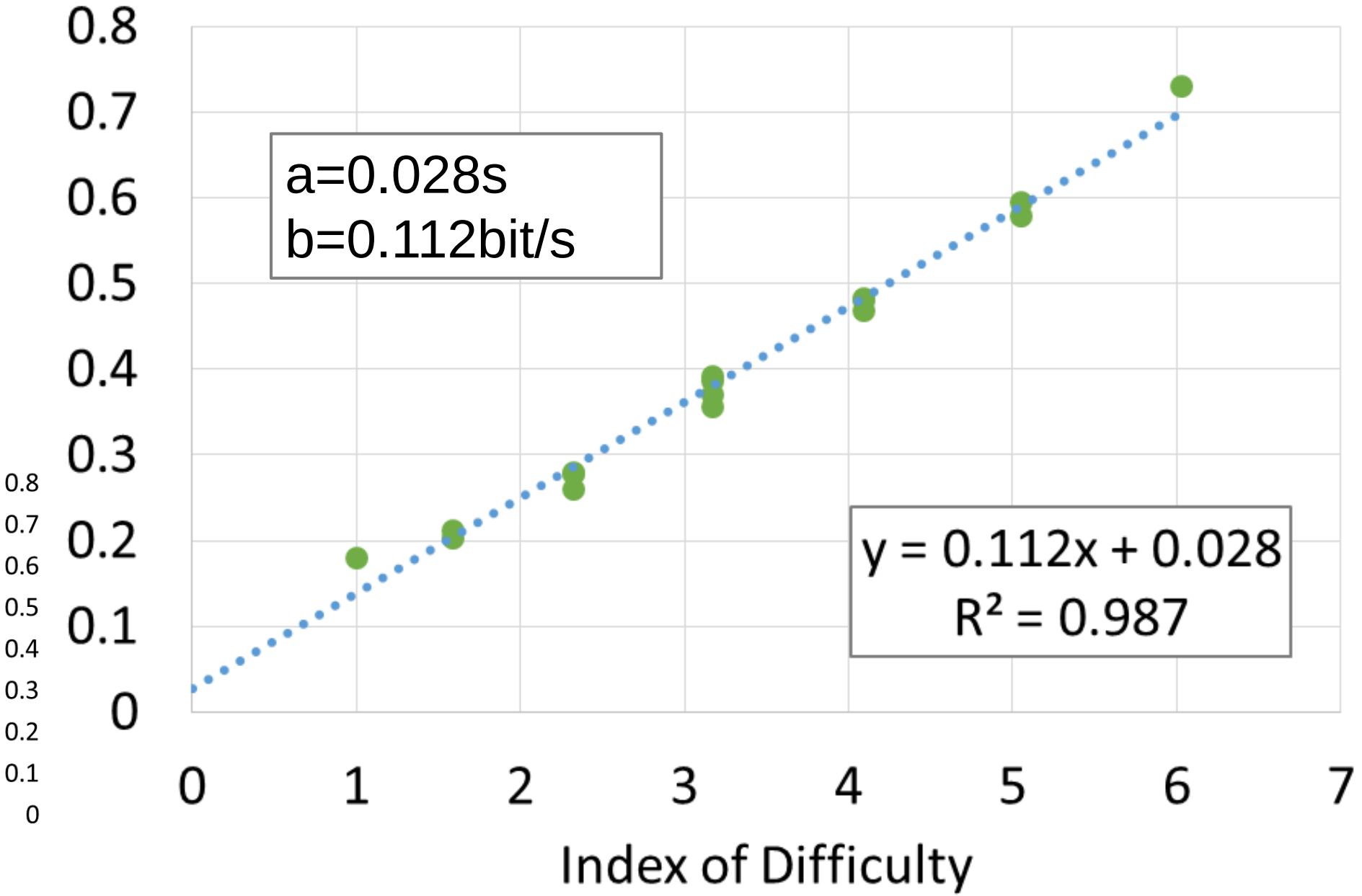
- Units:
  - a is measured in seconds
  - b is measured in seconds per bit
  - Index of Difficulty (ID) is described in bits



$$ID = \log_2\left(1 + \frac{D}{W}\right)$$



- D=16, W=0.25
- ID=$\log_2(1+64)$=6.02


a=0.028s
b=0.112bit/s
y = 0.112x + 0.028
R² = 0.987
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
Index of Difficulty

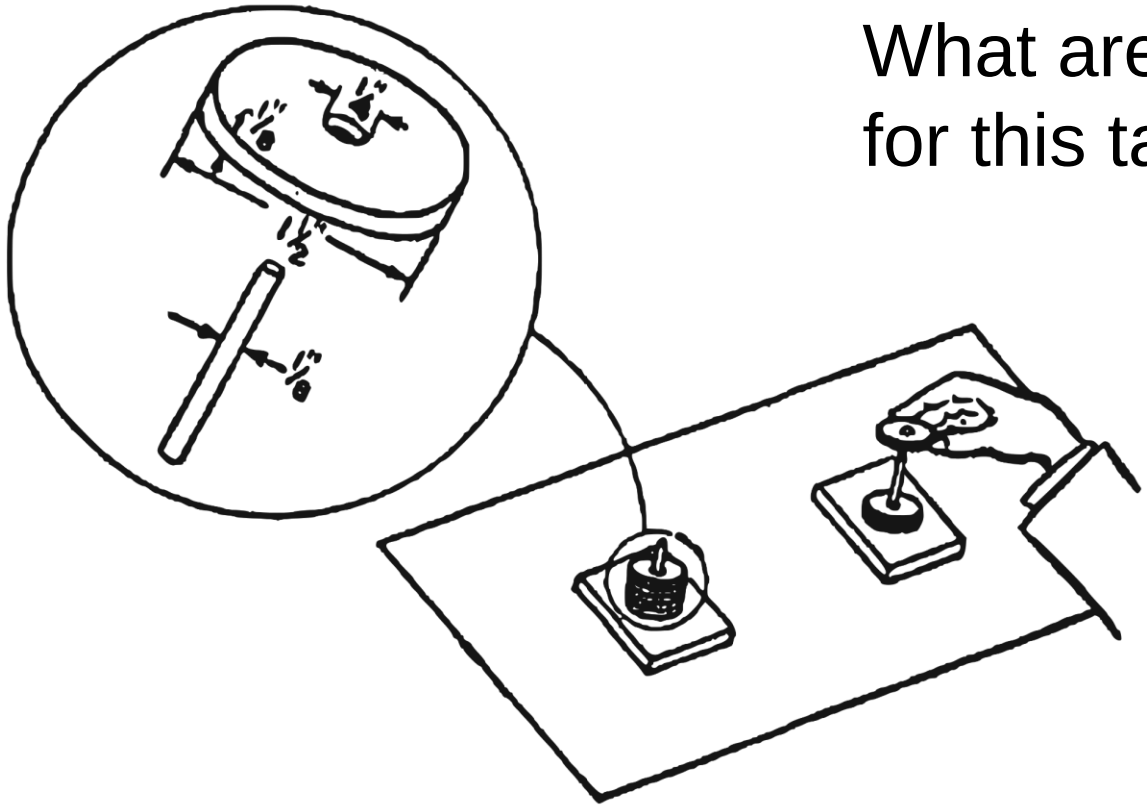
$$MT = a + b \log_2\left(1 + \frac{D}{W}\right)$$

- a=0.028s
- b=0.112s/bit

- How long does it take to select a target that is 21 inch away and 3 inch wide?
- MT = $0.028+0.112*\log_2(1+7)$
- = $0.028+0.112*\log_2(8)$
- = $0.028+0.112*3$
- = 0.364ms

From: Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of experimental psychology, 47(6), 381.

width	distance	MT
0.0625	4	0.697
0.0625	8	0.771
0.0625	16	0.896
0.0625	32	1.096
0.125	4	0.649
0.125	8	0.734
0.125	16	0.844
0.125	32	1.028
0.25	4	0.607
0.25	8	0.672
0.25	16	0.771
0.25	32	0.975
0.5	4	0.535
0.5	8	0.623
0.5	16	0.724
0.5	32	0.902



What are a and b for this task?

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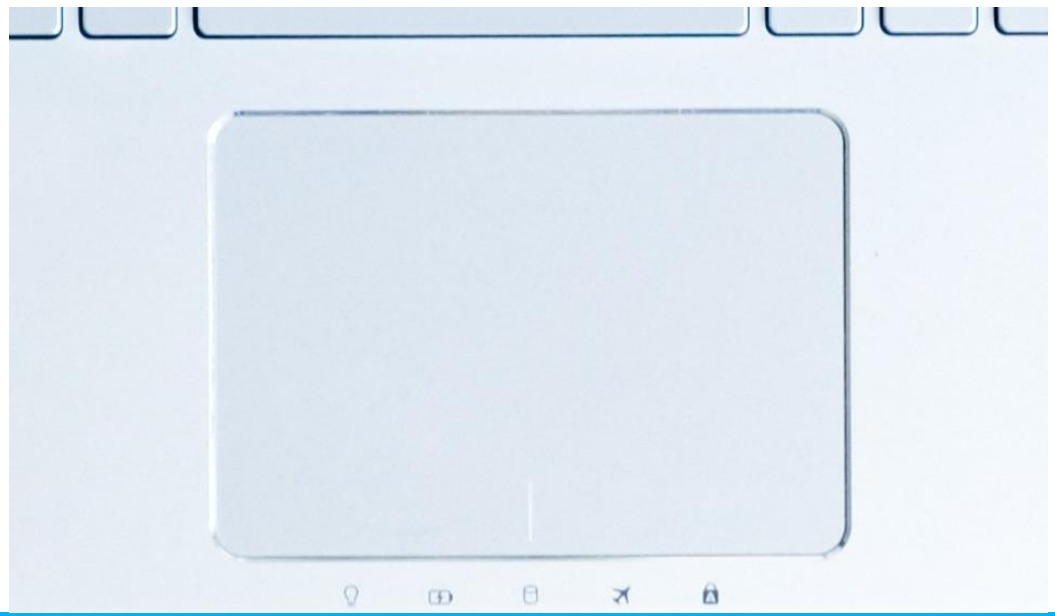
For more content see: https://hci-lecture.de

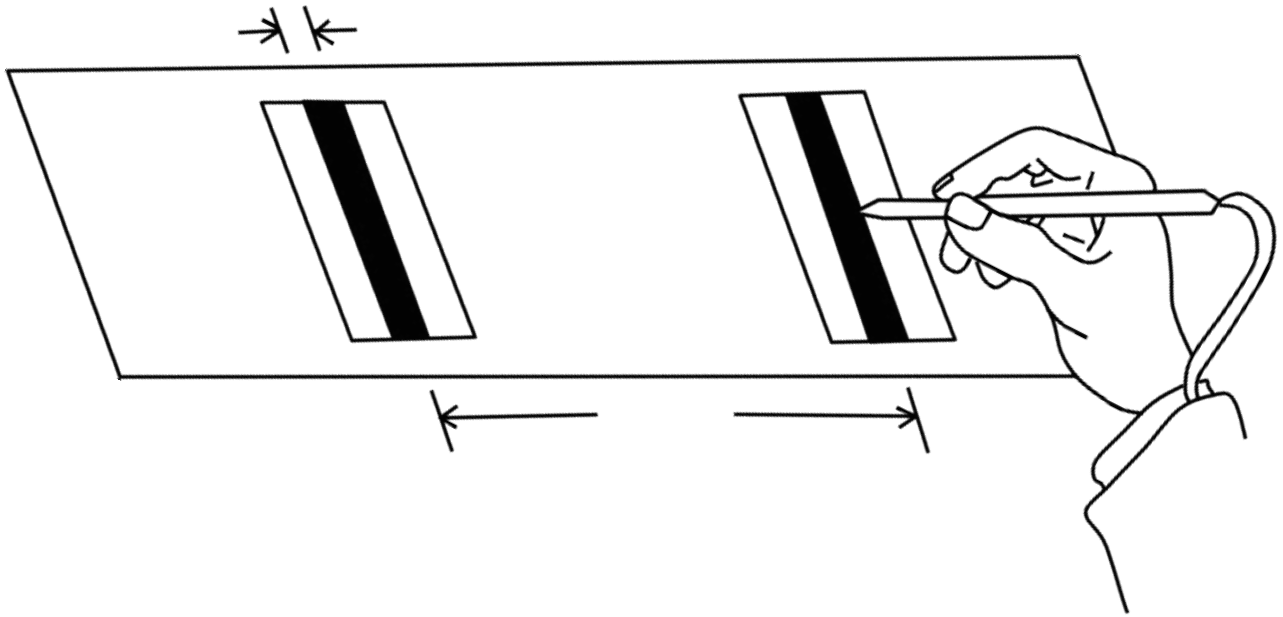



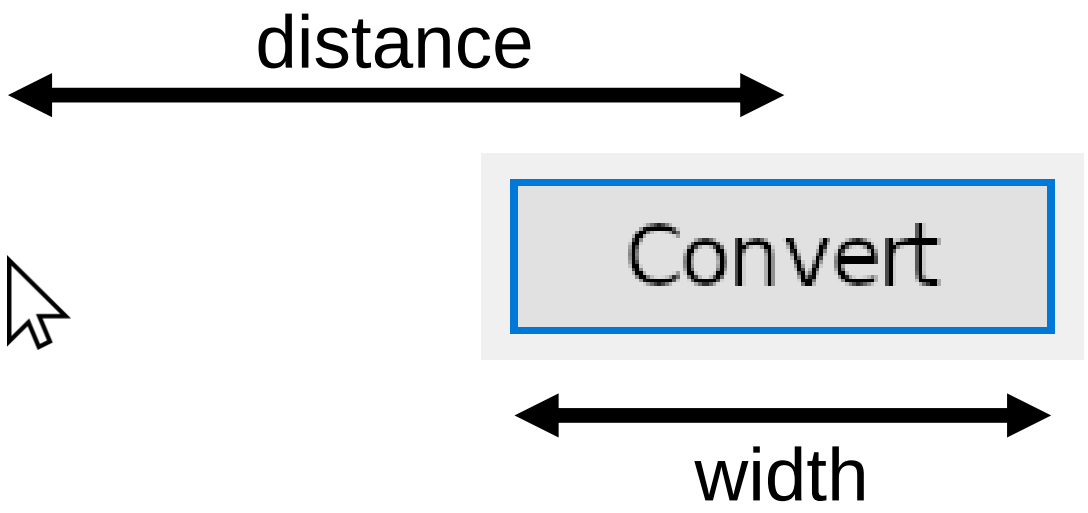
Applications of Fitts' Law

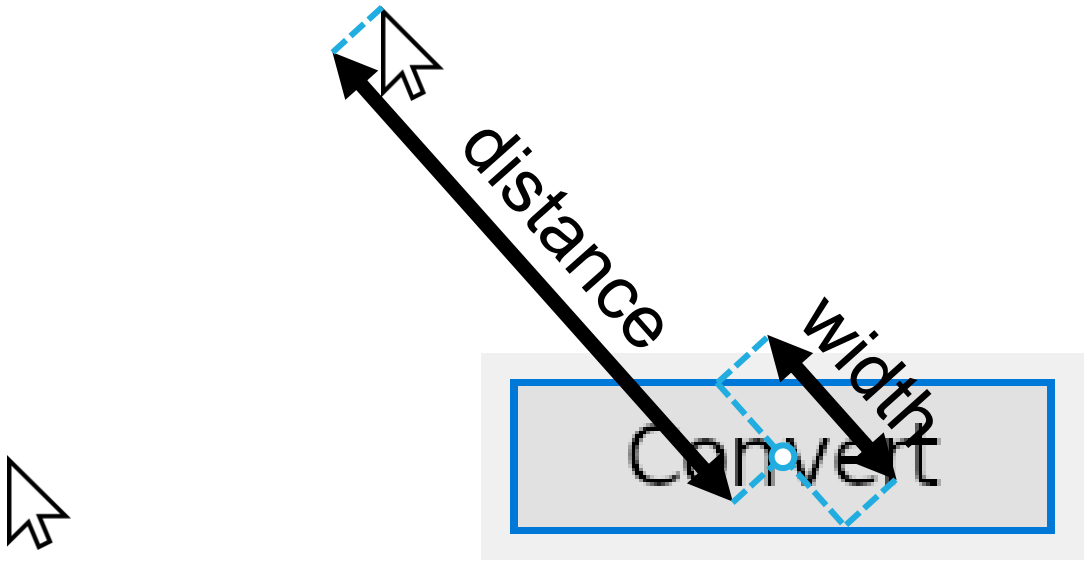
Images adapted from https://pixabay.com/de/photos/computer-laptop-arbeitsplatz-maus-2982270 by Skitterphoto

Learning Goals

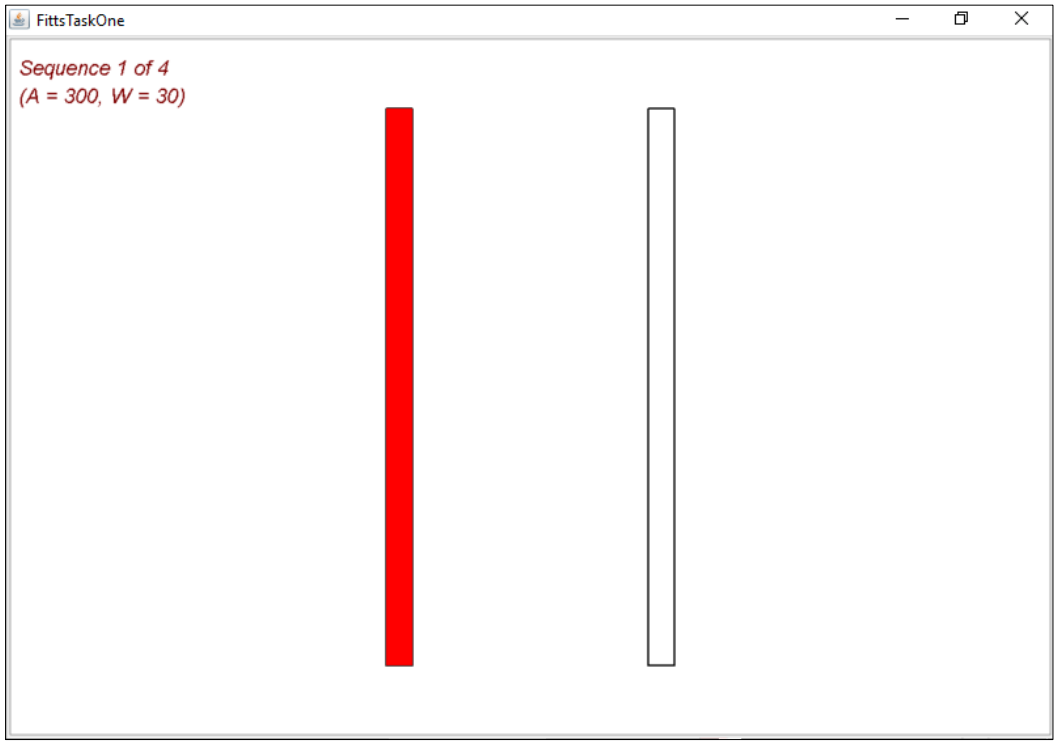
- Know how to extend Fitts' Law to two dimensions
- Understand how Fitts' Law can be helpful for HCI
- Being able to compare input devices using throughput

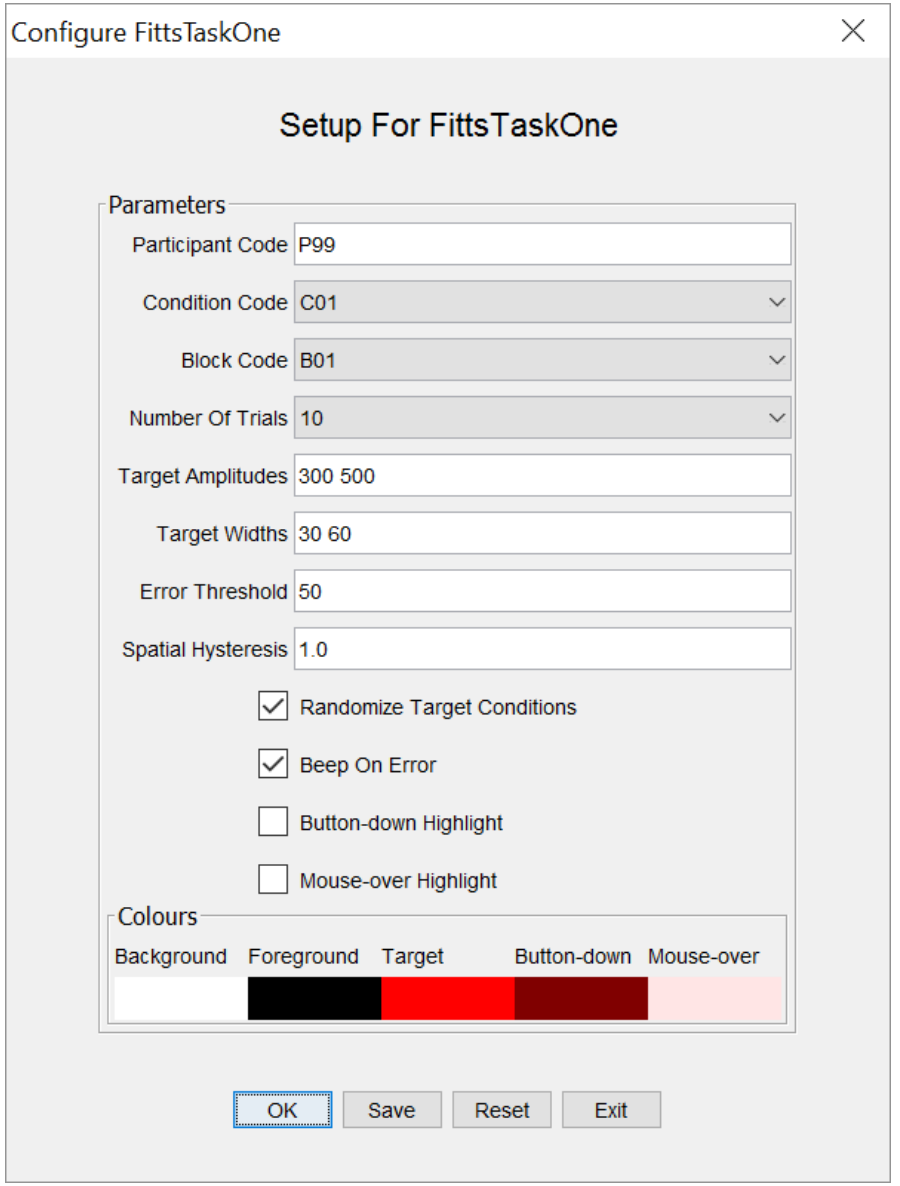



distance
Convert
width



What are width
and distance?

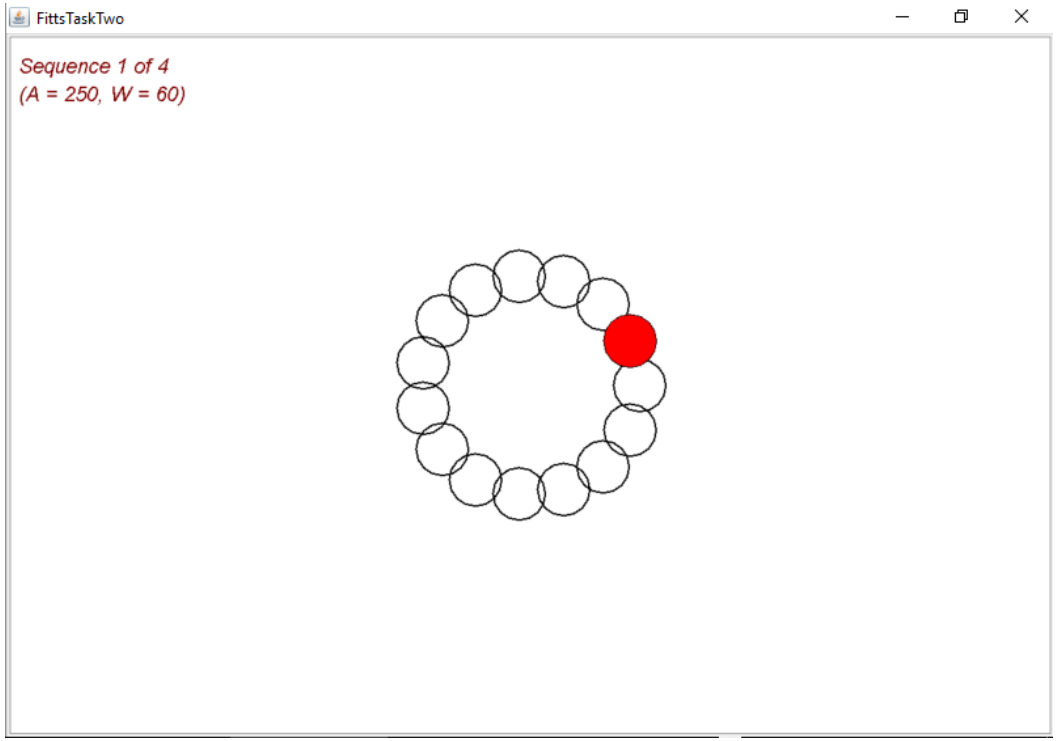


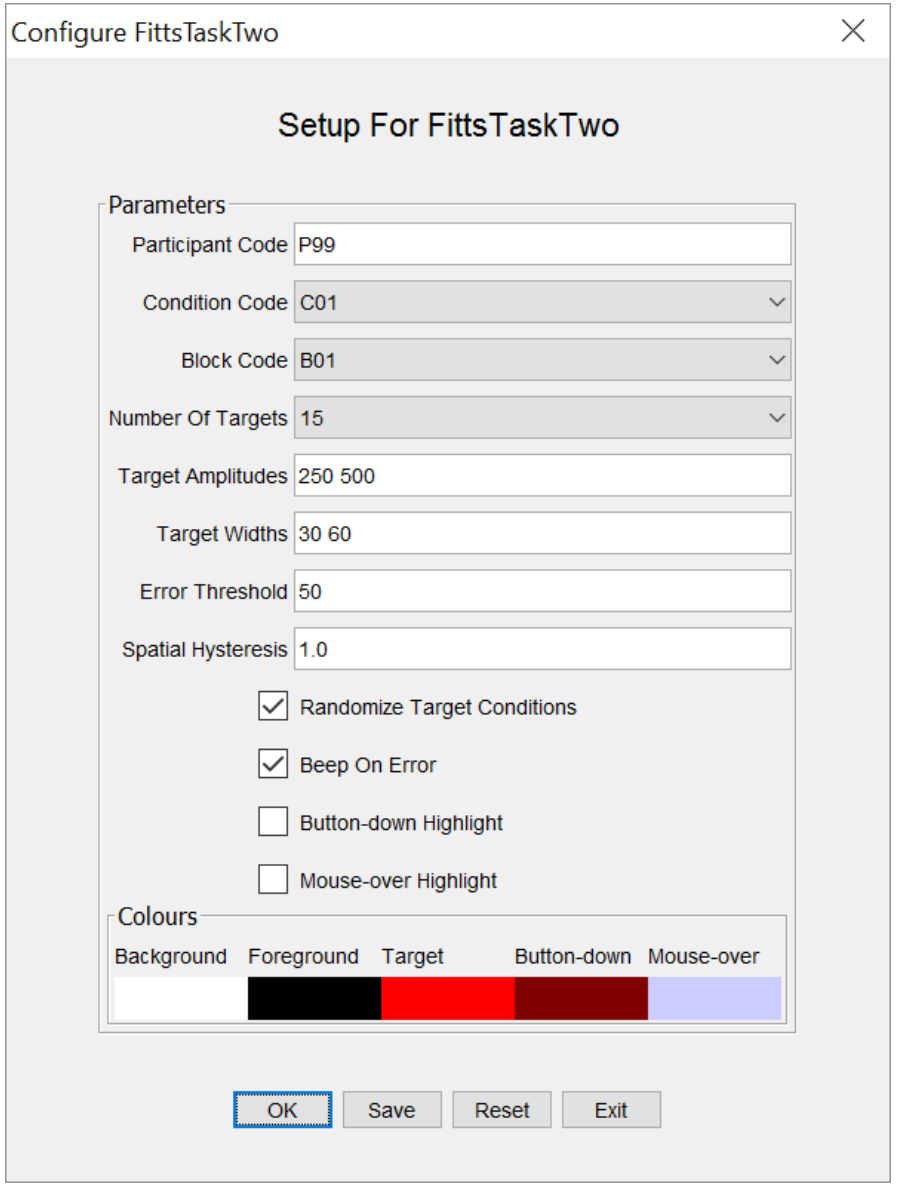


Commonly using a fixed set of amplitudes and Widths, e.g.:

- Amplitude (A): 64, 128, 256, 512 pixels
- Width (W): 8, 16, 32, 64 pixels

By Scott MacKenzie from http://www.yorku.ca/mack/

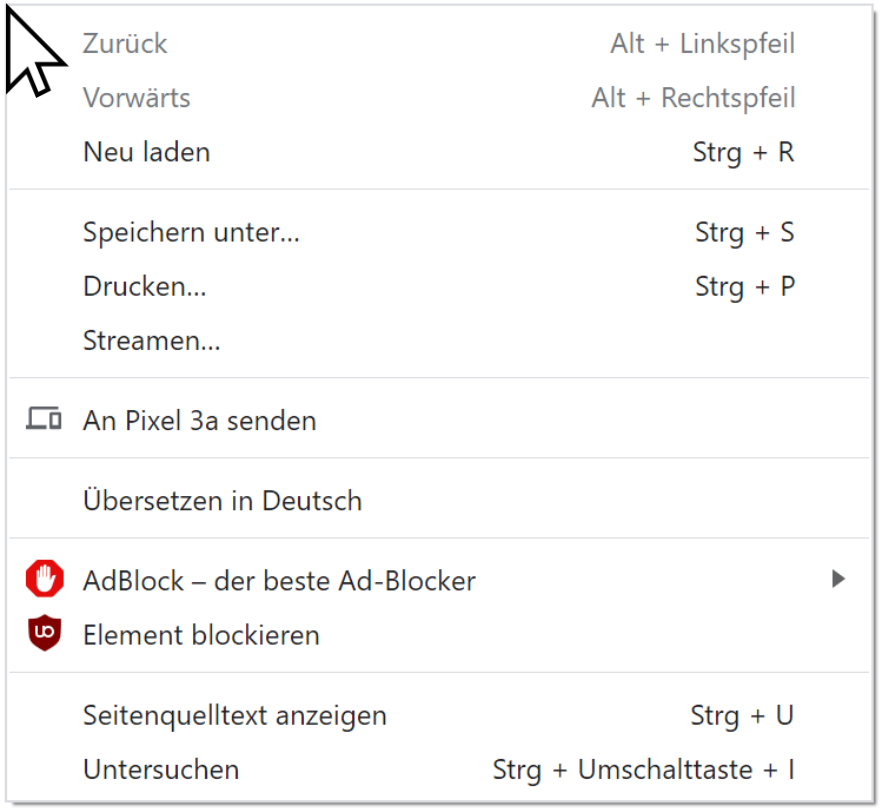




Commonly using a fixed set of amplitudes and Widths, e.g.:

- Amplitude (A): 64, 128, 256, 512 pixels
- Width (W): 8, 16, 32, 64 pixels


Convert


Zurück
Alt + Linkspfeil
Vorwärts
Alt + Rechtspfeil
Neu laden
Strg + R
Speichern unter...
Strg + S
Drucken...
Strg + P
Streamen...
An Pixel 3a senden
Übersetzen in Deutsch
AdBlock – der beste Ad-Blocker
Element blockieren
Seitenquelltext anzeigen
Strg + U
Untersuchen
Strg + Umschalttaste + I

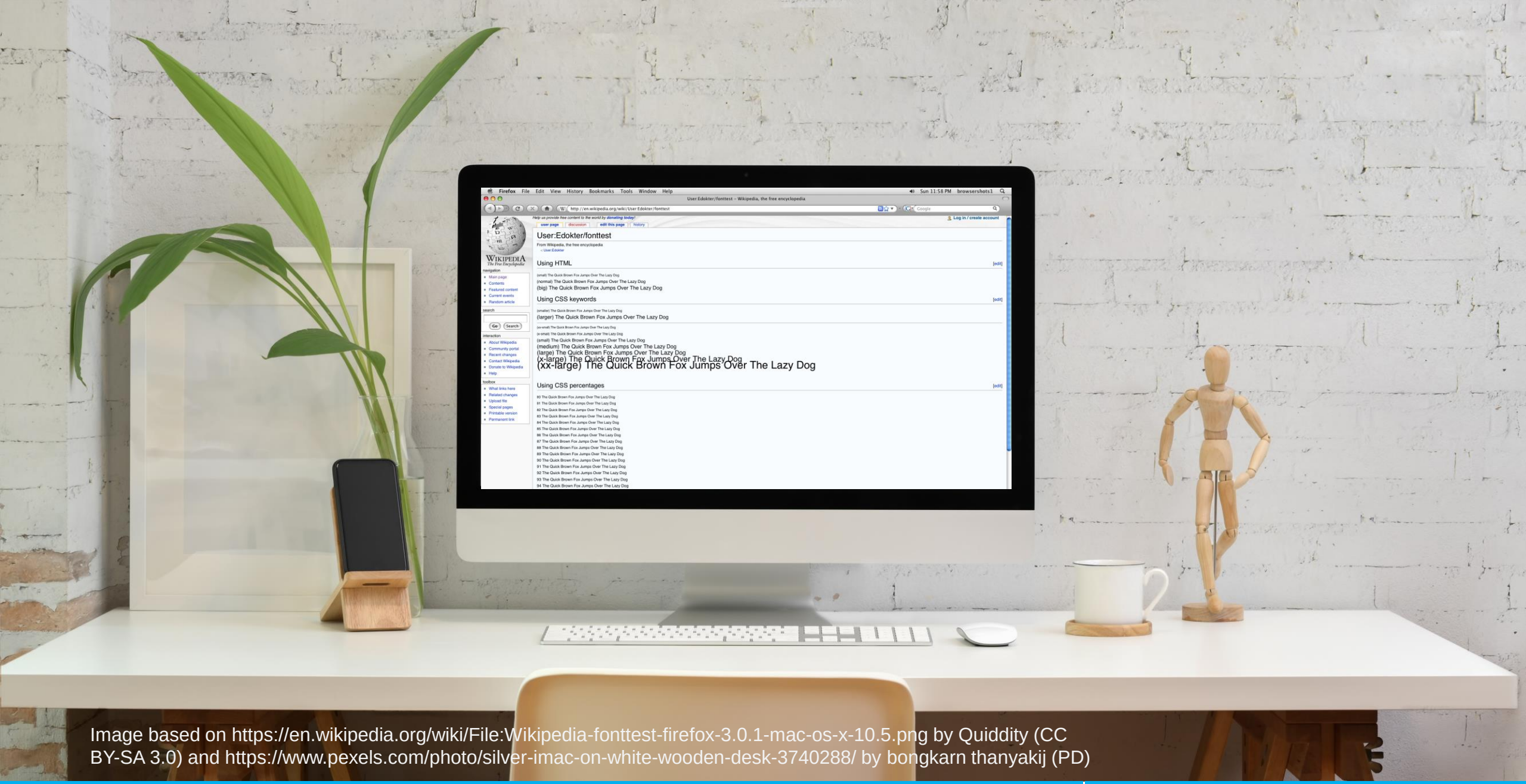
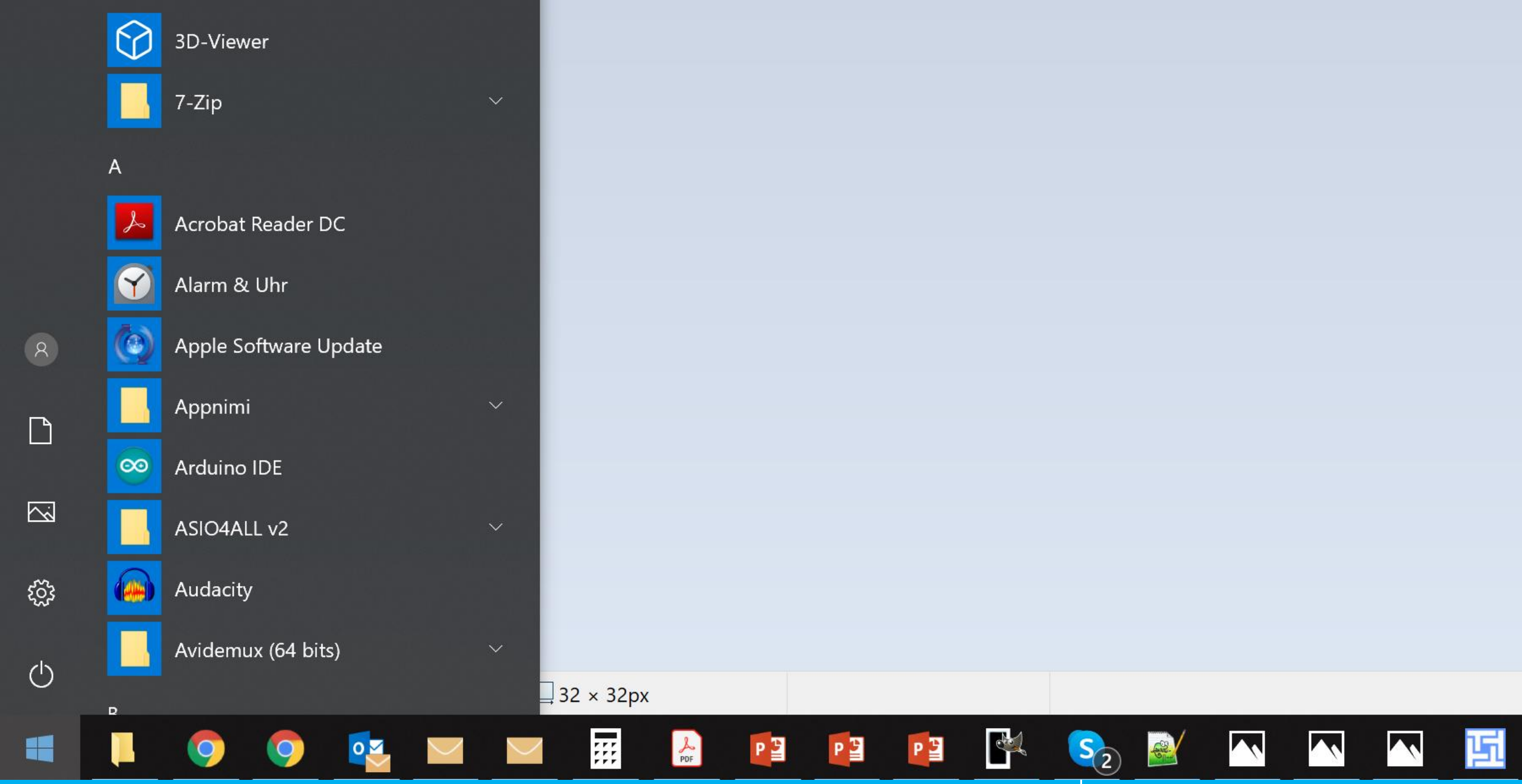
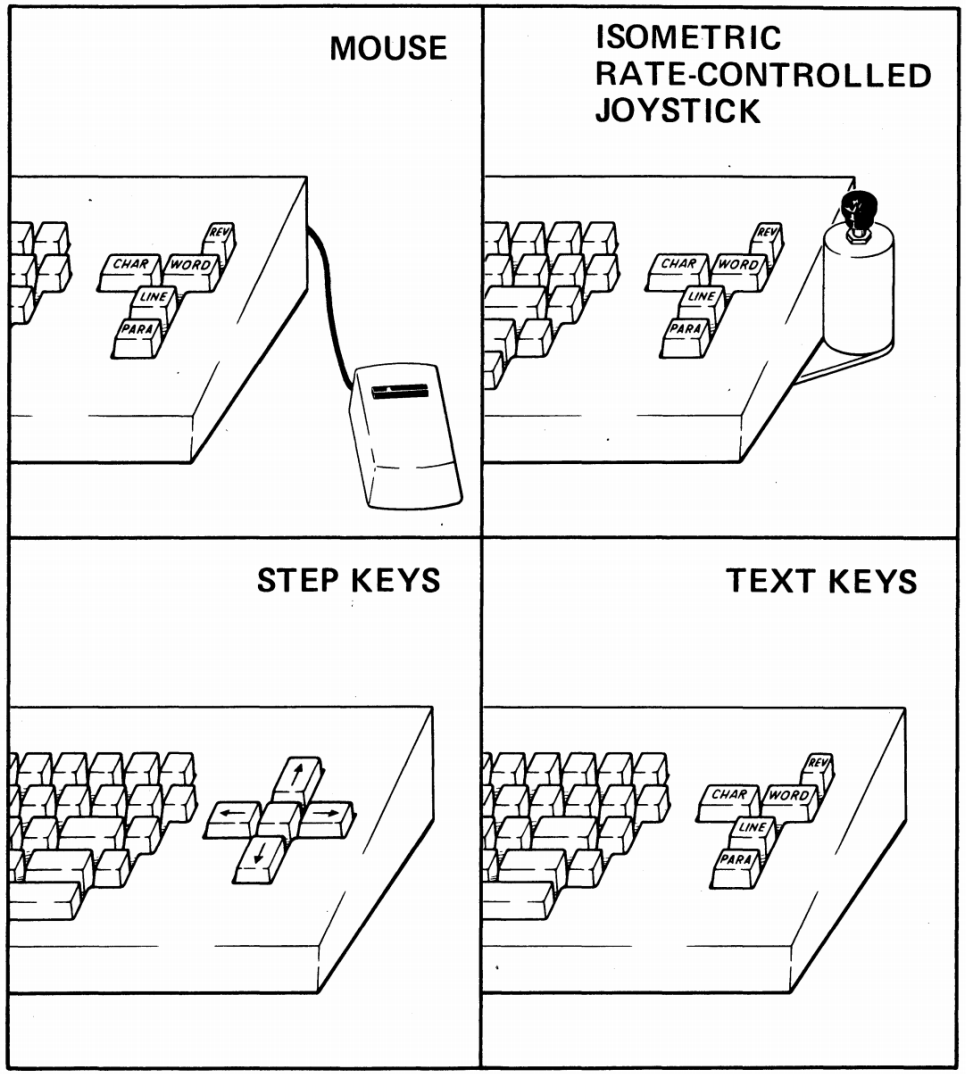


Image based on https://en.wikipedia.org/wiki/File:Wikipedia-fonttest-firefox-3.0.1-mac-os-x-10.5.png by Quiddity (CC BY-SA 3.0) and https://www.pexels.com/photo/silver-imac-on-white-wooden-desk-3740288/ by bongkarn thanyakij (PD)


3D-Viewer
7-Zip
A
Acrobat Reader DC
Alarm & Uhr
Apple Software Update
Appnimi
Arduino IDE
ASIO4ALL v2
Audacity
Avidemux (64 bits)
32 × 32px



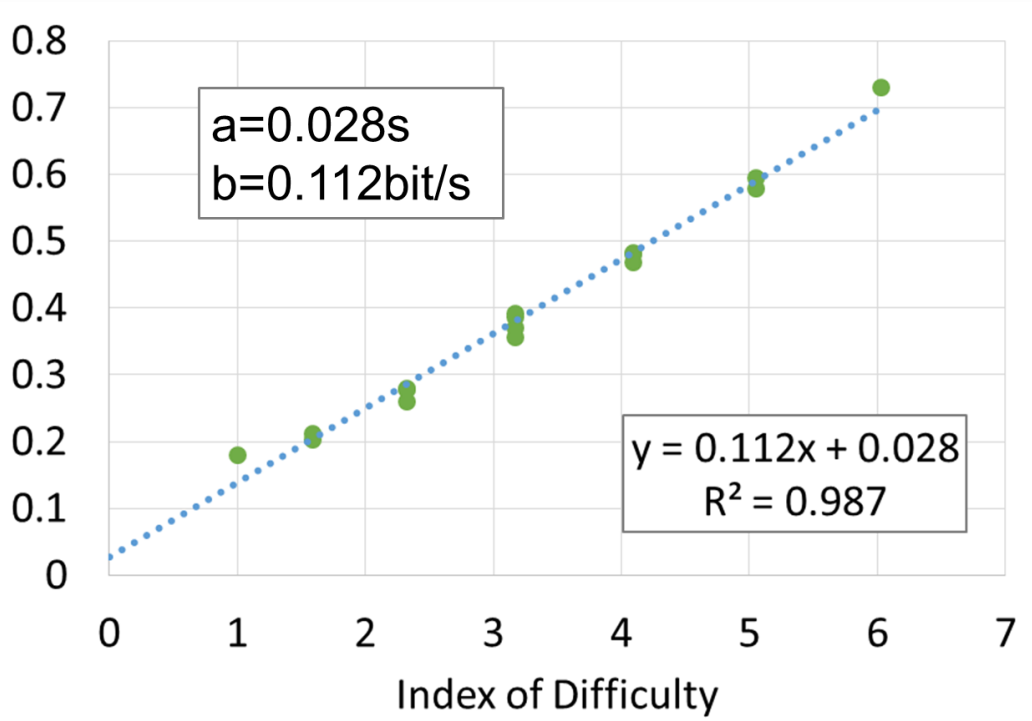
Using Fitts' Law "was a major factor leading to the mouse's commercial introduction by Xerox"

http://www2.parc.com/istl/groups/uir/people/stuart/stuart.htm

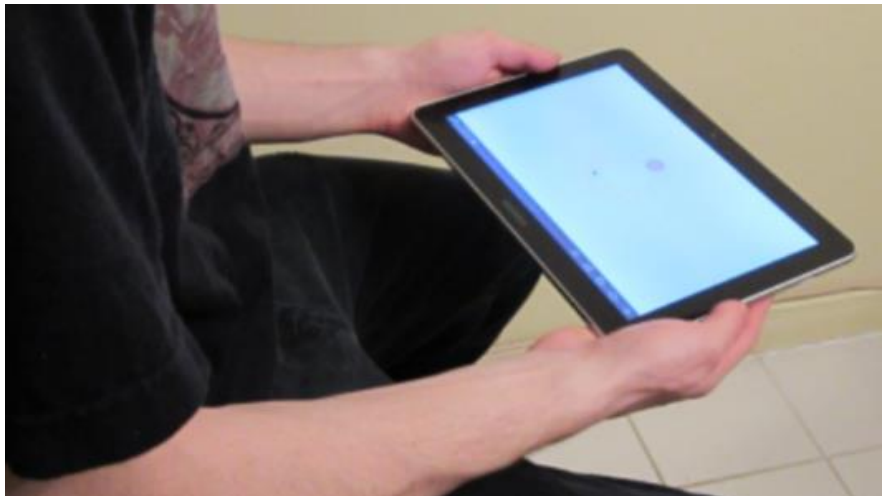
Image from Card, S. K., English, W. K., & Burr, B. J. (1978). Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT. Ergonomics, 21(8), 601-613.

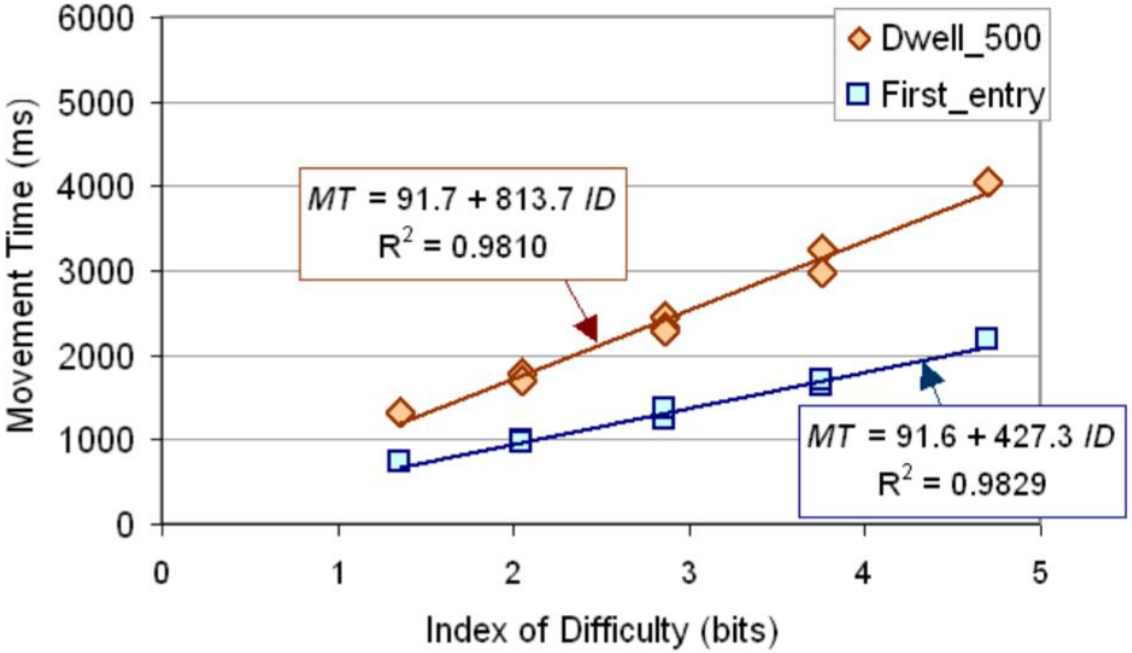
Throughput

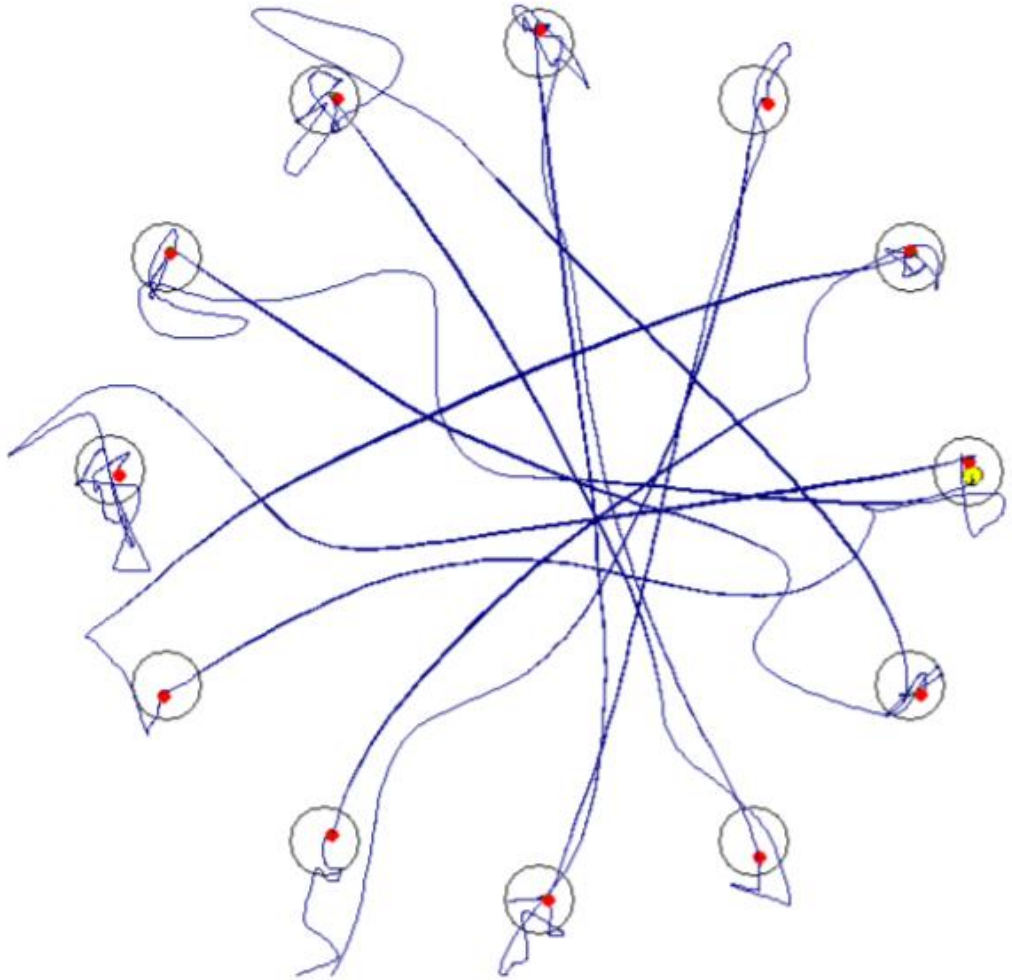
- Single metric for a pointing device
- Different definition:
  - TP = ID / MT (average ID and MT)
  - TP = 1 / b (equivalent to ID / MT if a=0)



- Sufficient to test 6 IDs to determine the device-specific constants a and b
- 6 IDs are enough to compare pointing devices







MacKenzie, I. S., & Teather, R. J. (2012). FittsTilt: the application of Fitts' law to tilt-based interaction. NordiCHI

mouse

touchscreen

Which device has the highest throughput?

touchpad

Images adapted from https://pixabay.com/de/photos/computer-laptop-arbeitsplatz-maus-2982270 by Skitterphoto

For more content see: https://hci-lecture.de

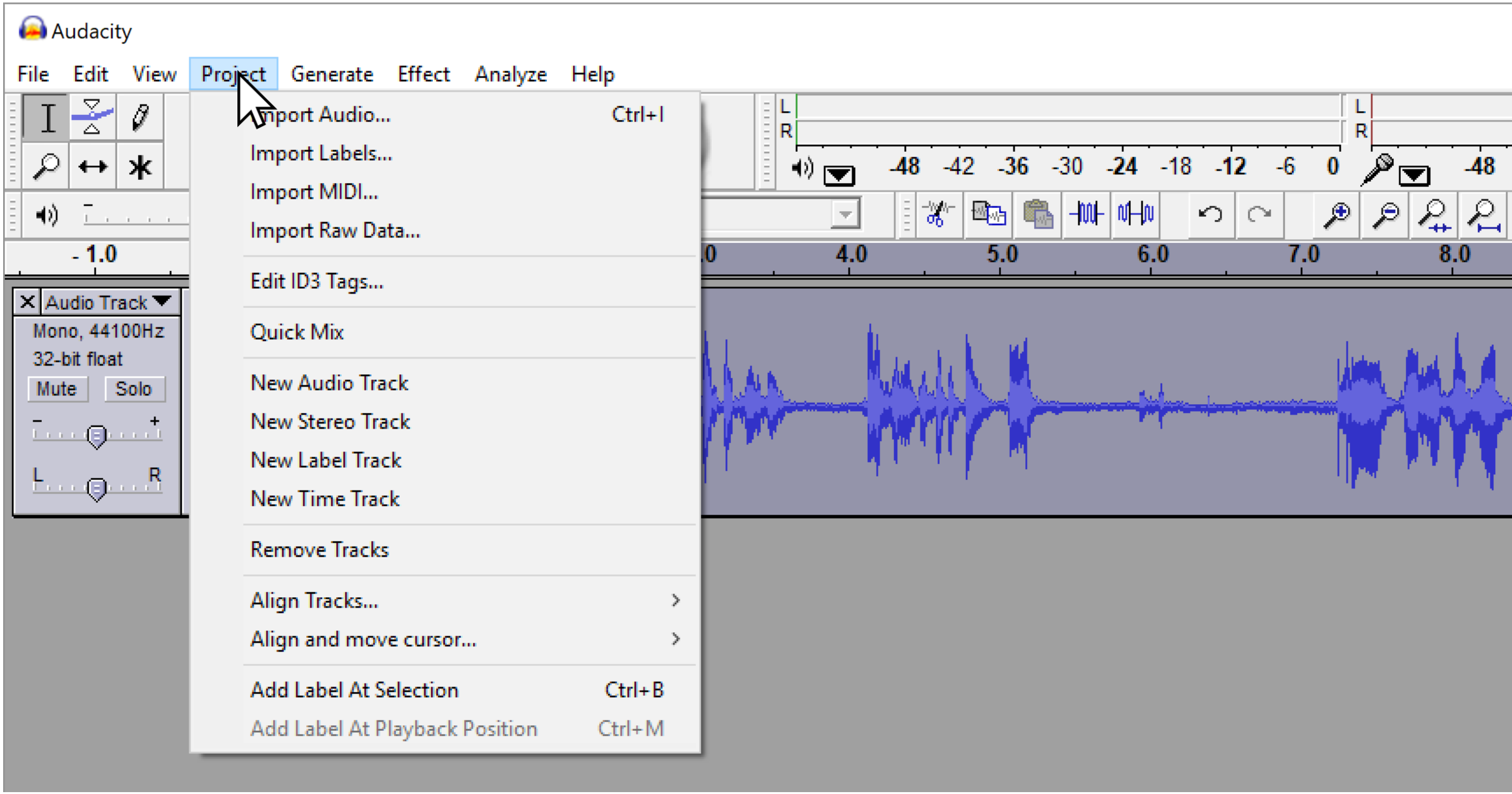

From https://www.pexels.com/photo/woman-sitting-in-vehicle-3007318/

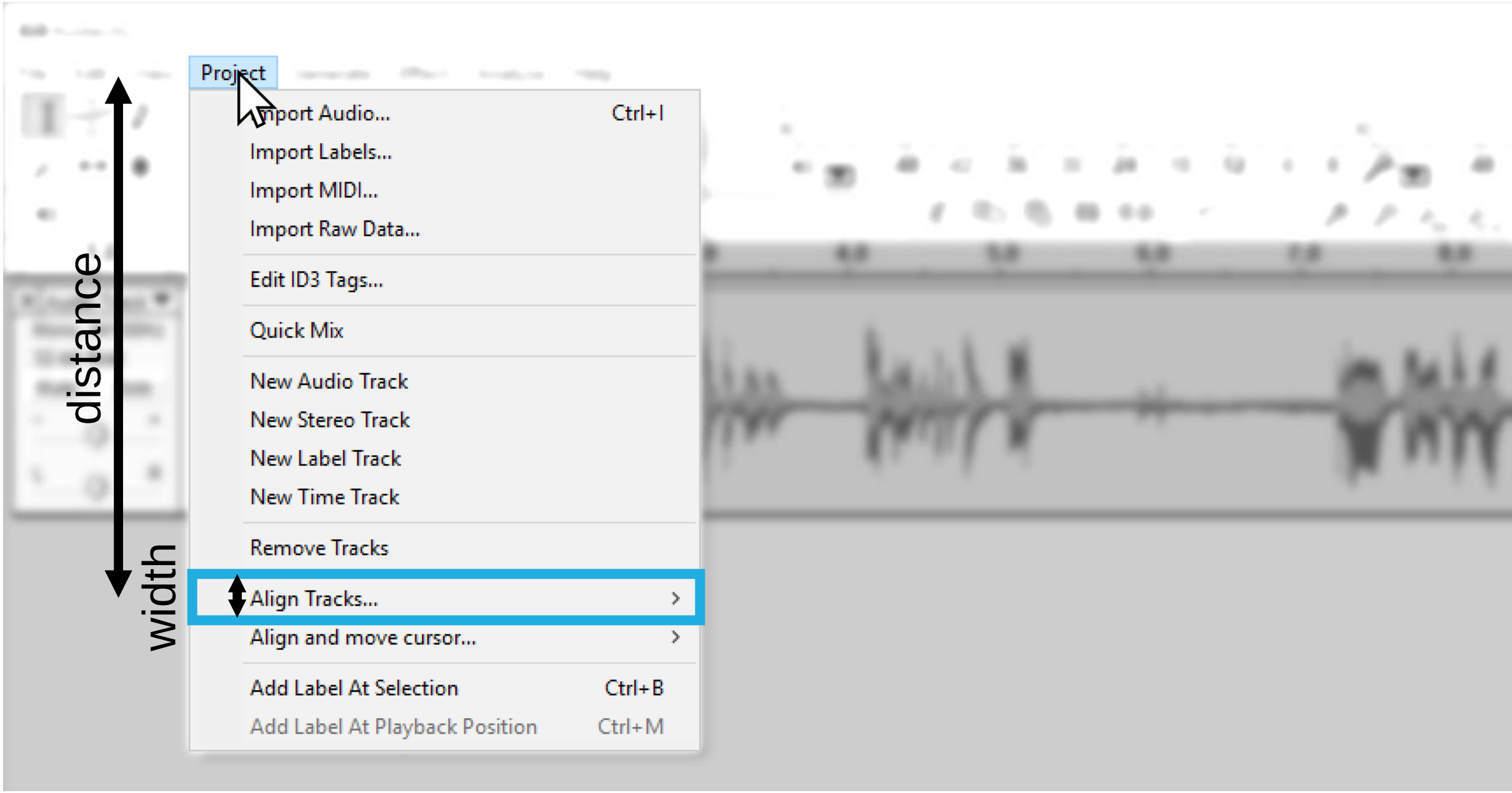
Steering through Tunnels

Niels Henze

Learning Goals

- Understand what we mean by ‘steering through a tunnel’
- Know the differences between Fitts’ Law and Steering Law
- Being able to determine the time to steer through a tunnel


Audacity
File
Edit
View
Project
Generate
Effect
Analyze
Help
Import Audio... Ctrl+I
Import Labels...
Import MIDI...
Import Raw Data...
Edit ID3 Tags...
Quick Mix
New Audio Track
New Stereo Track
New Label Track
New Time Track
Remove Tracks
Align Tracks...
Align and move cursor...
Add Label At Selection Ctrl+B
Add Label At Playback Position Ctrl+M
Audio Track
Mono, 44100Hz
32-bit float
Mute
Solo
L
R
-48 -42 -36 -30 -24 -18 -12 -6 0
- 1.0
4.0
5.0
6.0
7.0
8.0


Project
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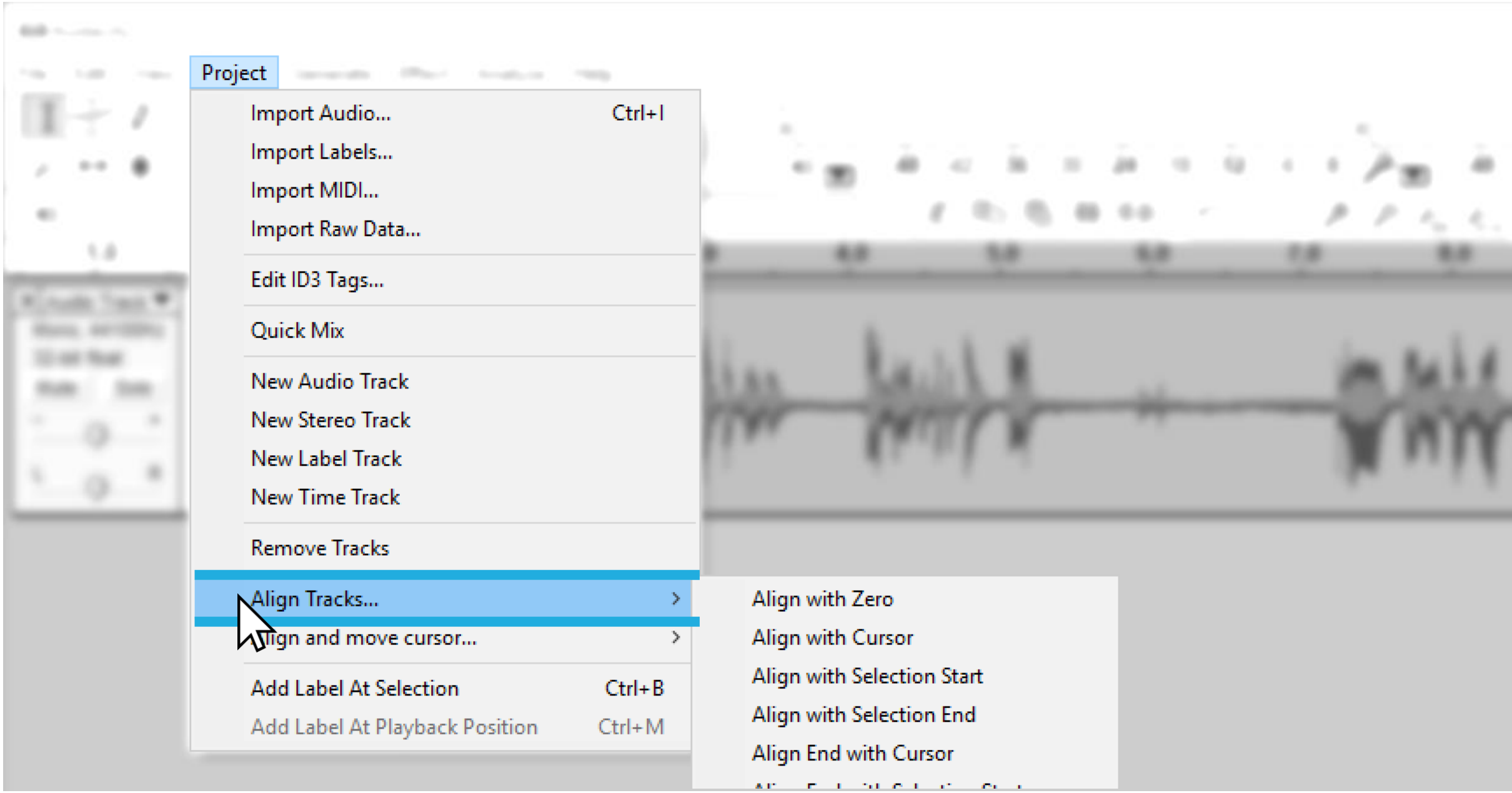
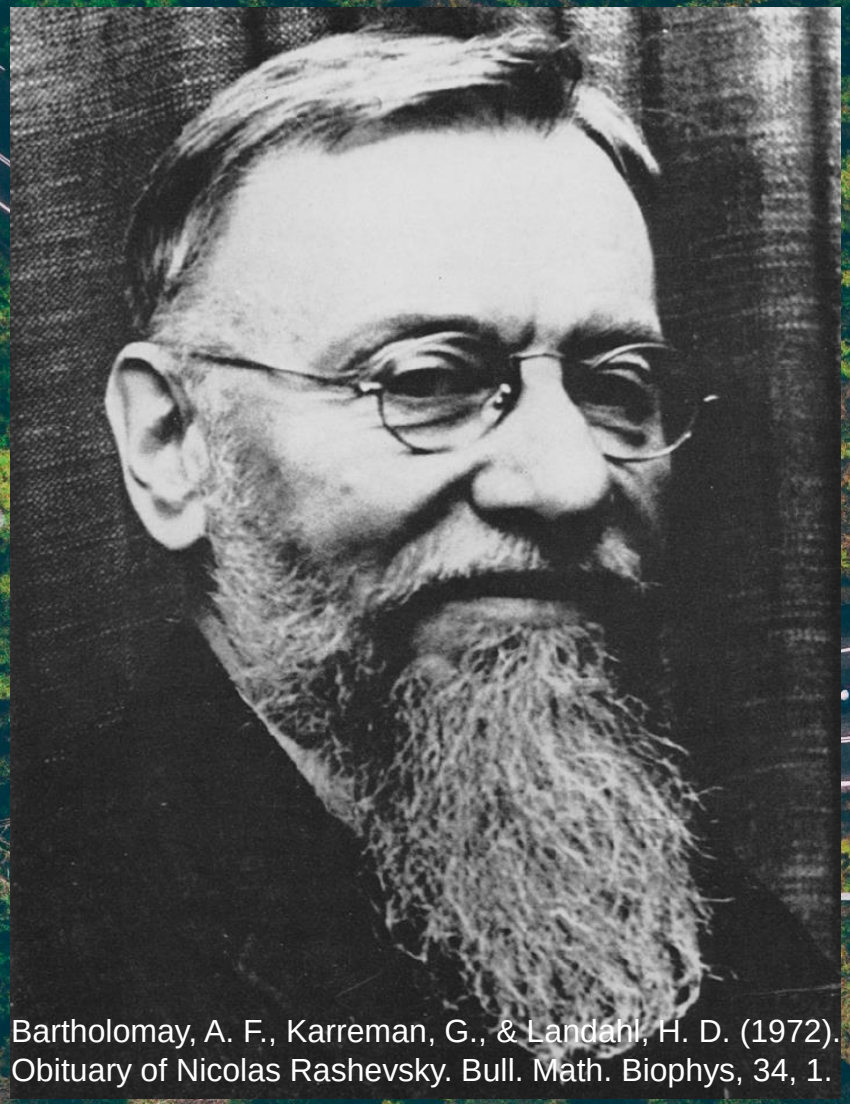
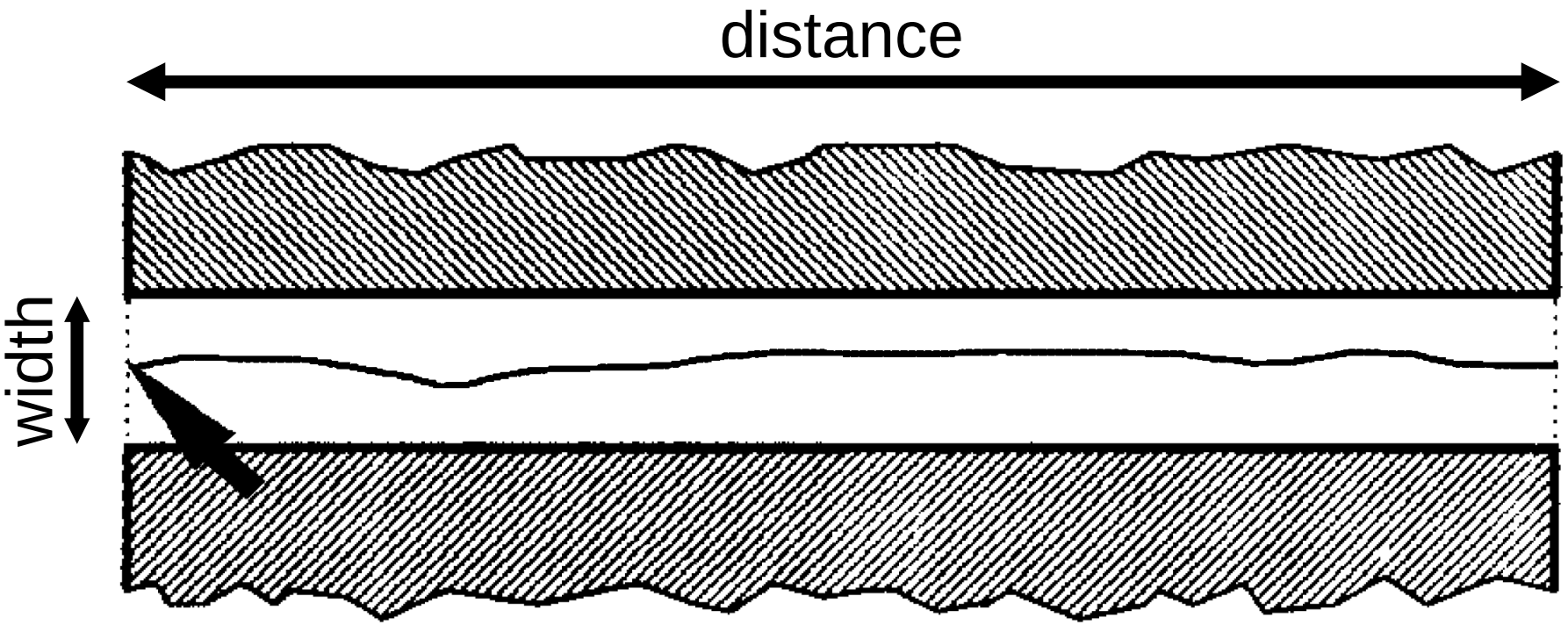
Import Labels...
Import MIDI...
Import Raw Data...
Edit ID3 Tags...
Quick Mix
New Audio Track
New Stereo Track
New Label Track
New Time Track
Remove Tracks
Align Tracks...
Align and move cursor...
Add Label At Selection Ctrl+B
Add Label At Playback Position Ctrl+M
distance
width


Project
Import Audio... Ctrl+I
Import Labels...
Import MIDI...
Import Raw Data...
Edit ID3 Tags...
Quick Mix
New Audio Track
New Stereo Track
New Label Track
New Time Track
Remove Tracks
Align Tracks...
Align and move cursor...
Add Label At Selection Ctrl+B
Add Label At Playback Position Ctrl+M
Align with Zero
Align with Cursor
Align with Selection Start
Align with Selection End
Align End with Cursor

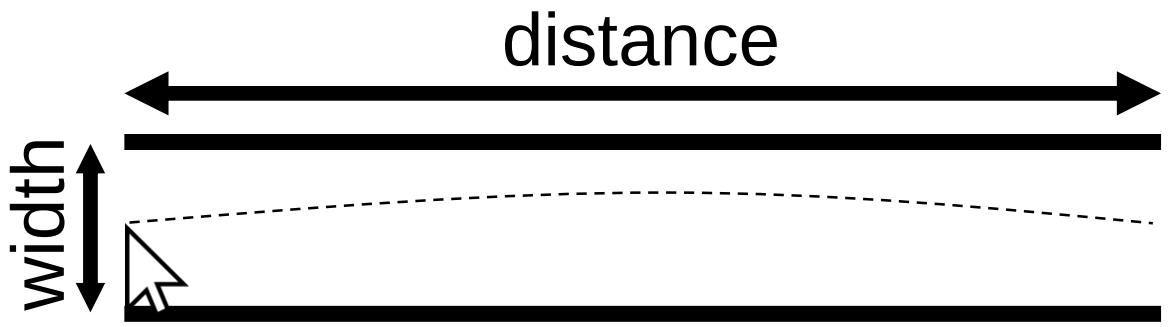


Bartholomay, A. F., Karreman, G., & Landahl, H. D. (1972). Obituary of Nicolas Rashevsky. Bull. Math. Biophys, 34, 1.

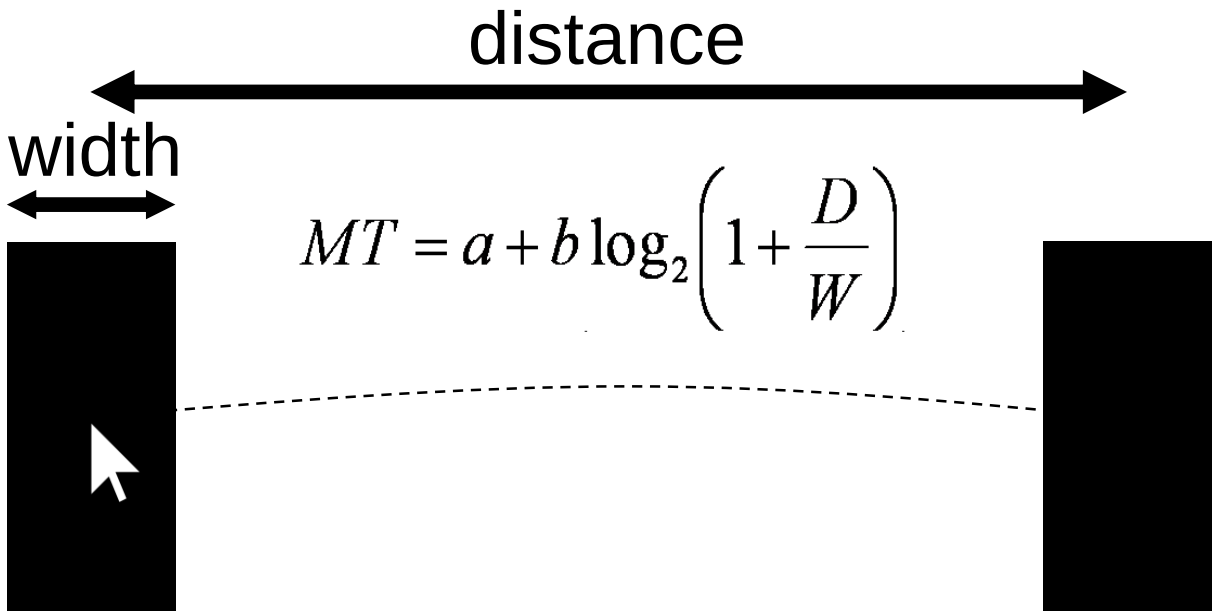
By Deva Darshan from https://www.pexels.com/photo/aerial-view-of-road-in-the-middle-of-trees-1173777 (PD)

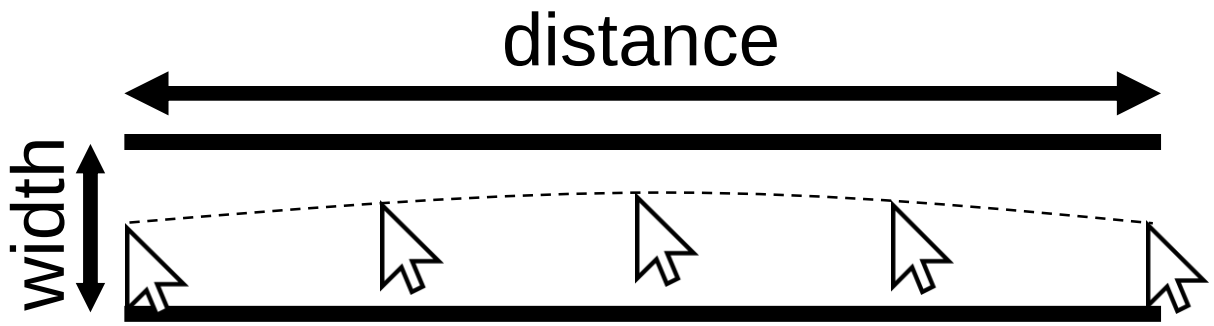


Accot, J., & Zhai, S. (1997). Beyond Fitts' law: models for trajectory-based HCI tasks. CHI'97



What is easier, steering through a tunnel or target selection?





How to change Fitts' Law to model steering tasks?

$$MT = a + b \left(1 + \frac{D}{W}\right)$$

(Accot–Zhai) Steering Law

$$MT = a + b\frac{D}{W}$$

Accot, J., & Zhai, S. (1997). Beyond Fitts' law: models for trajectory-based HCI tasks. CHI'97

(Accot–Zhai) Steering Law

$$MT = a + b\frac{D}{W}$$

From: http://www.amisducena.fr/authors/accot_johnny.shtml

By Kearniel from https://commons.wikimedia.org/wiki/File:Shuminprofile.png (CC BY-SA 4.0)

Accot, J., & Zhai, S. (1997). Beyond Fitts' law: models for trajectory-based HCI tasks. CHI'97

Steering Law Definition

$$MT = a + b\frac{D}{W} \qquad \text{ID} = \frac{D}{W}$$

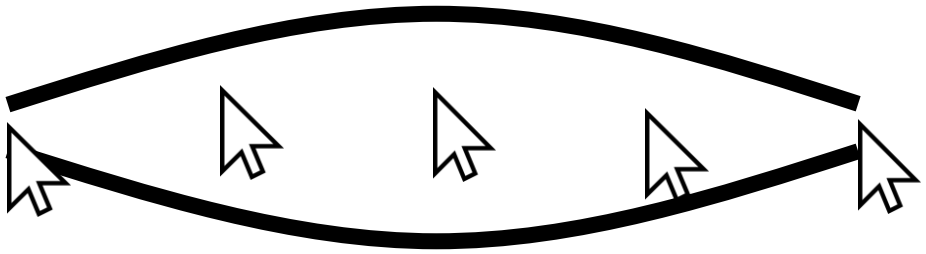
- The movement time (MT) to acquire a target through a tunnel is a function of the length (D) and width (W) of the tunnel. It depends on the input device.

- MT: movement time
- a and b: constants dependent on the pointing system
- D: distance, i.e. length of the tunnel
- W: width of the tunnel

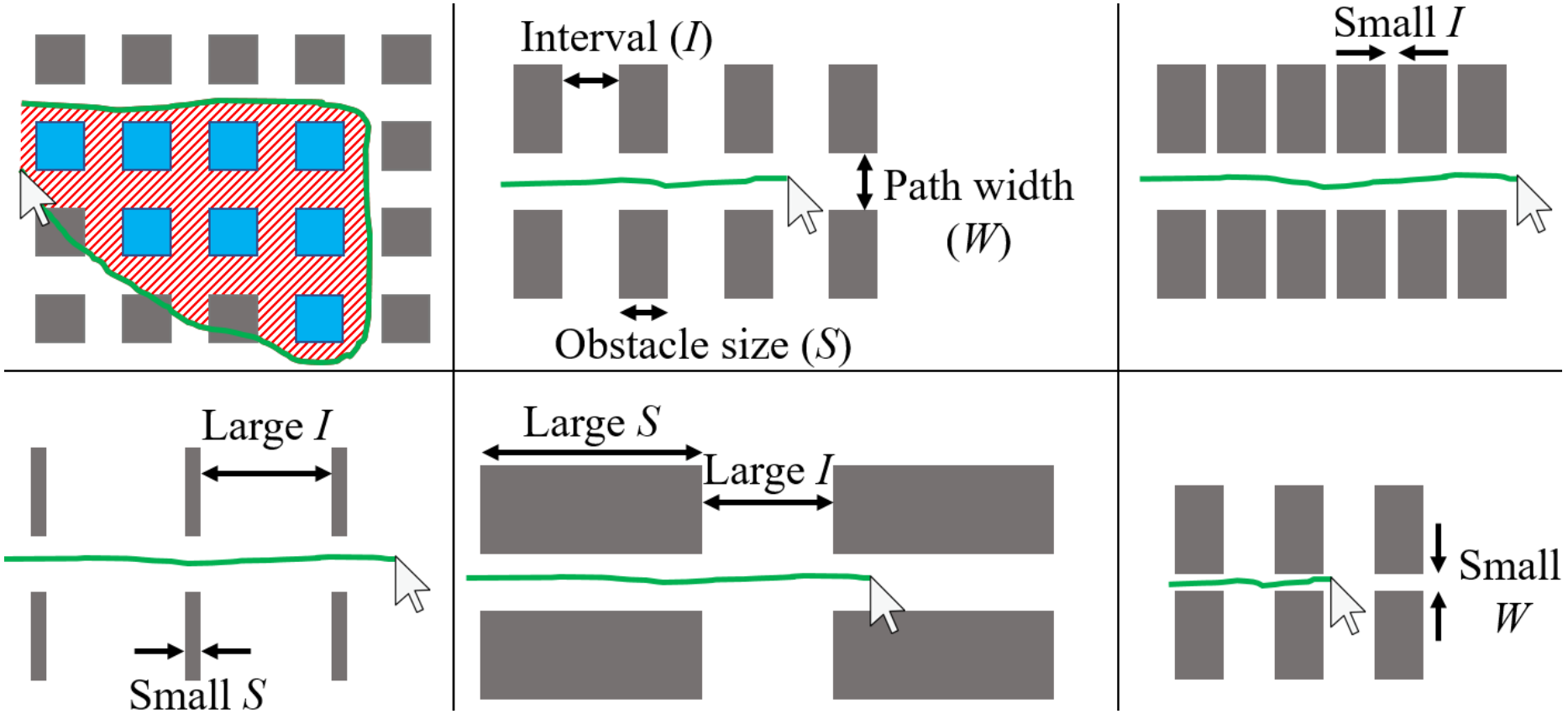
Accot, J., & Zhai, S. (1997). Beyond Fitts' law: models for trajectory-based HCI tasks. CHI’97

Steering Law Extensions

$$MT = a + b\frac{D}{W}$$

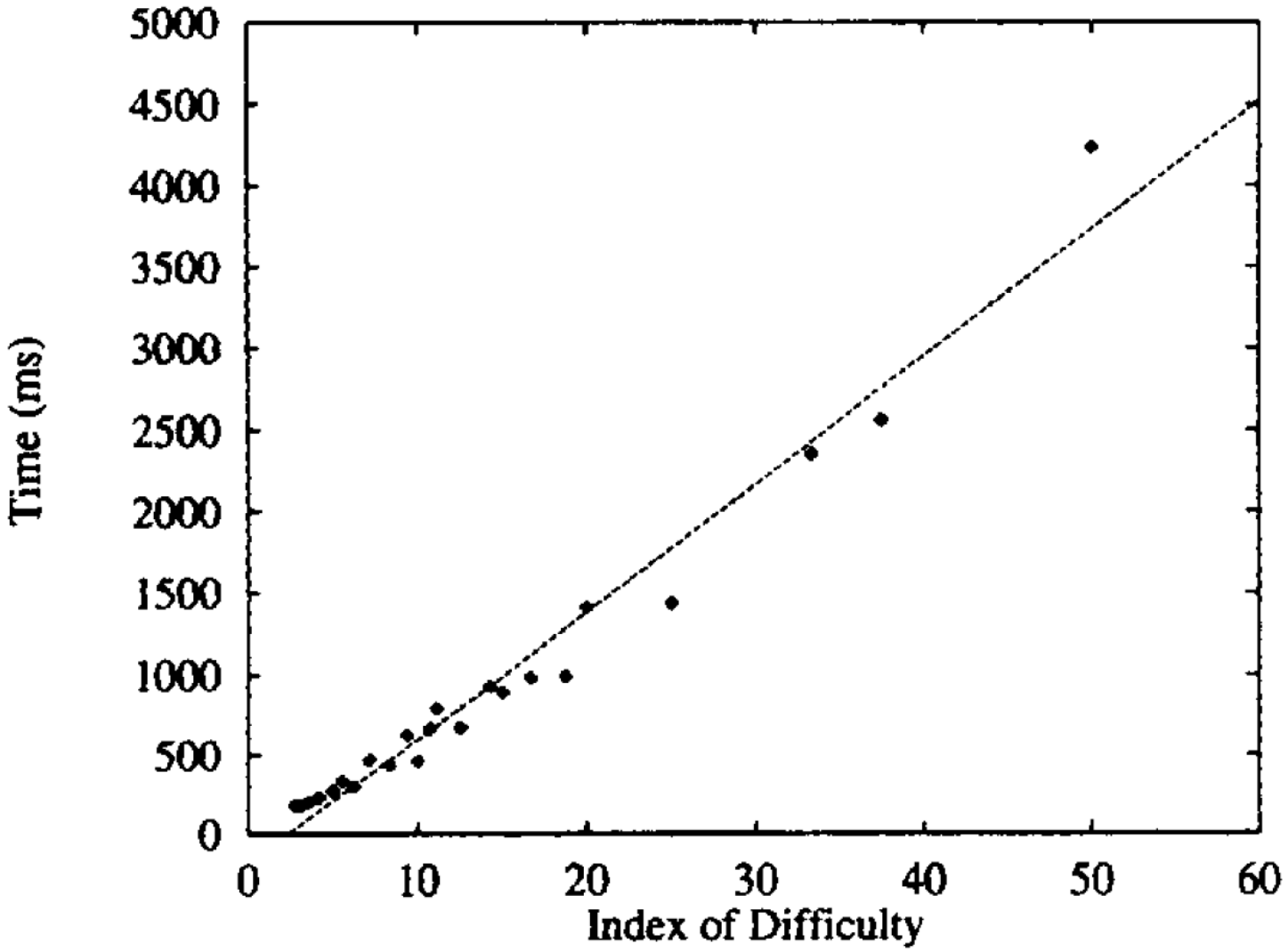


$$MT = a + b\int_C \frac{ds}{W(s)}$$



Yamanaka, S., Stuerzlinger, W., & Miyashita, H. (2018, April). Steering through successive objects. CHI'2018.

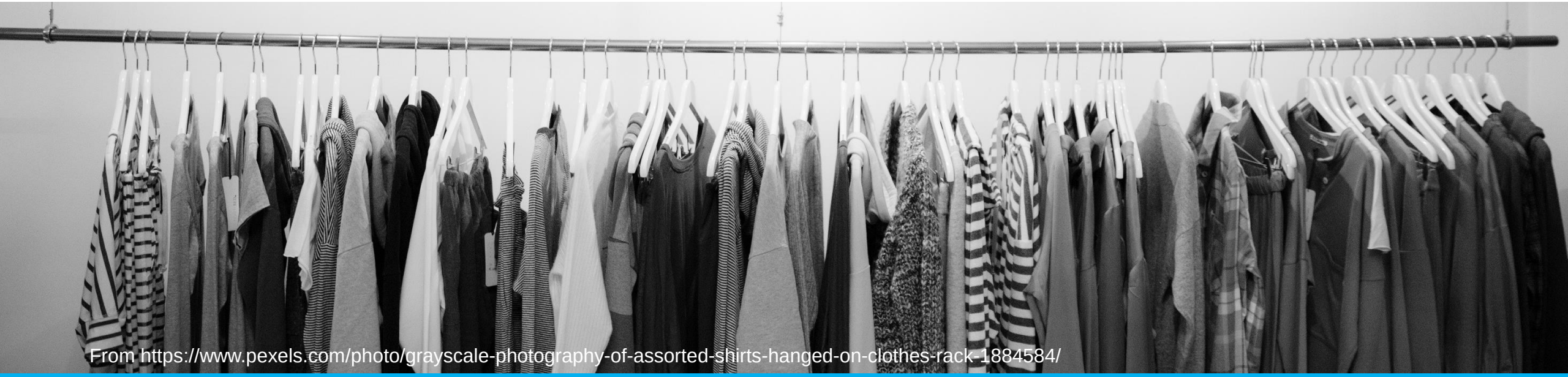
Zhai, S., Accot, J., & Woltjer, R. (2004). Human action laws in electronic virtual worlds: an empirical study of path steering performance in VR. Presence: Teleoperators & Virtual Environments, 13(2), 113-127.



What are a and b for this steering task?

Accot, J., & Zhai, S. (1997). Beyond Fitts' law: models for trajectory-based HCI tasks. CHI'97

For more content see: https://hci-lecture.de

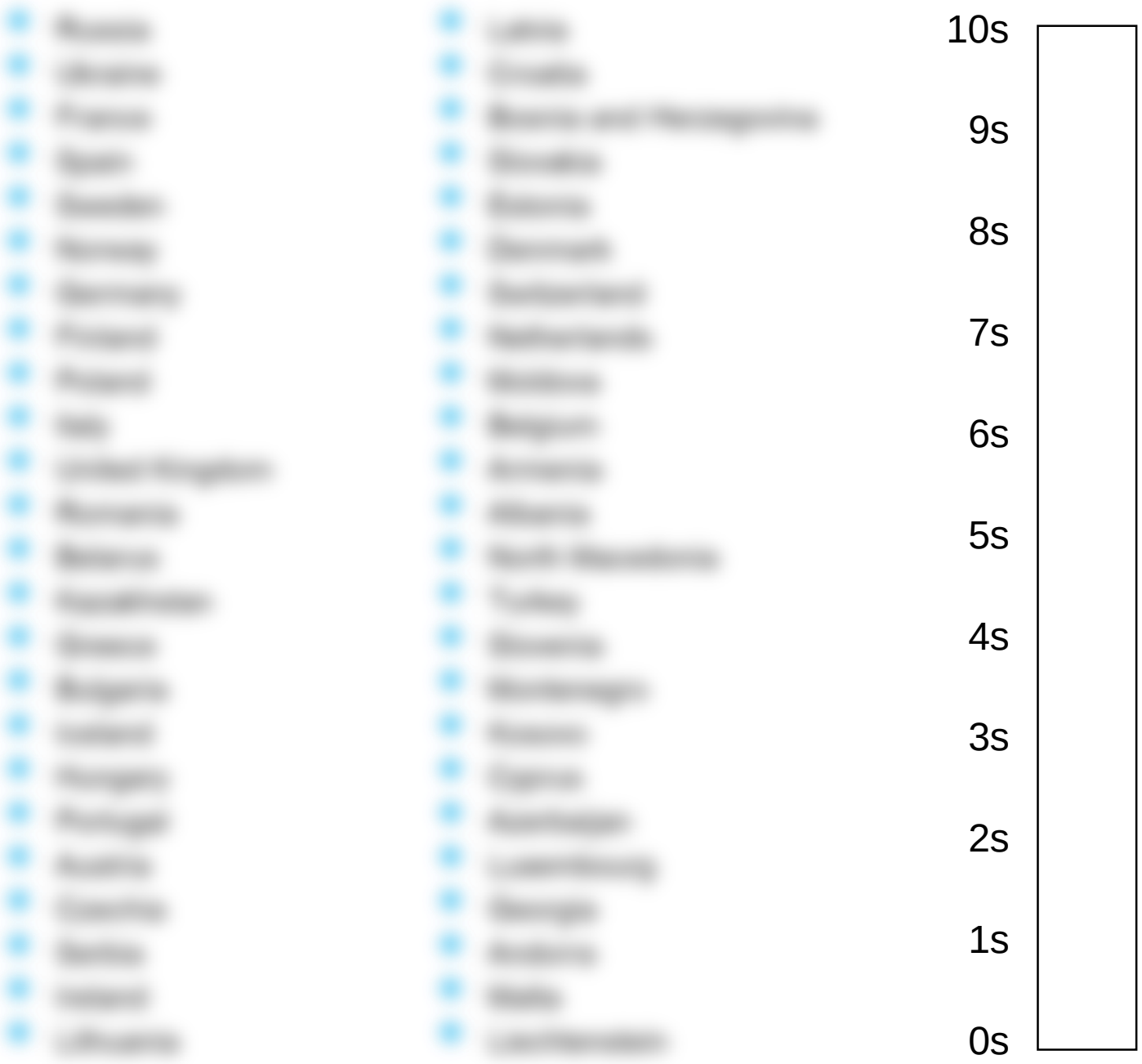

From https://www.pexels.com/photo/grayscale-photography-of-assorted-shirts-hanged-on-clothes-rack-1884584/

Lists and Hick's Law

Niels Henze

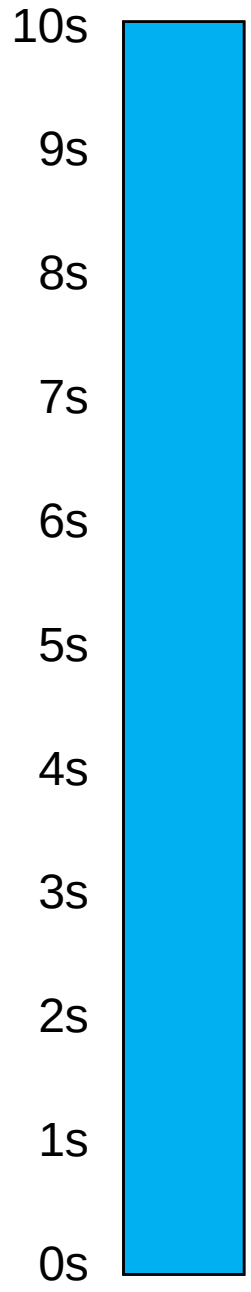
Learning Goals

- Know how long it takes to find an item in a list
- Understand why it is good to sort or group items



Find Denmark

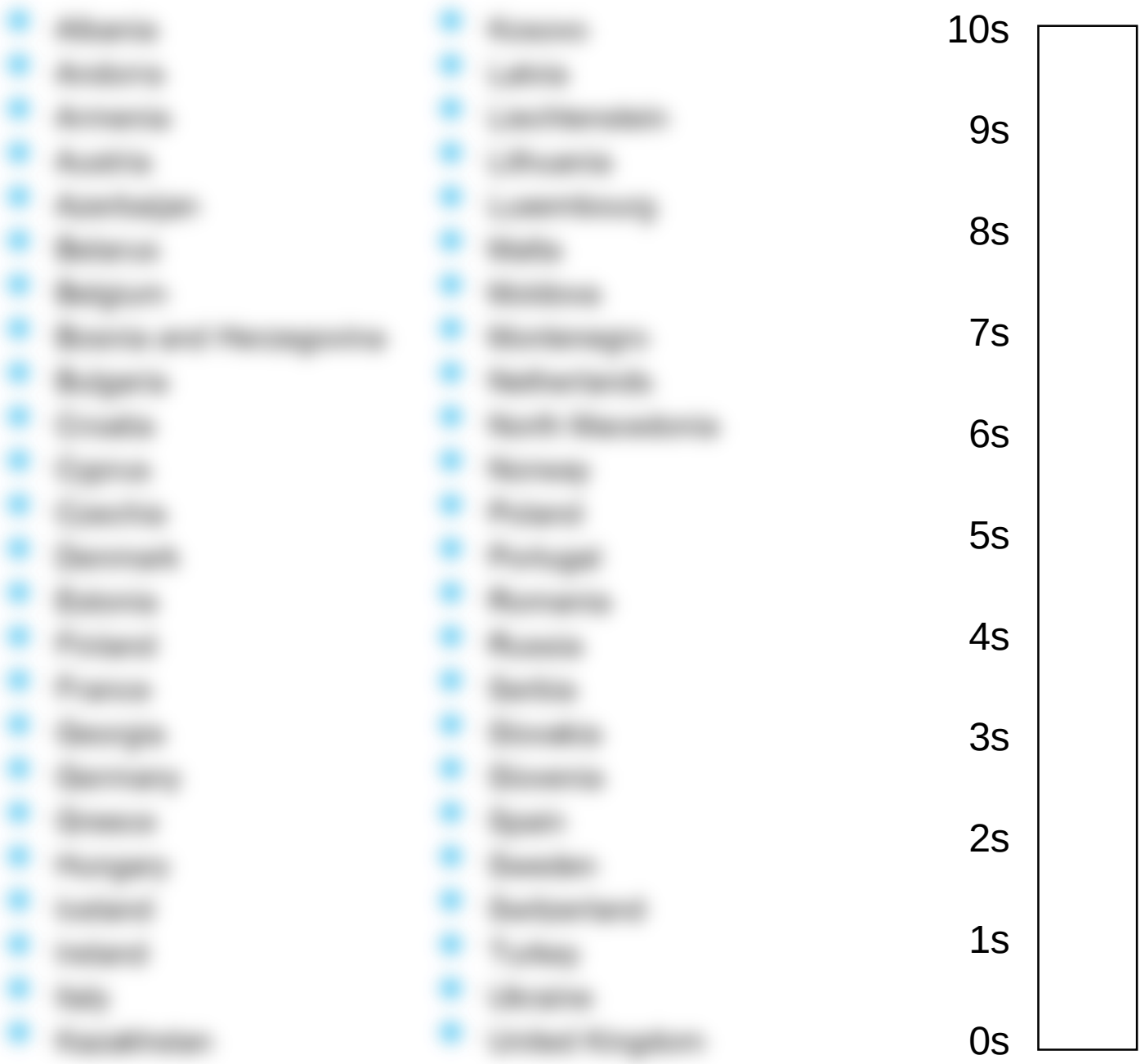
- Russia
- Ukraine
- France
- Spain
- Sweden
- Norway
- Germany
- Finland
- Poland
- Italy
- United Kingdom
- Romania
- Belarus
- Kazakhstan
- Greece
- Bulgaria
- Iceland
- Hungary
- Portugal
- Austria
- Czechia
- Serbia
- Ireland
- Lithuania
- Latvia
- Croatia
- Bosnia and Herzegovina
- Slovakia
- Estonia
- Denmark
- Switzerland
- Netherlands
- Moldova
- Belgium
- Armenia
- Albania
- North Macedonia
- Turkey
- Slovenia
- Montenegro
- Kosovo
- Cyprus
- Azerbaijan
- Luxembourg
- Georgia
- Andorra
- Malta
- Liechtenstein



Find Denmark

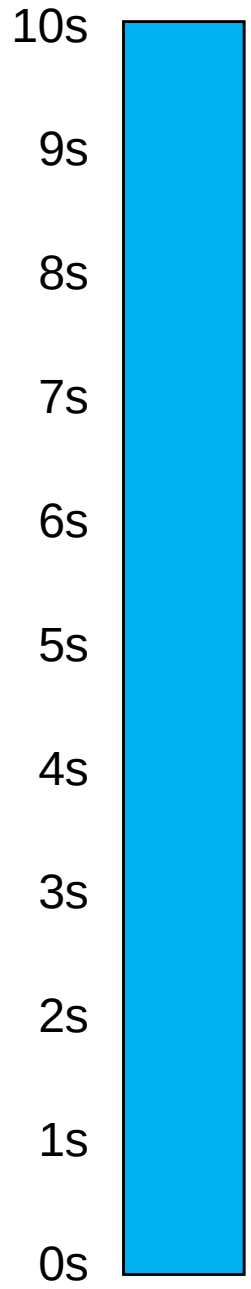
- We have a list with n items in an unknown order
- Time obviously increases with n

- What is the time complexity for an algorithm in Big O notation?
- O(n)



Find Denmark

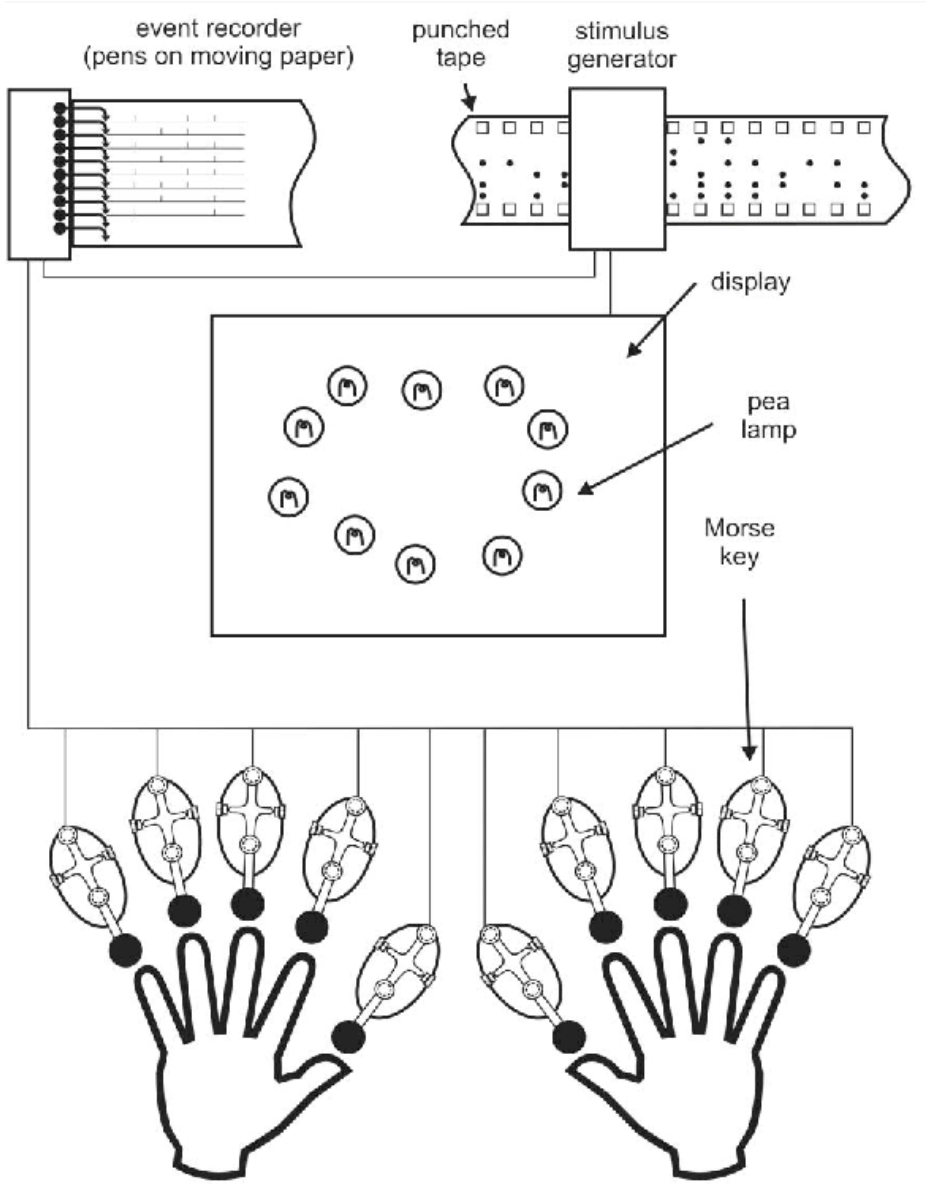
- Albania
- Andorra
- Armenia
- Austria
- Azerbaijan
- Belarus
- Belgium
- Bosnia and Herzegovina
- Bulgaria
- Croatia
- Cyprus
- Czechia
- Denmark
- Estonia
- Finland
- France
- Georgia
- Germany
- Greece
- Hungary
- Iceland
- Ireland
- Italy
- Kazakhstan
- Kosovo
- Latvia
- Liechtenstein
- Lithuania
- Luxembourg
- Malta
- Moldova
- Montenegro
- Netherlands
- North Macedonia
- Norway
- Poland
- Portugal
- Romania
- Russia
- Serbia
- Slovakia
- Slovenia
- Spain
- Sweden
- Switzerland
- Turkey
- Ukraine
- United Kingdom



Find Denmark

- We have a list with n items in a known order
- Time obviously increases with n

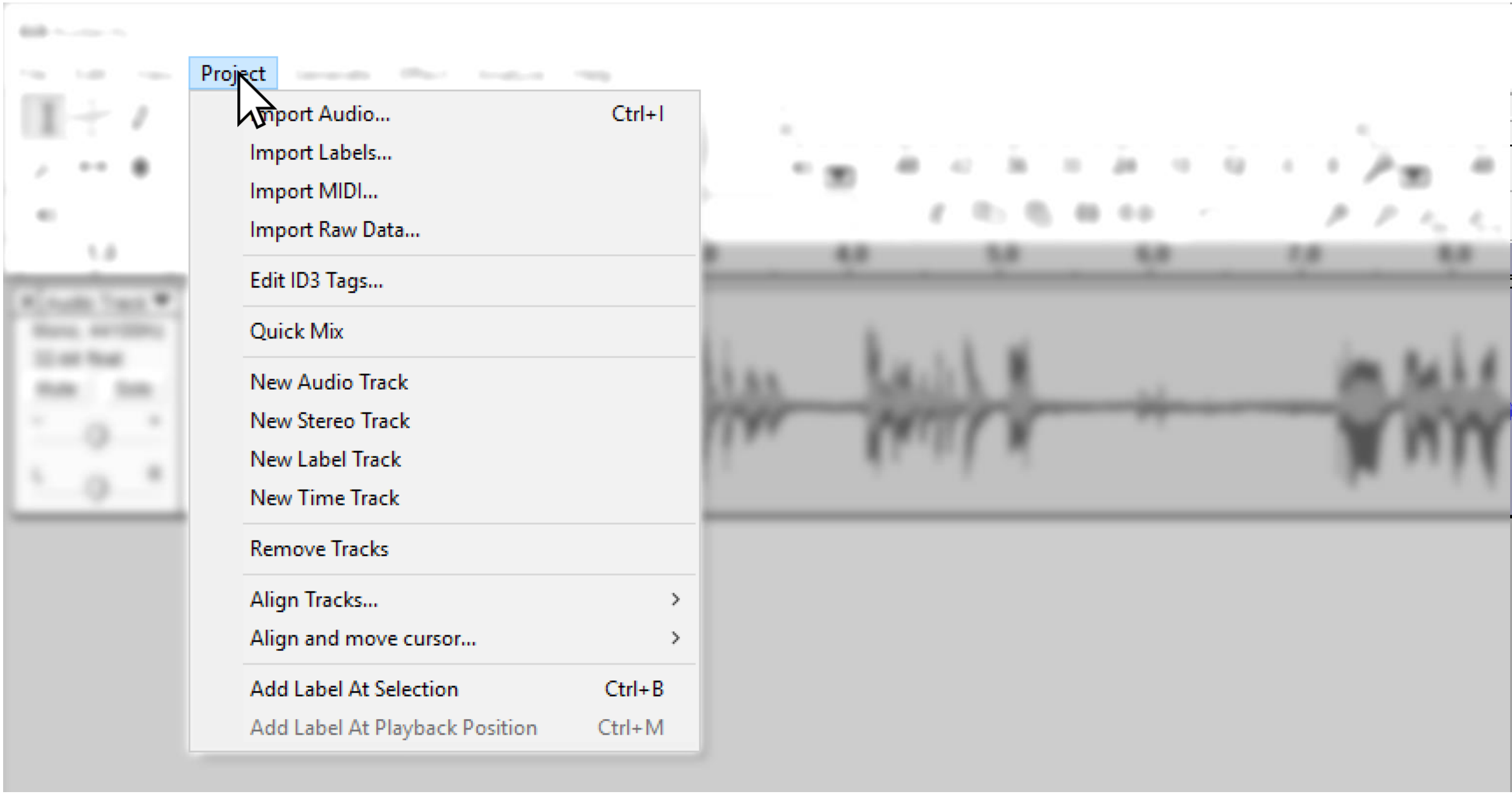
- What is the time complexity for an algorithm in Big O notation?
- O(log(n))



From Seow, S. C. (2005). Information theoretic models of HCI: a comparison of the Hick-Hyman law and Fitts' law. Human-computer interaction, 20(3), 315-352.

- Given n equally probable choices, the average reaction time T required to choose among the choices is approximately:
- $T = b*\log_2(n + 1)$
- Common practical value: b=150 ms/bit

- Hick's Law is often used to motivate menu designns
  - In an unordered list, search time is linear
  - In an ordered list, search time becomes logarithmic


Project
Import Audio... Ctrl+I
Import Labels...
Import MIDI...
Import Raw Data...
Edit ID3 Tags...
Quick Mix
New Audio Track
New Stereo Track
New Label Track
New Time Track
Remove Tracks
Align Tracks...
Align and move cursor...
Add Label At Selection Ctrl+B
Add Label At Playback Position Ctrl+M

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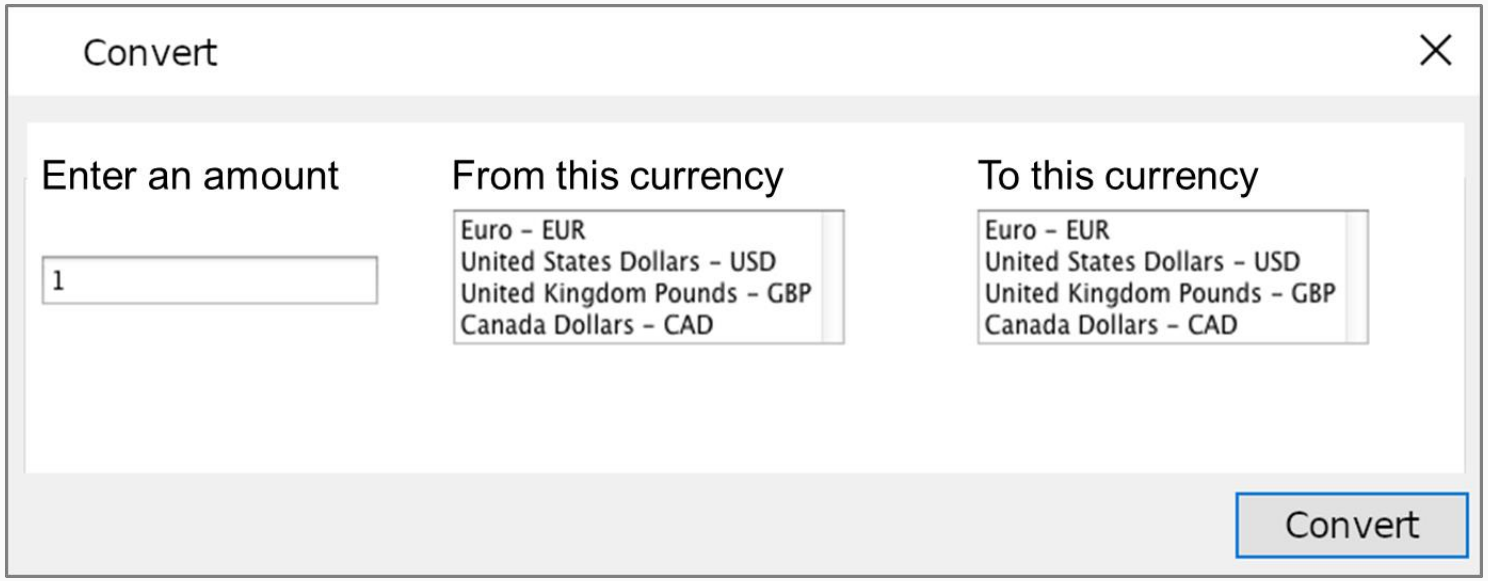
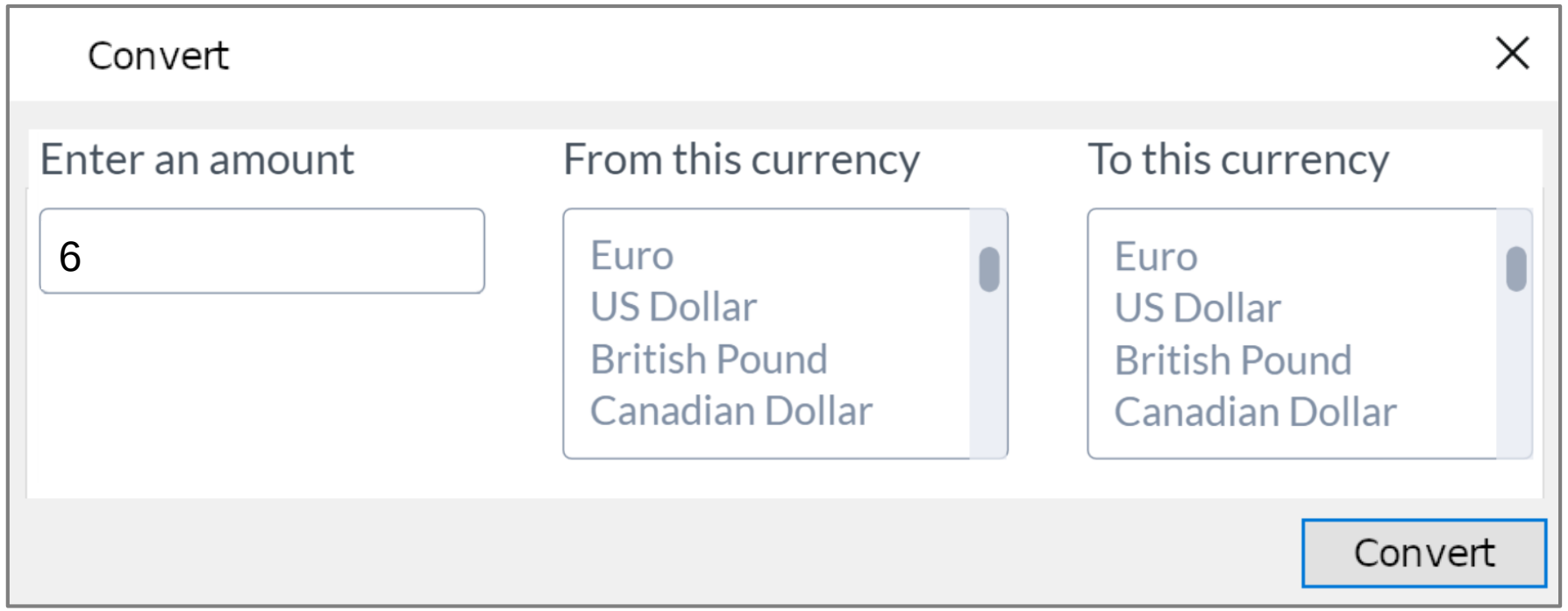


Keystroke-Level Model

Learning Goals

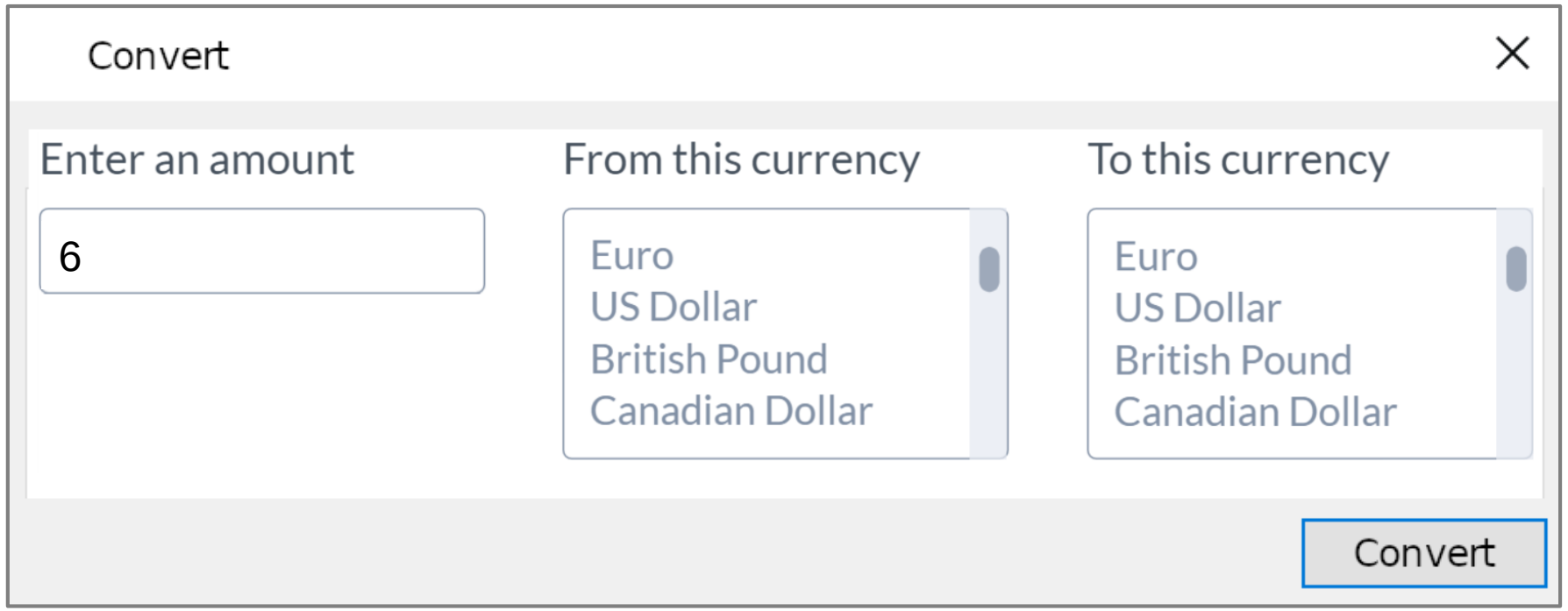
- Know what KLM stands for
- Know the KLM operators
- Being able to predict how long tasks take using KLM



- Task: Convert 12 Euro in US Dollar
- One hand on the mouse, nothing selected

- What do we need to know?

- Task: Convert 12 Euro in US Dollar
- One hand on the mouse, nothing selected



select text field
delete value
enter value
select Euro
select Dollar
select Convert

Keystroke-Level Model (KLM)

- Simplified version of the "**G**oals, **O**perators, **M**ethods, and **S**elections rules" (GOMS) Model
- KLM predicts how much time it takes to execute a task

- Execution of a task is decomposed into primitive operators
  - Physical motor operators
    - Pressing a button, pointing, drawing a line, …
  - Mental operator
    - Preparing for a physical action
  - System response operator
    - User waits for the system to do something

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	
H	‘Homing’, moving the hand between mouse and keyboard	
B/BB	Pressing (B) or clicking (BB) a button	
P	Pointing with a mouse to a target	
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	
M	Subsumed time for mental acts; sometimes used as ‘look-at’	
R(t)	System response time, time during which the user cannot act	

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	Expert typist (90 wpm): 0.12s Averaged skilled typist (55 wpm): 0.20s Average non-secretarial typist (40 wpm): 0.28 Worst typist (unfamiliar with keyboard): 1.2s
H	‘Homing’, moving the hand between mouse and keyboard	
B/BB	Pressing (B) or clicking (BB) a button	
P	Pointing with a mouse to a target	
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	
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H	‘Homing’, moving the hand between mouse and keyboard	0.4s
B/BB	Pressing (B) or clicking (BB) a button	
P	Pointing with a mouse to a target	
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	
M	Subsumed time for mental acts; sometimes used as ‘look-at’	
R(t)	System response time, time during which the user cannot act	

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	Expert typist (90 wpm): 0.12s Averaged skilled typist (55 wpm): 0.20s Average non-secretarial typist (40 wpm): 0.28 Worst typist (unfamiliar with keyboard): 1.2s
H	‘Homing’, moving the hand between mouse and keyboard	0.4s
B/BB	Pressing (B) or clicking (BB) a button	0.1s / 2*0.1s
P	Pointing with a mouse to a target	
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	
M	Subsumed time for mental acts; sometimes used as ‘look-at’	
R(t)	System response time, time during which the user cannot act	

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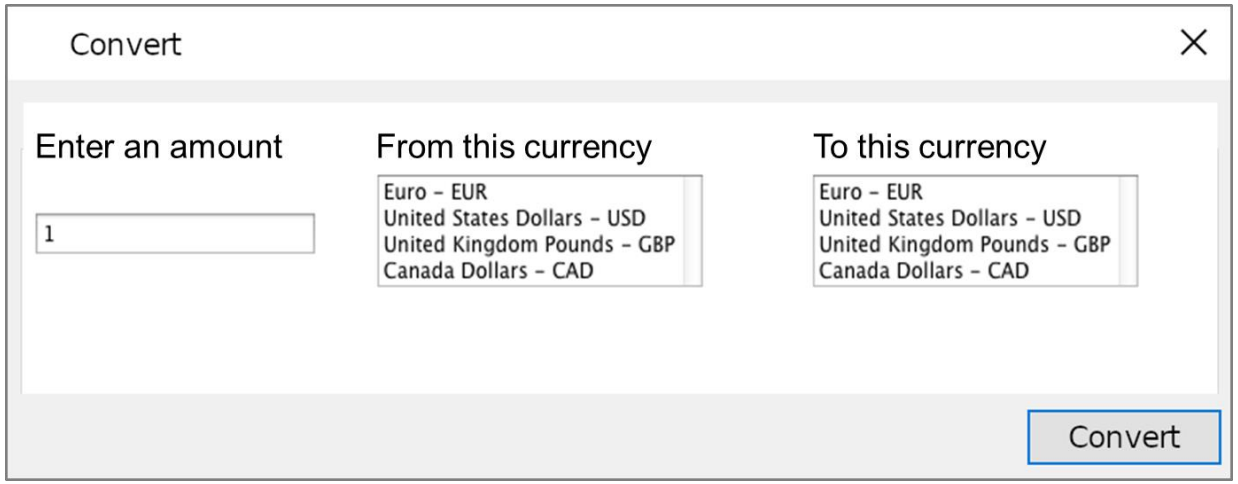
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	Expert typist (90 wpm): 0.12s Averaged skilled typist (55 wpm): 0.20s Average non-secretarial typist (40 wpm): 0.28 Worst typist (unfamiliar with keyboard): 1.2s
H	‘Homing’, moving the hand between mouse and keyboard	0.4s
B/BB	Pressing (B) or clicking (BB) a button	0.1s / 2*0.1s
P	Pointing with a mouse to a target	0.8s to 1.5s with an average of 1.1s Can also use Fitts’ Law
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	
M	Subsumed time for mental acts; sometimes used as ‘look-at’	
R(t)	System response time, time during which the user cannot act	

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	Expert typist (90 wpm): 0.12s Averaged skilled typist (55 wpm): 0.20s Average non-secretarial typist (40 wpm): 0.28 Worst typist (unfamiliar with keyboard): 1.2s
H	‘Homing’, moving the hand between mouse and keyboard	0.4s
B/BB	Pressing (B) or clicking (BB) a button	0.1s / 2*0.1s
P	Pointing with a mouse to a target	0.8s to 1.5s with an average of 1.1s Can also use Fitts’ Law
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	$0.9s*n_D + 0.16*l_D$
M	Subsumed time for mental acts; sometimes used as ‘look-at’	
R(t)	System response time, time during which the user cannot act	

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	Expert typist (90 wpm): 0.12s Averaged skilled typist (55 wpm): 0.20s Average non-secretarial typist (40 wpm): 0.28 Worst typist (unfamiliar with keyboard): 1.2s
H	‘Homing’, moving the hand between mouse and keyboard	0.4s
B/BB	Pressing (B) or clicking (BB) a button	0.1s / 2*0.1s
P	Pointing with a mouse to a target	0.8s to 1.5s with an average of 1.1s Can also use Fitts’ Law
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	$0.9s*n_D + 0.16*l_D$
M	Subsumed time for mental acts; sometimes used as ‘look-at’	1.35s
R(t)	System response time, time during which the user cannot act	

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key such as ‘CRTL’ or ‘SHIFT’	Expert typist (90 wpm): 0.12s Averaged skilled typist (55 wpm): 0.20s Average non-secretarial typist (40 wpm): 0.28 Worst typist (unfamiliar with keyboard): 1.2s
H	‘Homing’, moving the hand between mouse and keyboard	0.4s
B/BB	Pressing (B) or clicking (BB) a button	0.1s / 2*0.1s
P	Pointing with a mouse to a target	0.8s to 1.5s with an average of 1.1s Can also use Fitts’ Law
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	$0.9s*n_D + 0.16*l_D$
M	Subsumed time for mental acts; sometimes used as ‘look-at’	1.35s
R(t)	System response time, time during which the user cannot act	Dependent on the system

- Task: Convert 12 Euro in US Dollar
- One hand on the mouse, nothing selected



select text field	P, BB
delete value	H, K
enter value	M, K, K
select Euro	H, M, P, BB
select Dollar	M, P, BB
select Convert	P, BB

select text field	P, BB
delete value	H, K
enter value	M, K, K
select Euro	H, M, P, BB
select Dollar	M, P, BB
select Convert	P, BB

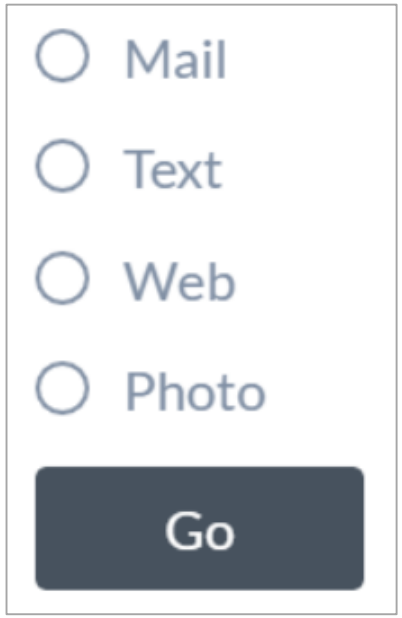
Operator Times:

P ≈ 1.1s B = 0.1s H = 0.4s

M = 1.35s K = 0.28s

4*P =	4.40s
8*B =	0.80s
2*H =	0.80s
3*M =	4.05s
3*K =	0.84s
Total =	**10,89s**

Version 1

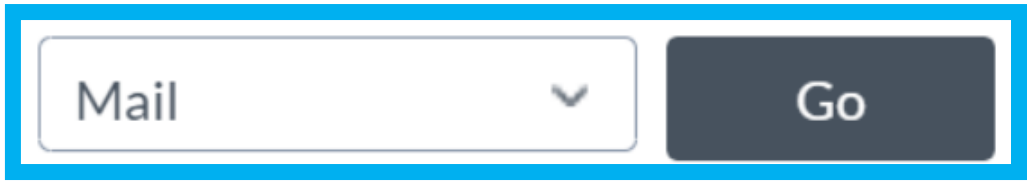


Version 2

Hand on mouse, nothing selected, go to photo:

- Which is the fastest interface?
- Which is the slowest?

Version 3



Version 4

Wrap-up

- The Keystroke-Level Model predicts task completion time for simple dialogs
- Assumes a trained average user
- Especially useful to compare alternatives
- Using KLM by hand can become lengthy and complex
- KLM is not useful for tasks that require reasoning

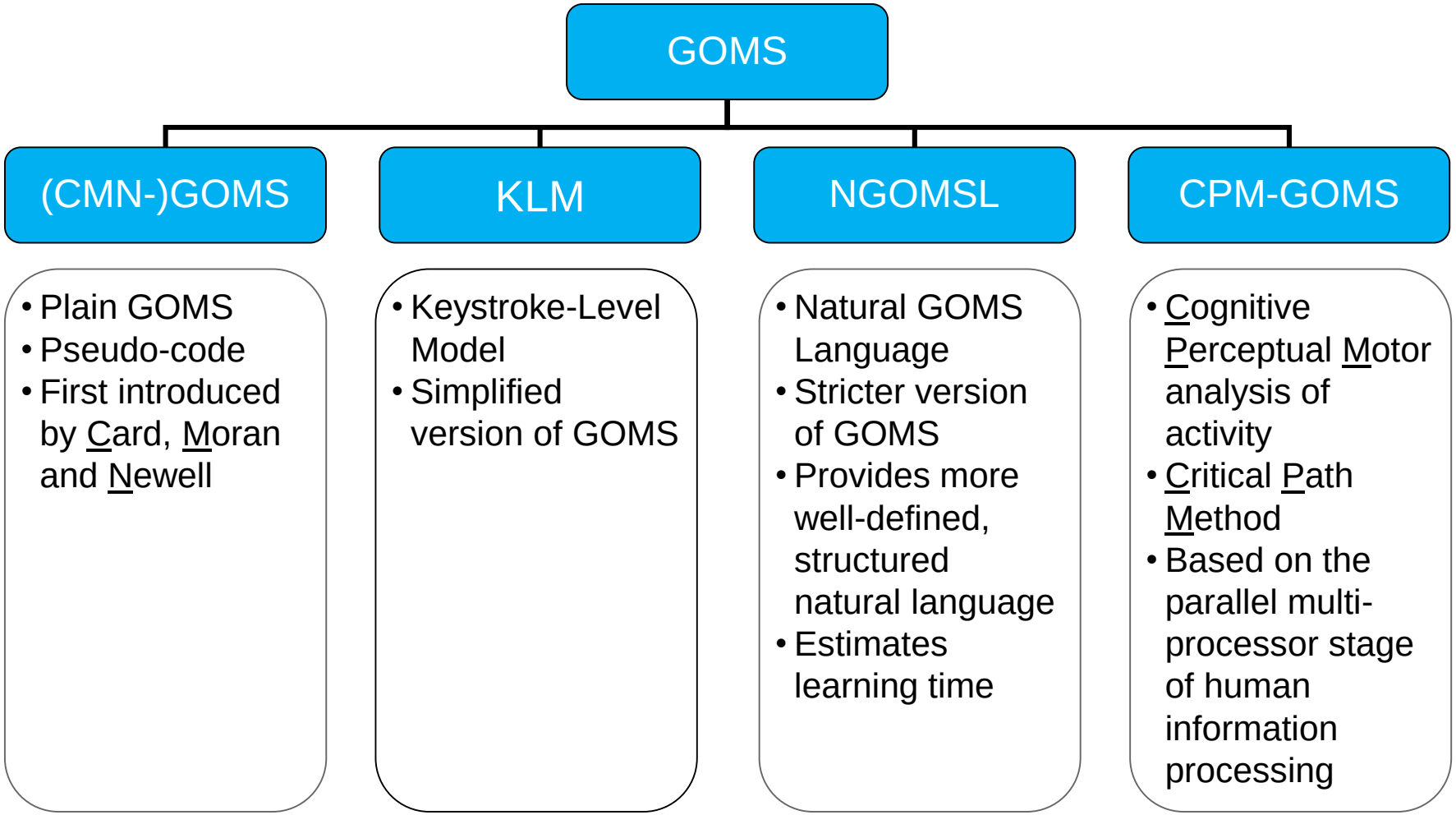
For more content see: https://hci-lecture.de

By Andrea Piacquadio from https://www.pexels.com/photo/man-in-black-suit-holding-banknotes-and-credit-card-3831185 (PD)

GOMS

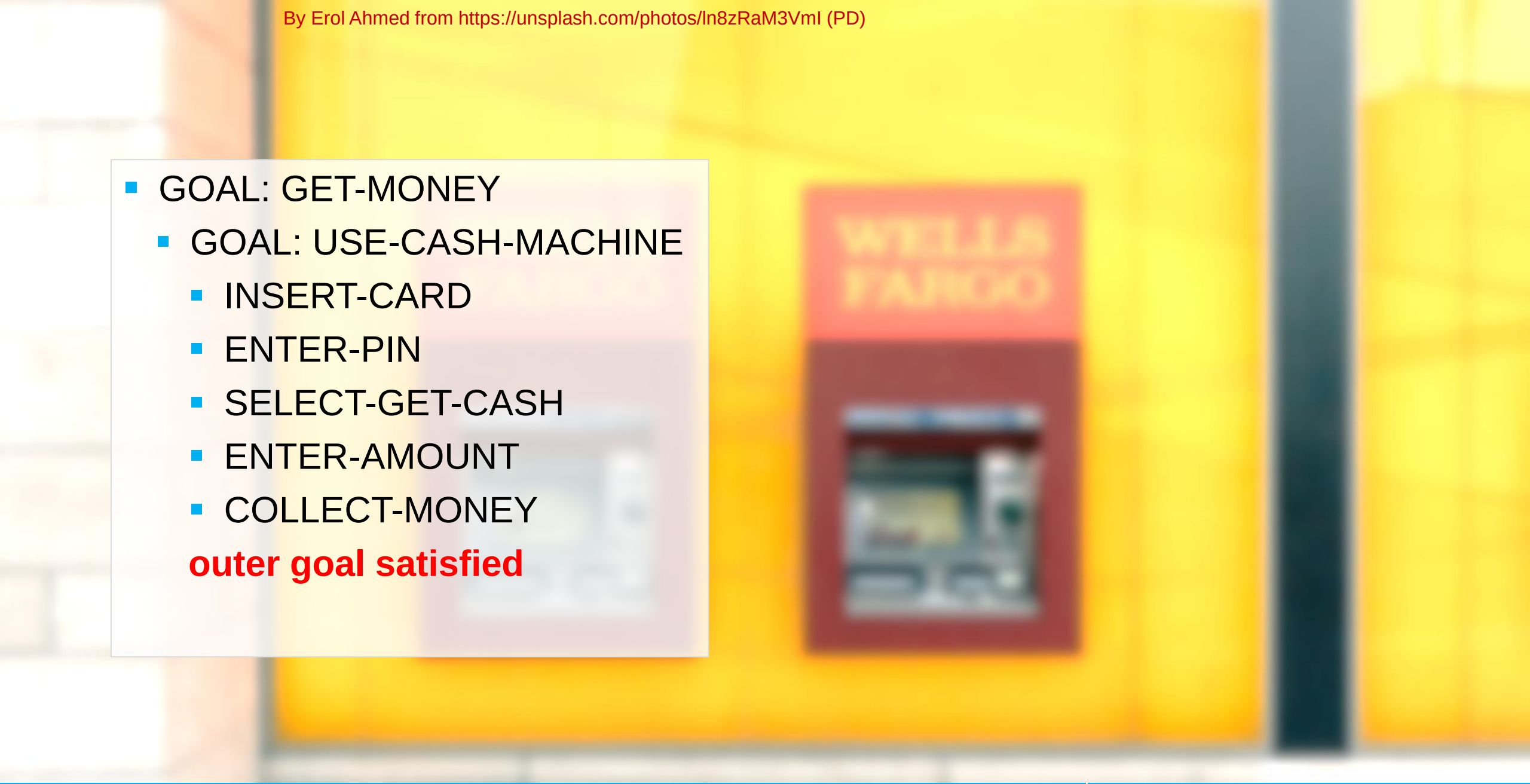
Learning Goals

- Know about the GOMS family
- Be able to use GOMS for simple tasks


GOMS
(CMN-)GOMS
KLM
NGOMSL
CPM-GOMS
• Plain GOMS
• Pseudo-code
• First introduced by Card, Moran and Newell
• Keystroke-Level Model
• Simplified version of GOMS
• Natural GOMS Language
• Stricter version of GOMS
• Provides more well-defined, structured natural language
• Estimates learning time
• Cognitive Perceptual Motor analysis of activity
• Critical Path Method
• Based on the parallel multi-processor stage of human information processing

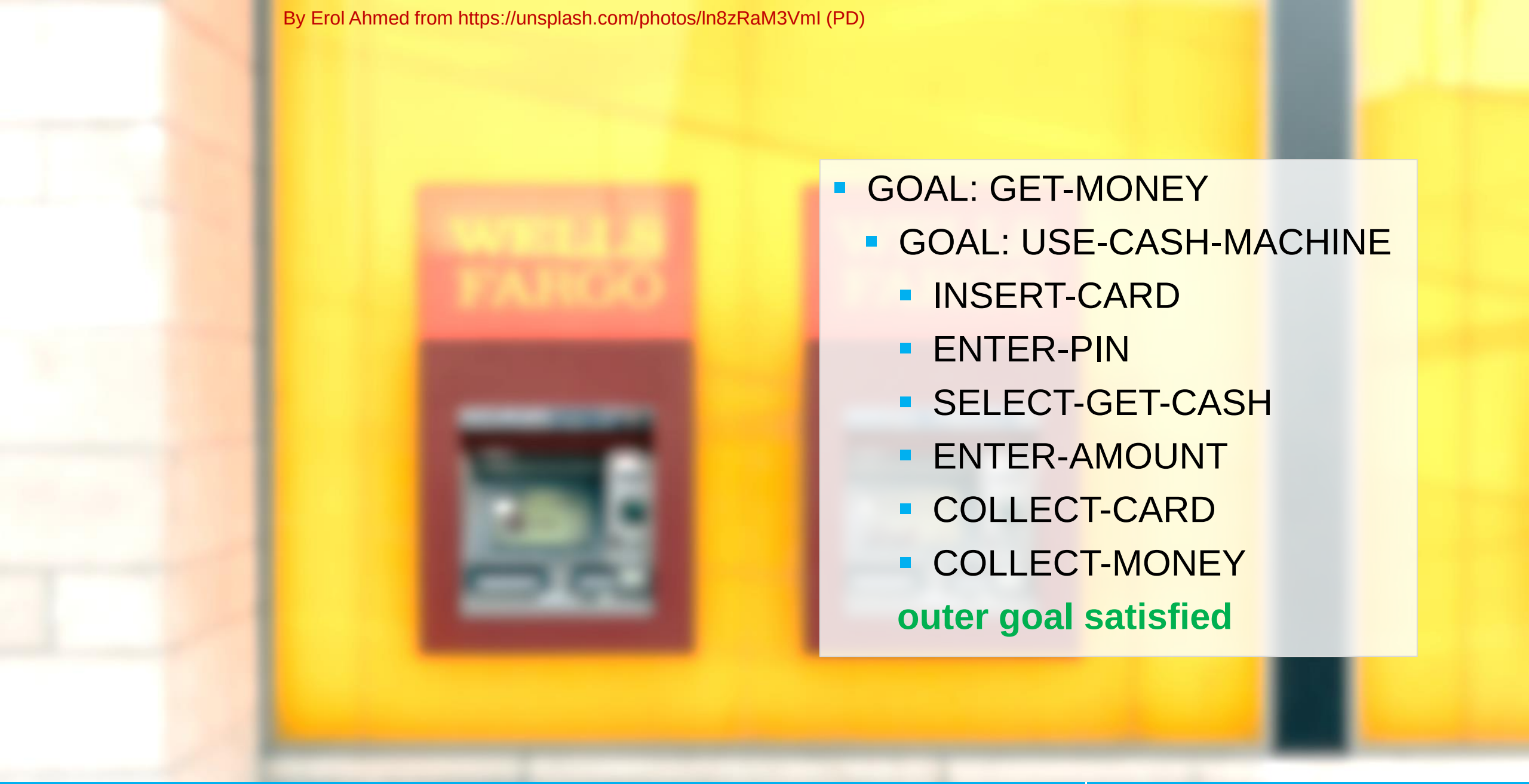
By Erol Ahmed from https://unsplash.com/photos/ln8zRaM3VmI (PD)

By Erol Ahmed from https://unsplash.com/photos/ln8zRaM3VmI (PD)



- GOAL: GET-MONEY
  - GOAL: USE-CASH-MACHINE
    - INSERT-CARD
    - ENTER-PIN
    - SELECT-GET-CASH
    - ENTER-AMOUNT
    - COLLECT-MONEY

  outer goal satisfied



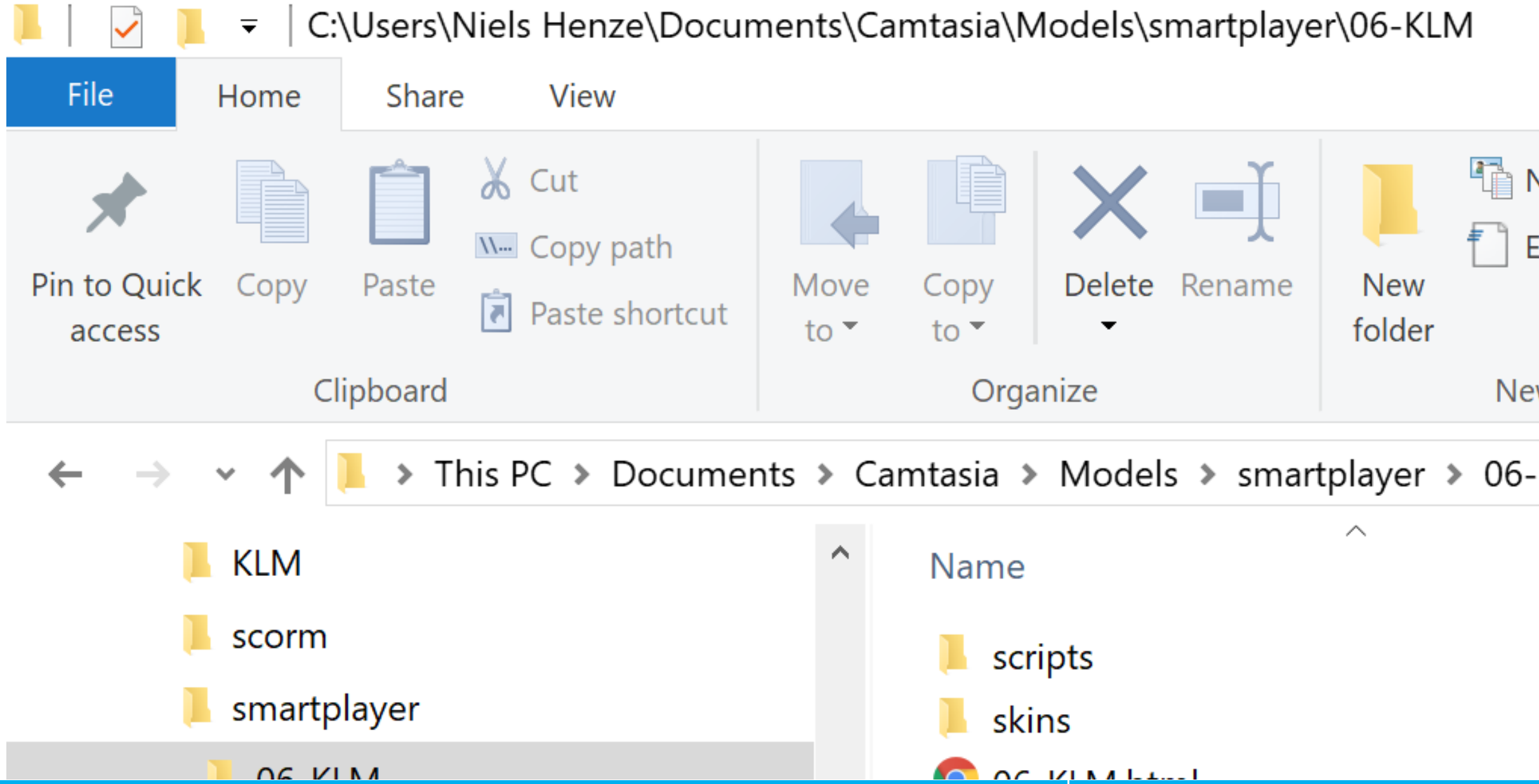
By Erol Ahmed from https://unsplash.com/photos/ln8zRaM3VmI (PD)

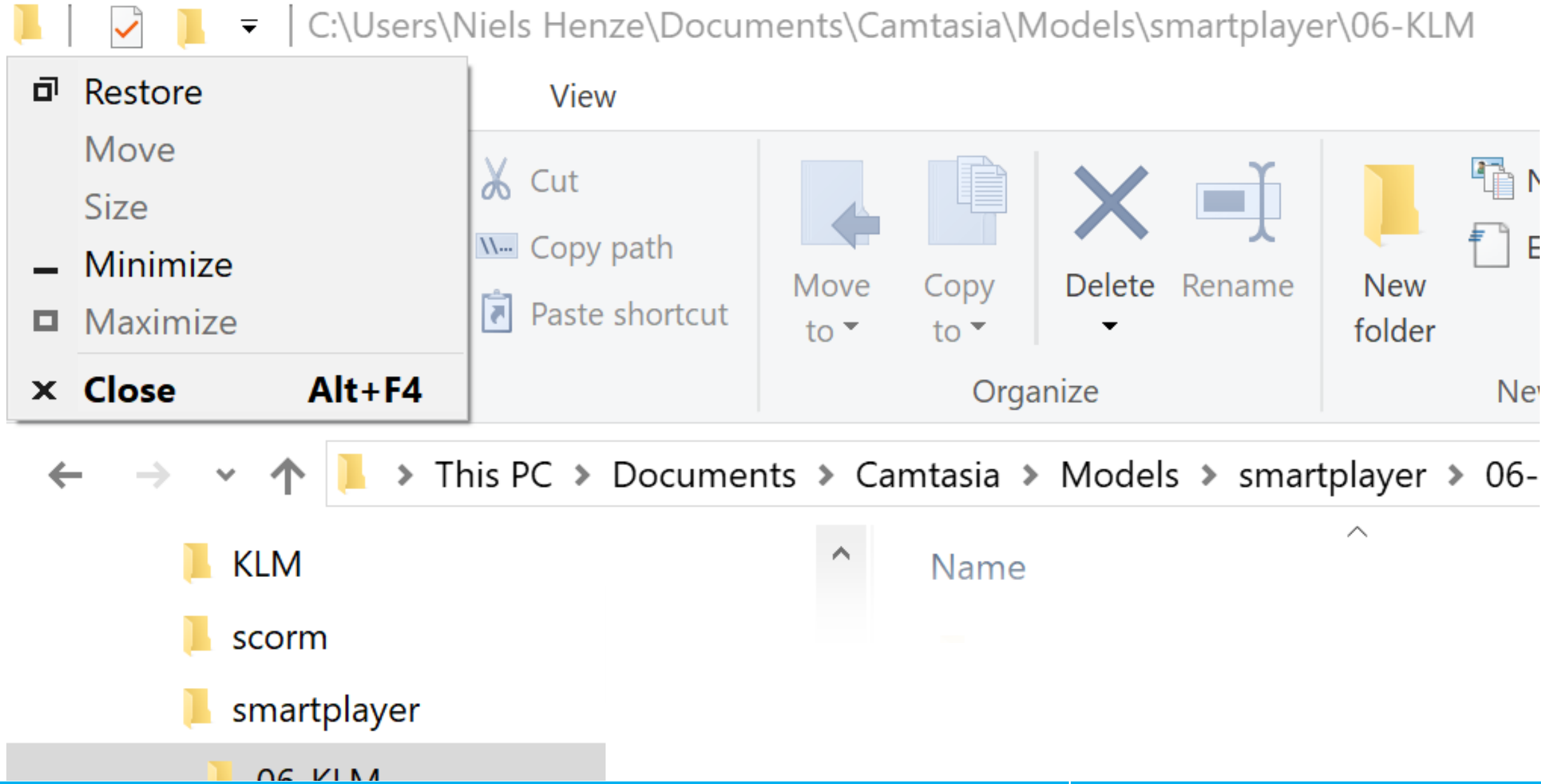
- GOAL: GET-MONEY
  - GOAL: USE-CASH-MACHINE
    - INSERT-CARD
    - ENTER-PIN
    - SELECT-GET-CASH
    - ENTER-AMOUNT
    - COLLECT-CARD
    - COLLECT-MONEY

  outer goal satisfied

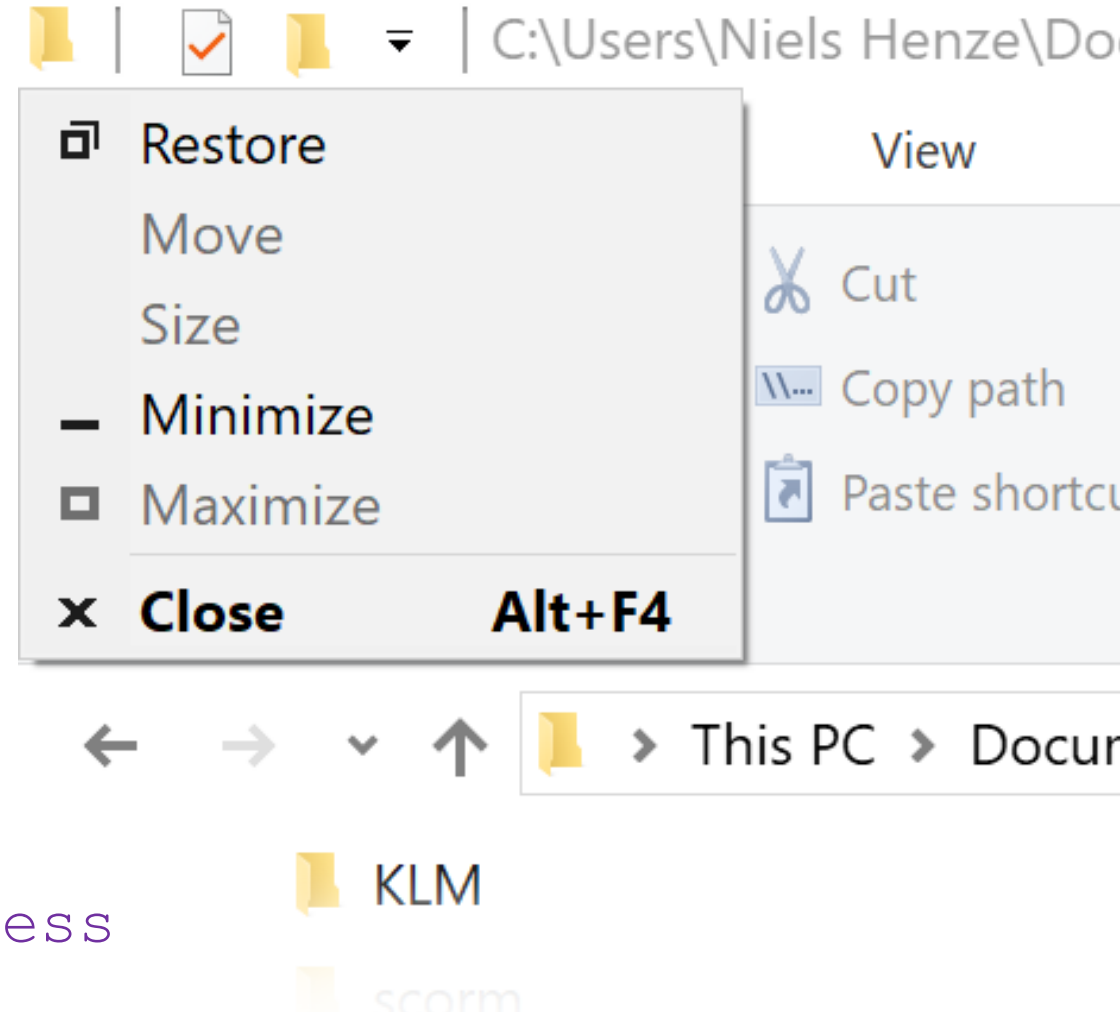
The GOMS Model

- **G**oals
  - (Verbal) description of what a user wants to accomplish
  - Various levels of complexity possible
- **O**perators
  - Possible actions in the system
  - Various levels of abstraction possible (sub-goals / ... / keystrokes)
- **M**ethods
  - Sequences of operators that achieve a goal
- **S**election rules
  - Rules that define when a user employs which method (among alternatives)


C:\Users\Niels Henze\Documents\Camtasia\Models\smartplayer\06-KLM
File
Home
Share
View
Pin to Quick access
Copy
Paste
Cut
Copy path
Paste shortcut
Clipboard
Move to
Copy to
Delete
Rename
New folder
Organize
This PC
Documents
Camtasia
Models
smartplayer
KLM
scorm
smartplayer
Name
scripts
skins


C:\Users\Niels Henze\Documents\Camtasia\Models\smartplayer\06-KLM
Restore
Move
Size
Minimize
Maximize
Close Alt+F4
View
Cut
Copy path
Paste shortcut
Move to
Copy to
Delete
Rename
New folder
Organize
This PC
Documents
Camtasia
Models
smartplayer
06-
KLM
scorm
smartplayer
Name

```
GOAL: CLOSE-WINDOW
  [select
    GOAL: USE-MENU-METHOD
      MOVE-MOUSE-TO-FILE-MENU
      PULL-DOWN-FILE-MENU
      CLICK-OVER-CLOSE-OPTION
    GOAL: USE-ALT-F4-METHOD
      HOLD-ALT-KEY
      PRESS-F4-KEY]
  VERIFY-CLOSE
```



For a particular user:

Rule 1: Select USE-MENU-METHOD unless another rule applies

Rule 2: If the application is GAME, select CTRL-F4-METHOD

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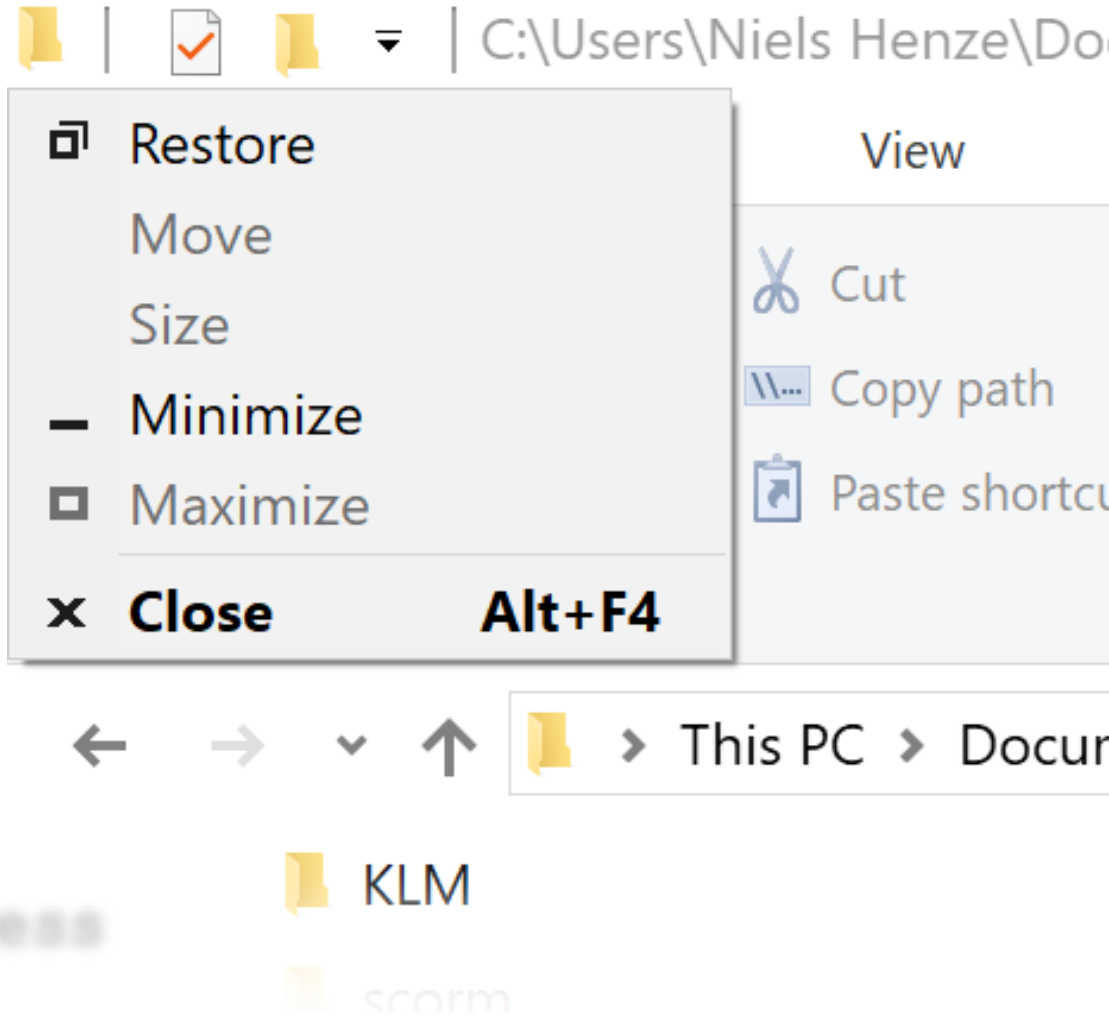

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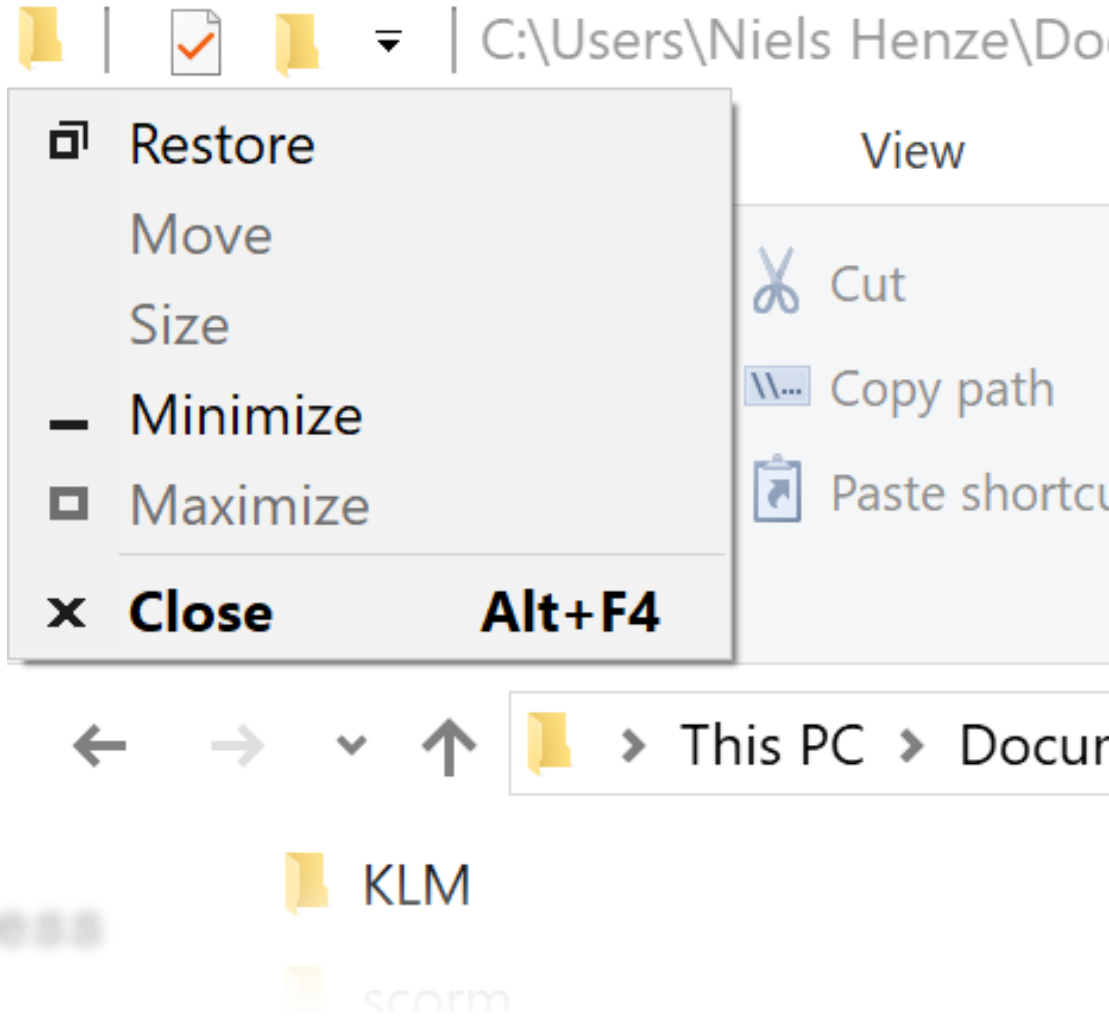

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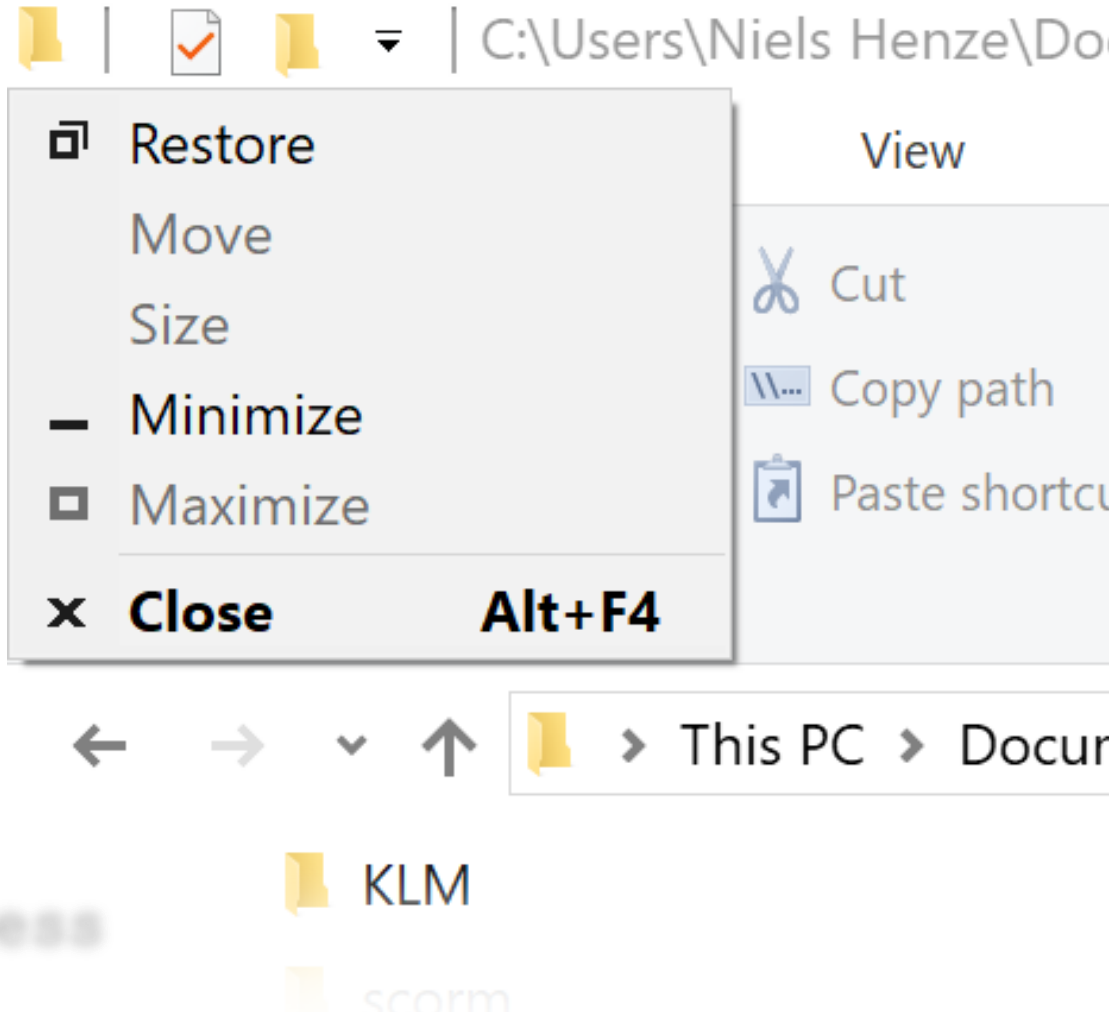


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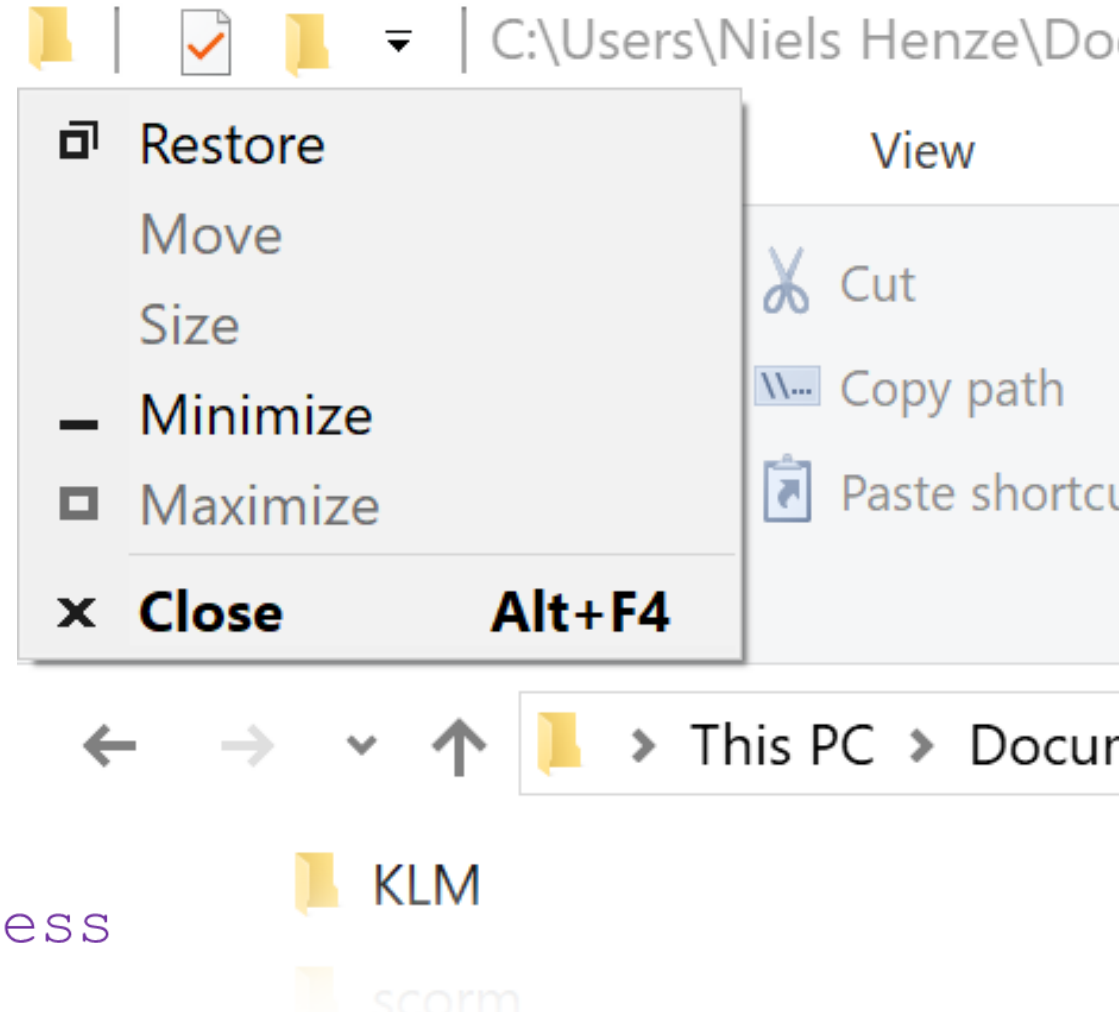

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GOMS – Characteristics

- Can be used to model complex tasks
- Cannot predict completion times
- But the simpler KLM can

- Predictions
  - More operators, longer completion
  - Deep depth of goal structure → high short term-memory load
  - Users stop when goals are satisfied

For more content see: https://hci-lecture.de

Video by Space Space from https://www.pexels.com/video/the-sun-illuminating-earth-s-surface-1851190/ (PD)

Seven Stages of Action

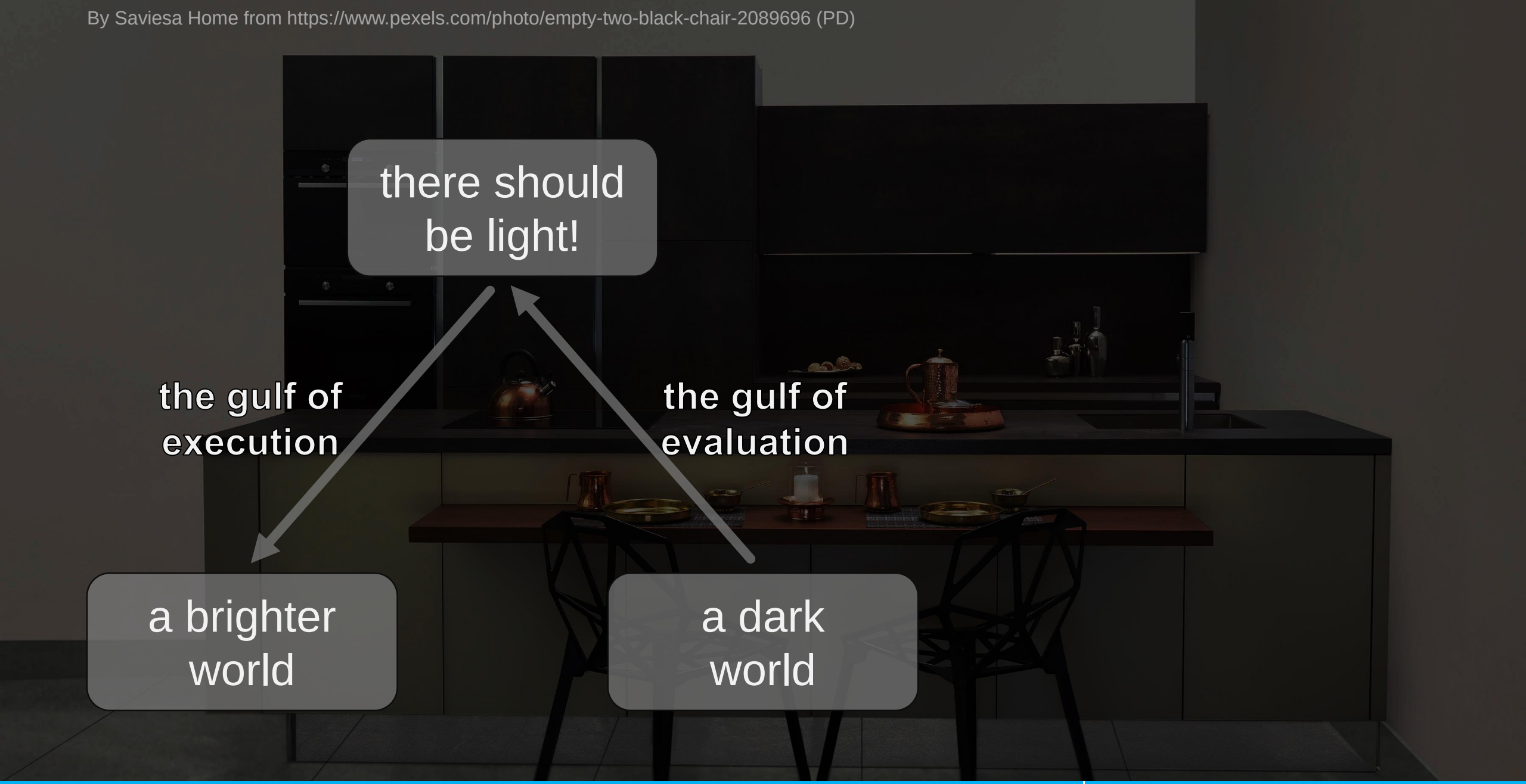
Niels Henze

Learning Goals

- Know how to apply Norman’s Seven Stages of Action
- Avoid the gulf of evaluation and execution

Photo by Paolo Sacchi / Meet the media Guru from https://www.flickr.com/photos/meetthemediaguru/5553249364/ (CC BY-SA 2.0)

By Saviesa Home from https://www.pexels.com/photo/empty-two-black-chair-2089696 (PD)



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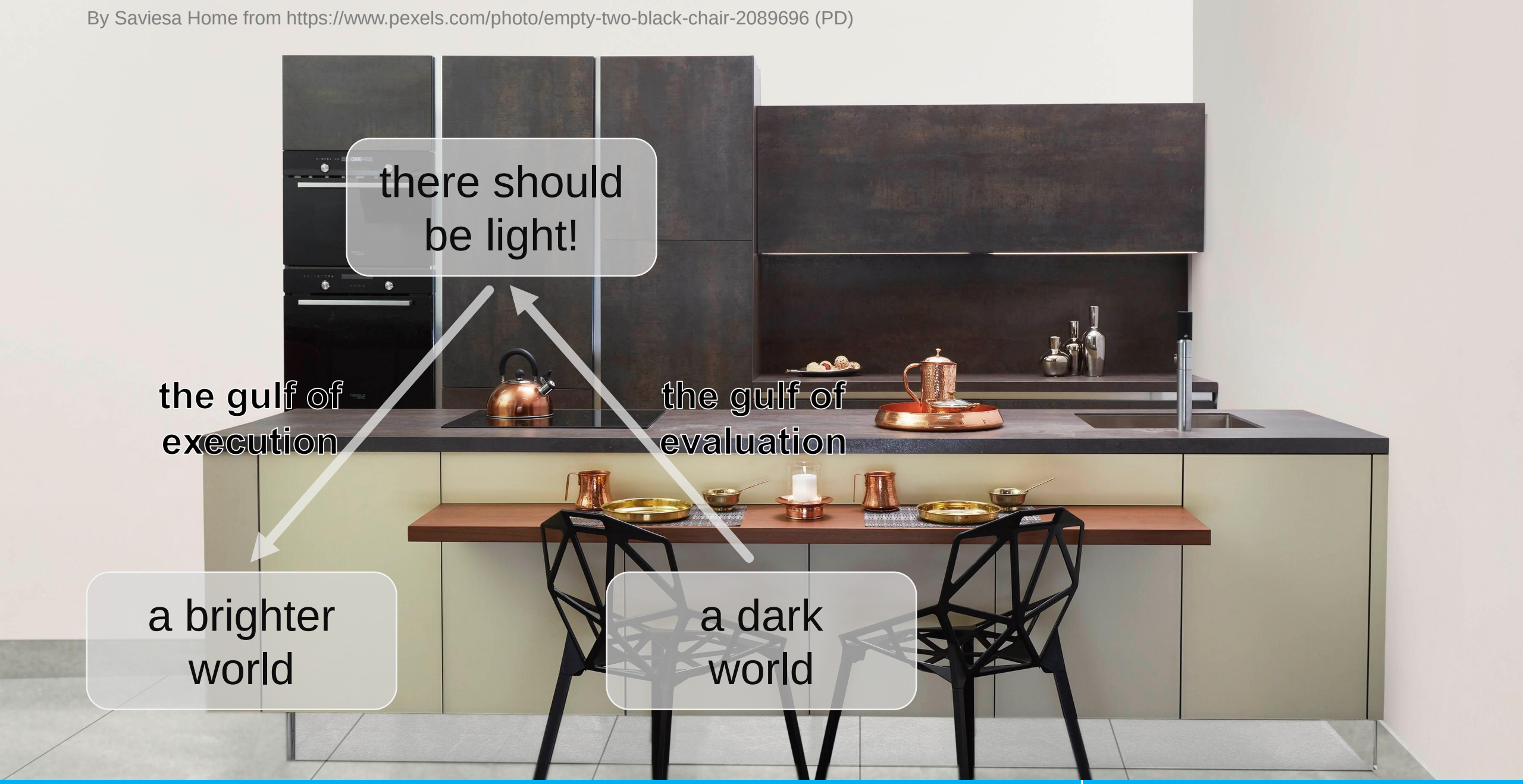

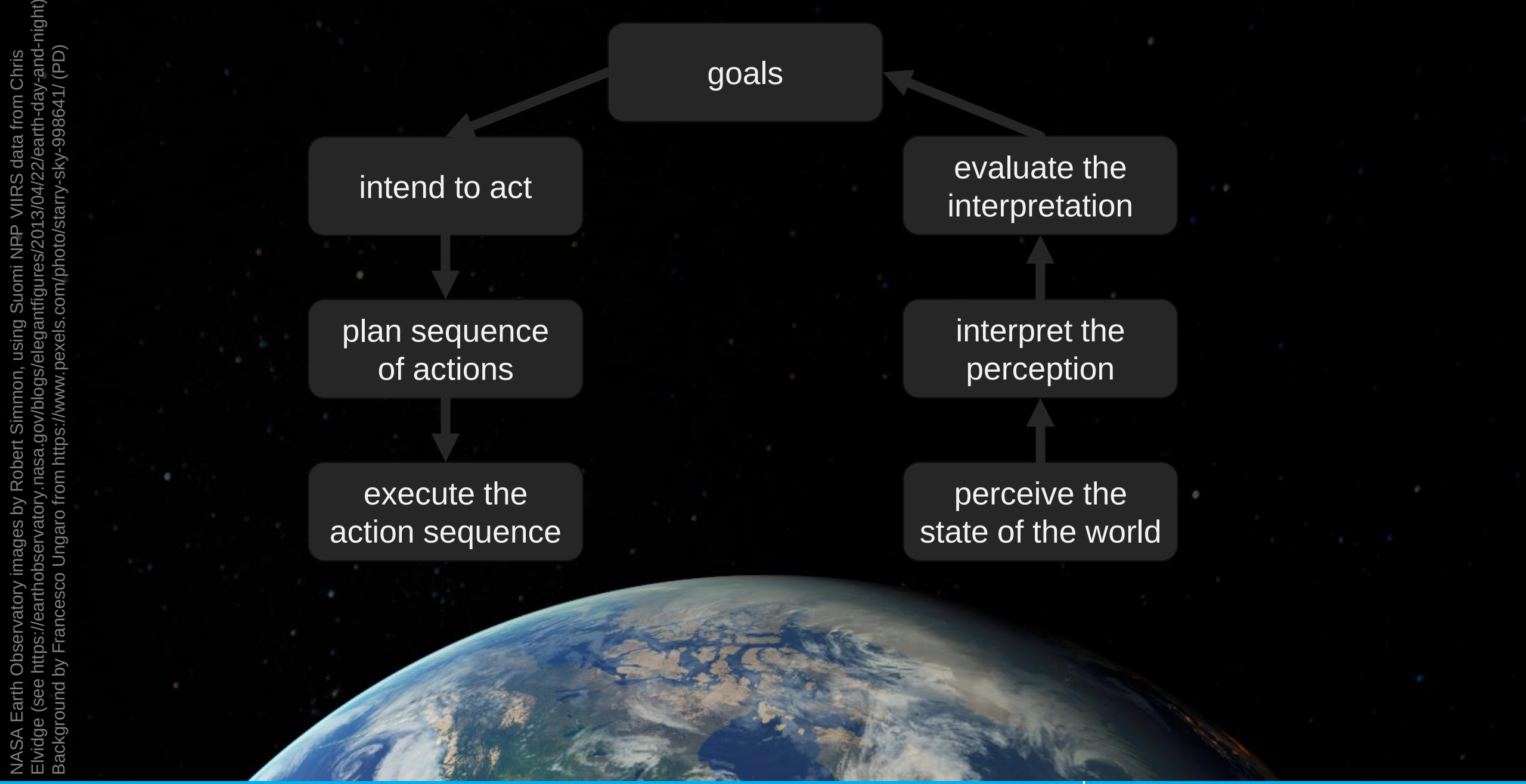

NASA Earth Observatory images by Robert Simmon, using Suomi NPP VIIRS data from Chris Elvidge (see https://earthobservatory.nasa.gov/blogs/elegantfigures/2013/04/22/earth-day-and-night/)
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Evaluation and Design Questions

- Avoid the gulf of evaluation
  - Can the user tell what state the system is in?
  - Can the user tell if the system is in the desired state?
  - Can the user map from the system state to an interpretation?

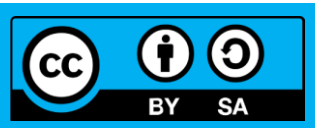
- Avoid the gulf of execution
  - Can the user tell what actions are possible?
  - Does the device easily support required actions?
  - Does the interface help with mapping from intention to physical movement?

Implications on Design

- Critical points
  - Forming inadequate goal
  - Not knowing the appropriate action
  - Not finding the correct action
  - Receiving inappropriate feedback

- Principles of good design
  - System state and actions are always visible
  - Good conceptual model with a consistent system image
  - Interfaces include good mappings that show the relationship between stages
  - Continuous feedback to the user

For more content see: https://hci-lecture.de



Video by Pressmaster from https://www.pexels.com/video/a-man-of-science-writing-scientific-formulas-in-glass-board-3191353 (PD)

Models – For What Else?

Learning Goals

- Know what else can be done with models in HCI
- See the links between different types of models

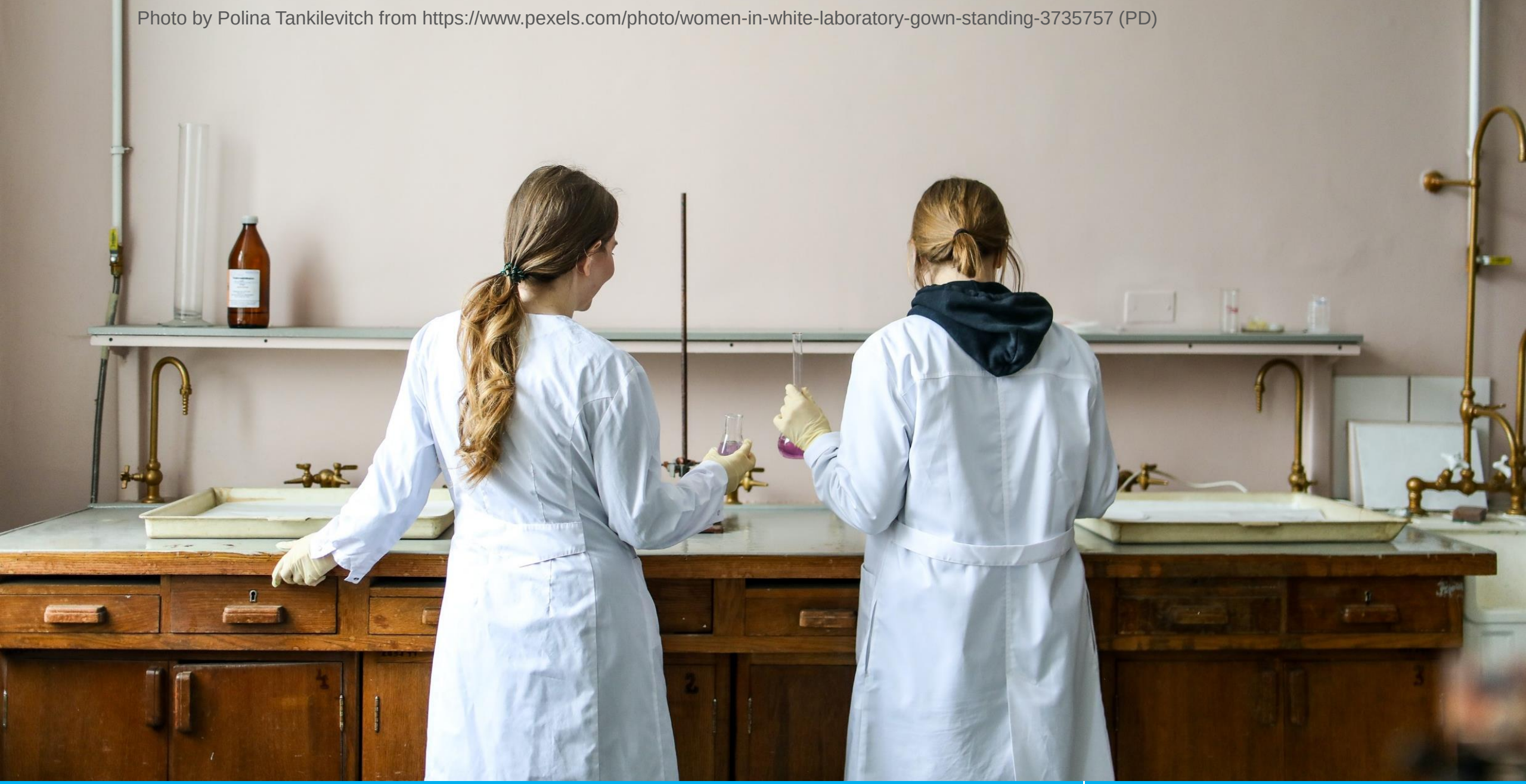
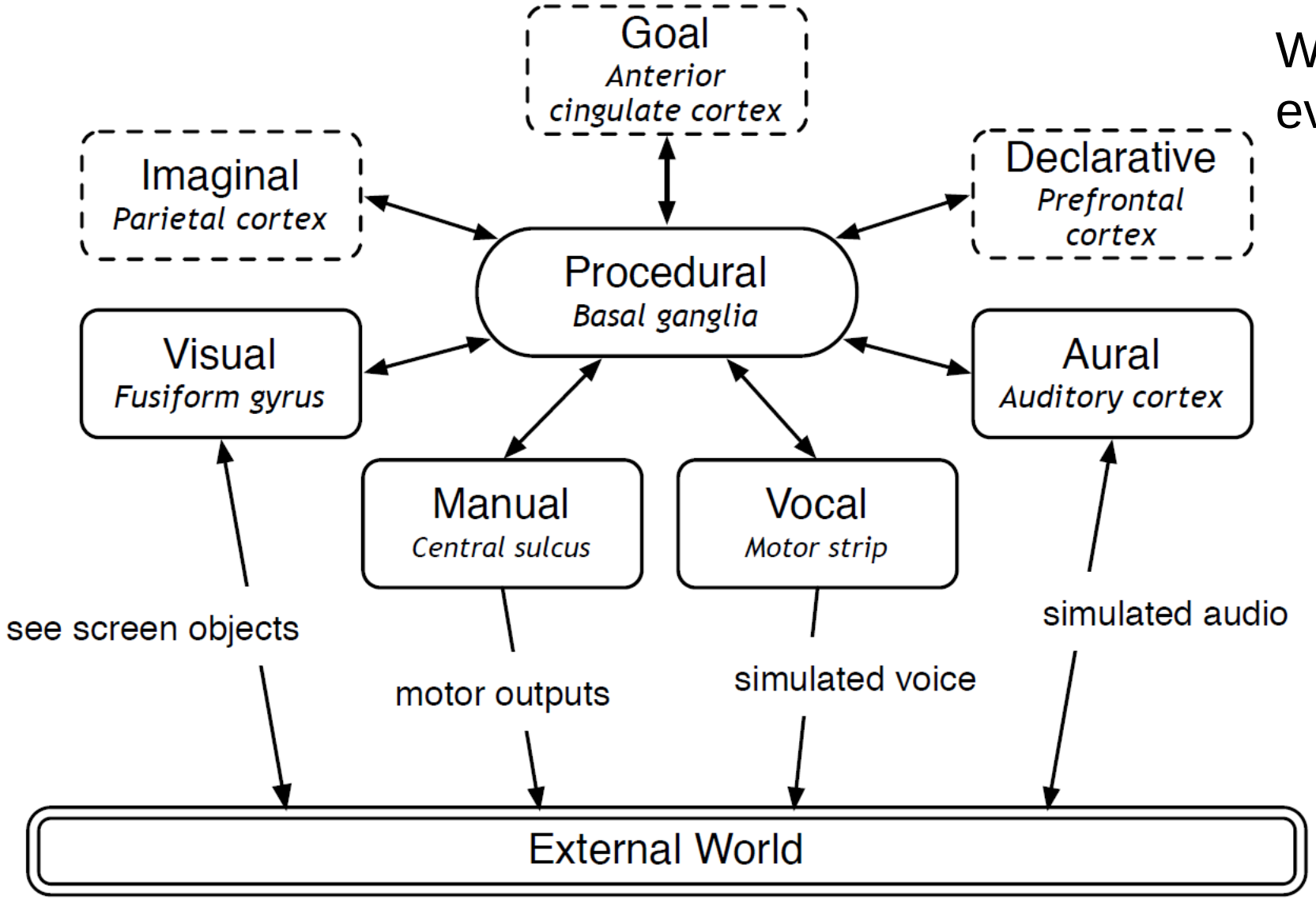


Photo by Polina Tankilevitch from https://www.pexels.com/photo/women-in-white-laboratory-gown-standing-3735757 (PD)

From Kim, J. W., & Hancock, P. (2010). Modeling operator performance under stress and fatigue: What can a cognitive architectural model tell us?



What are use case beyond evaluating interfaces?

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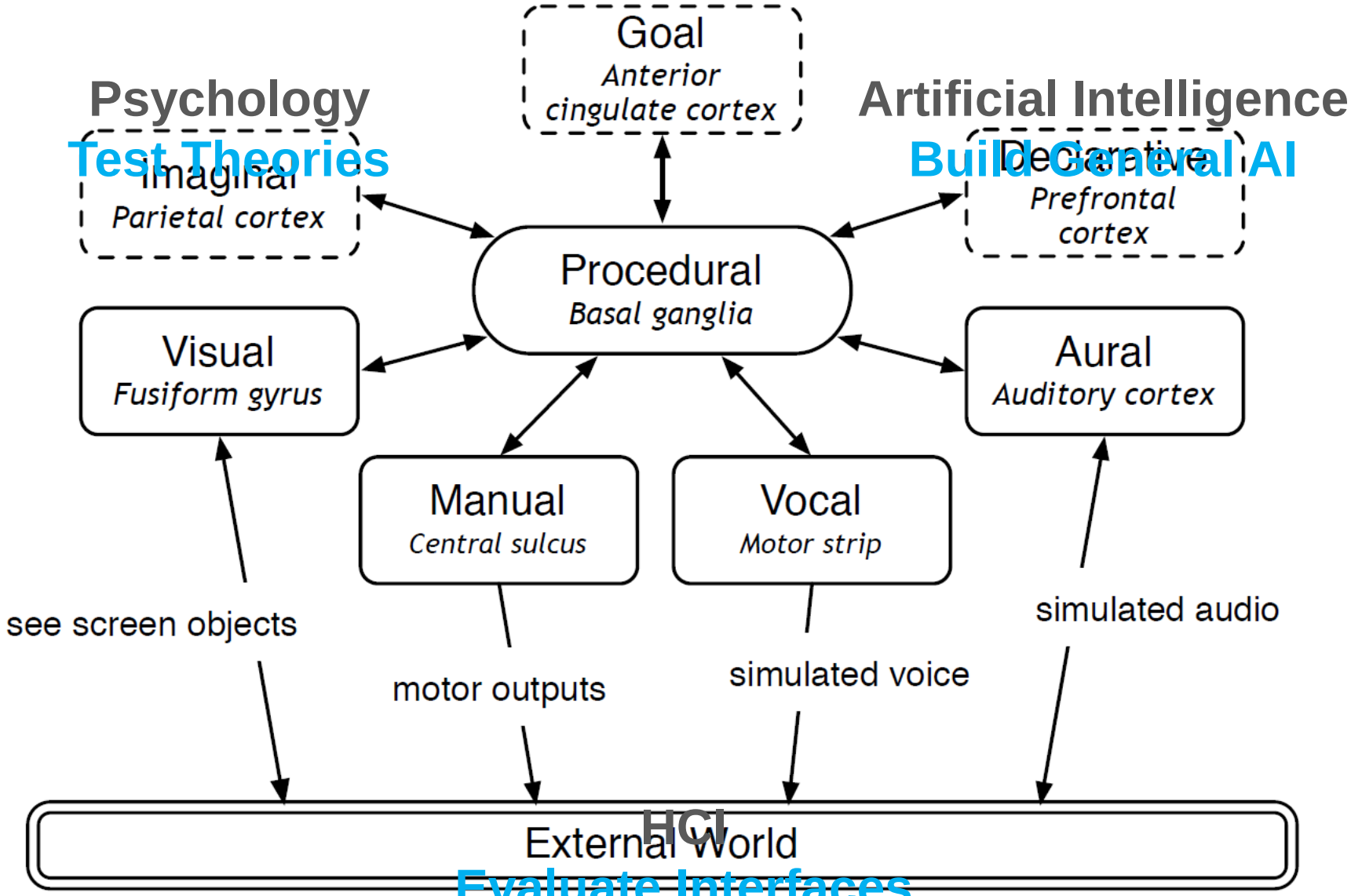

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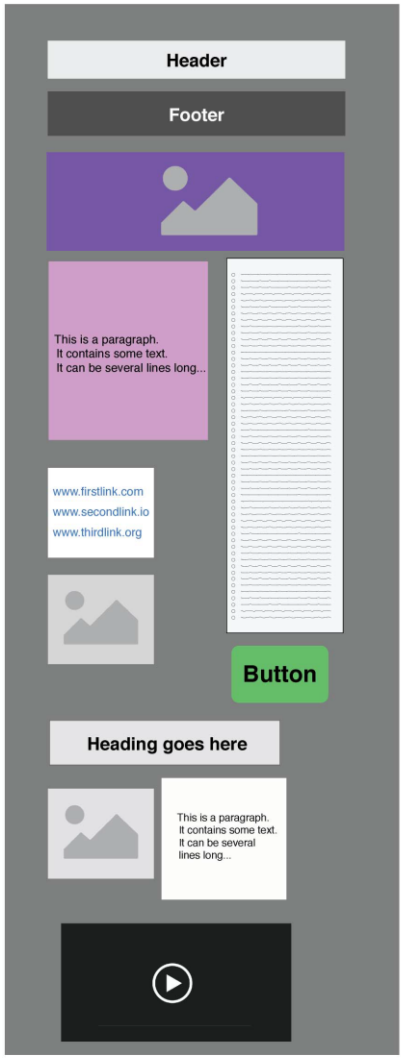
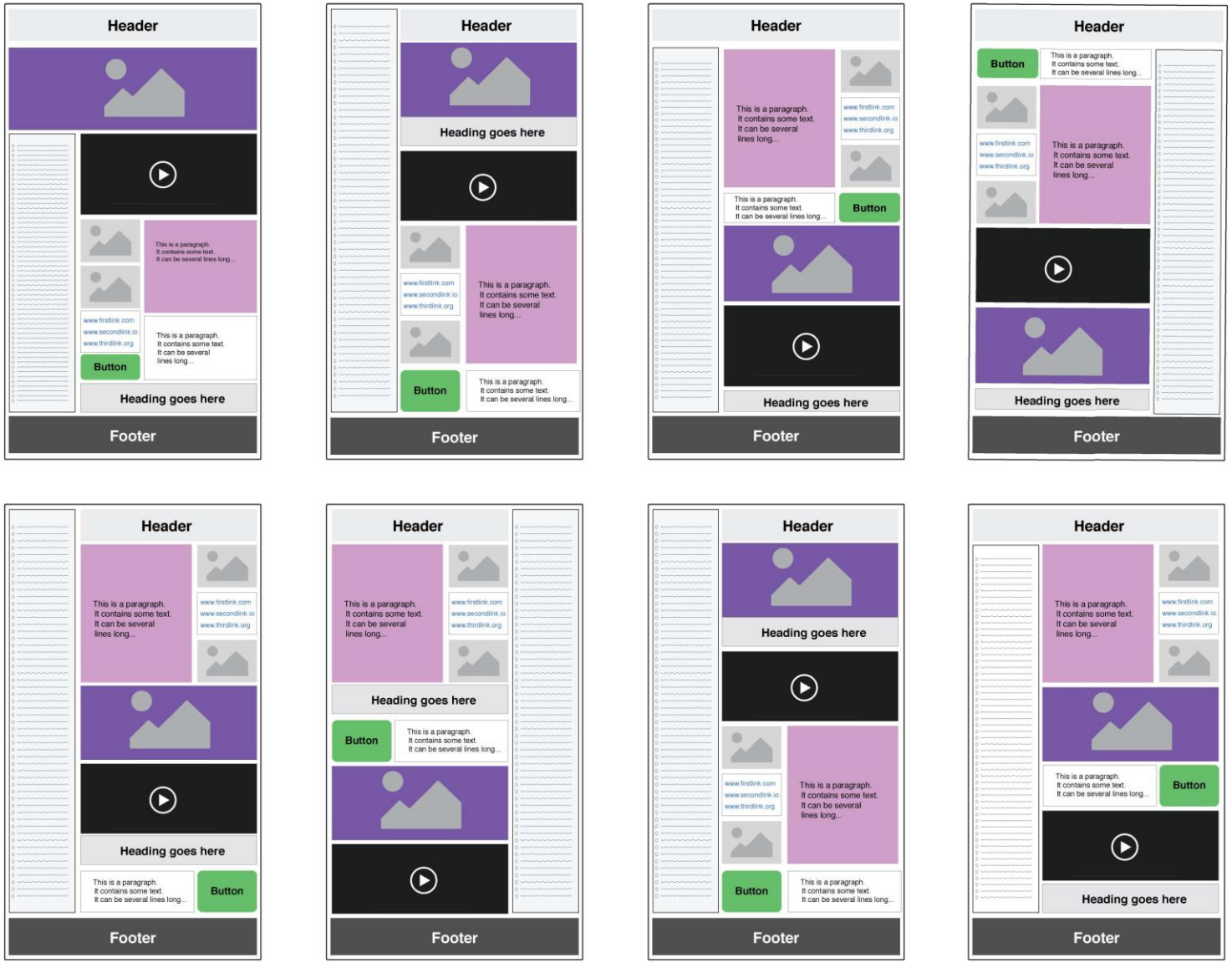


Input Design Task



Outputs

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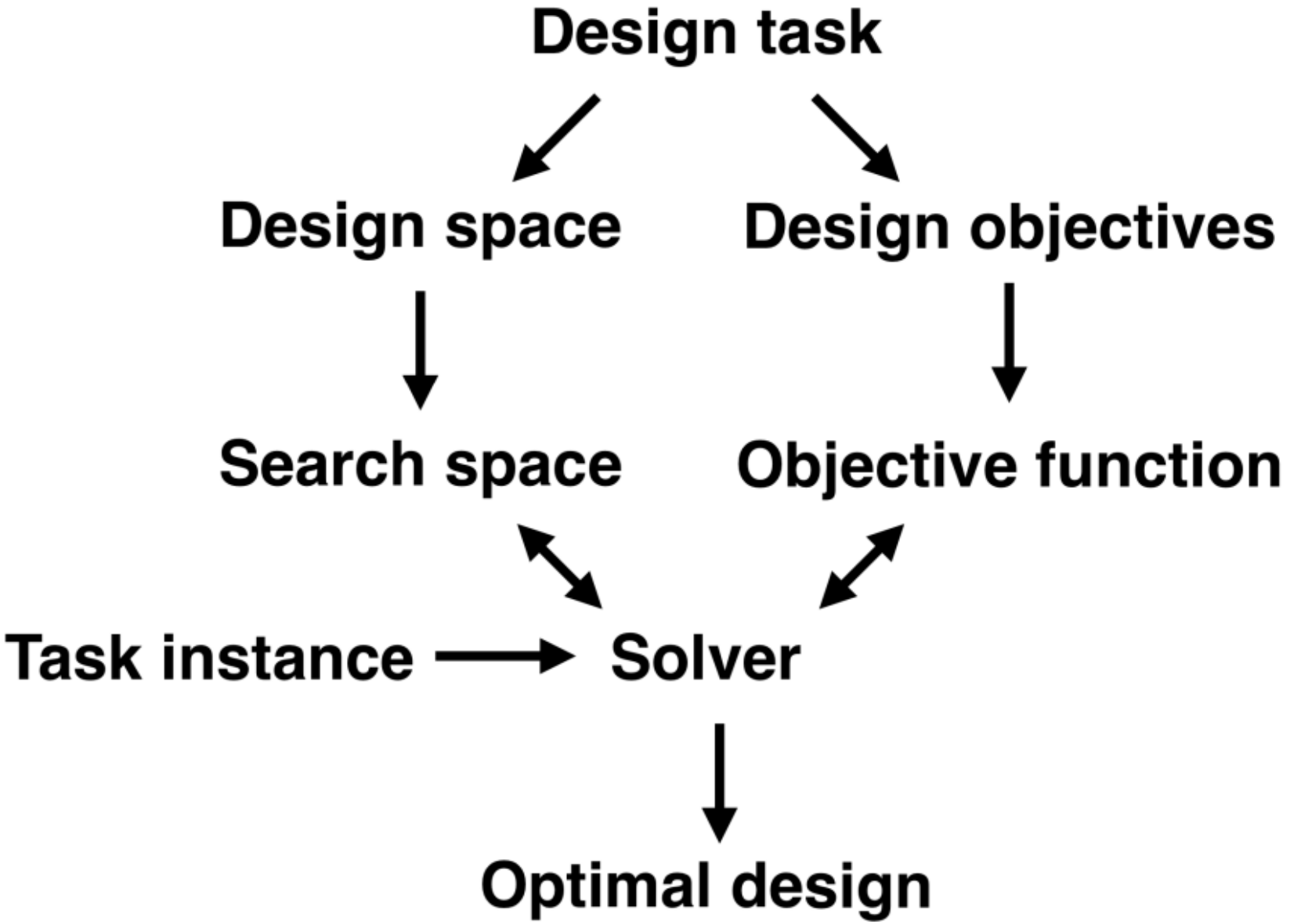

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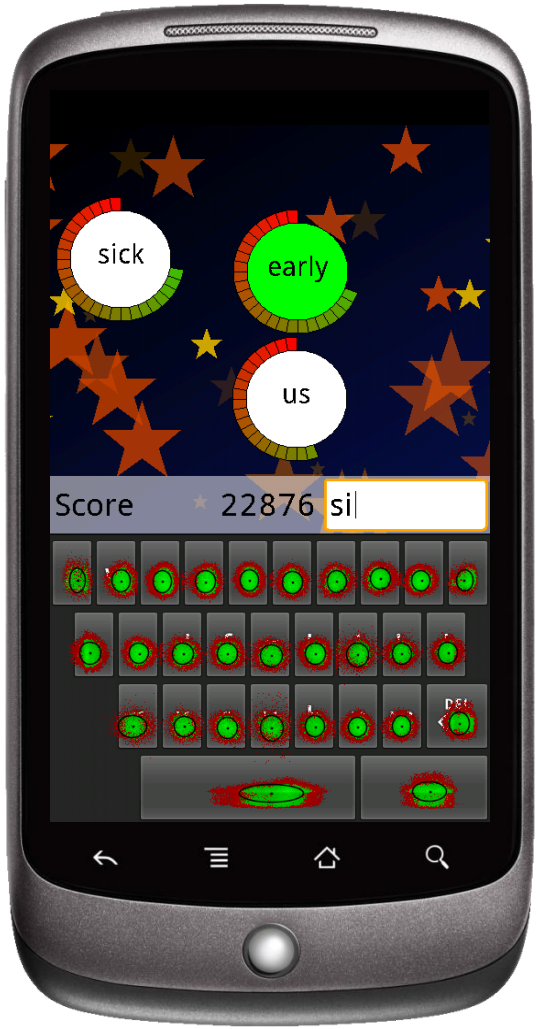
What can we do with this data?



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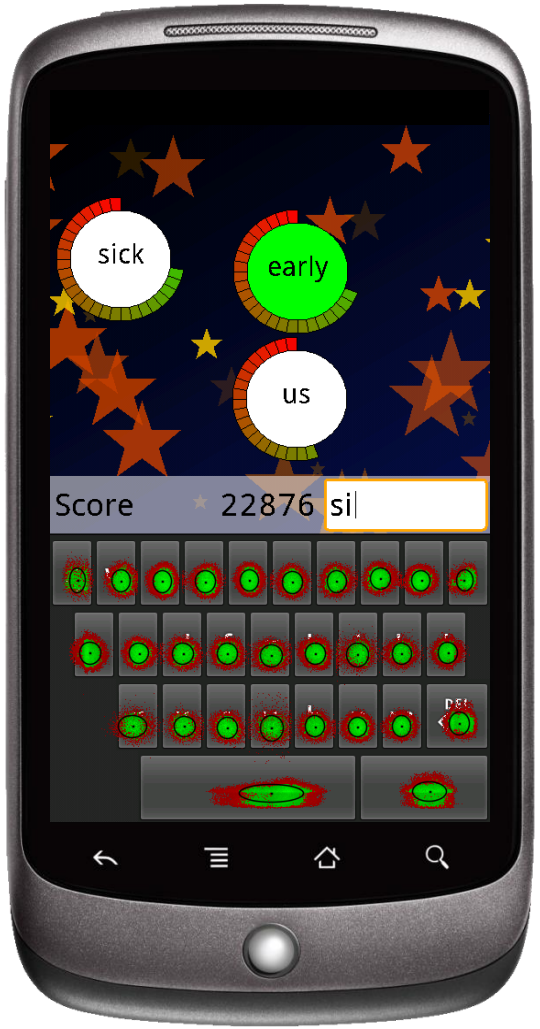

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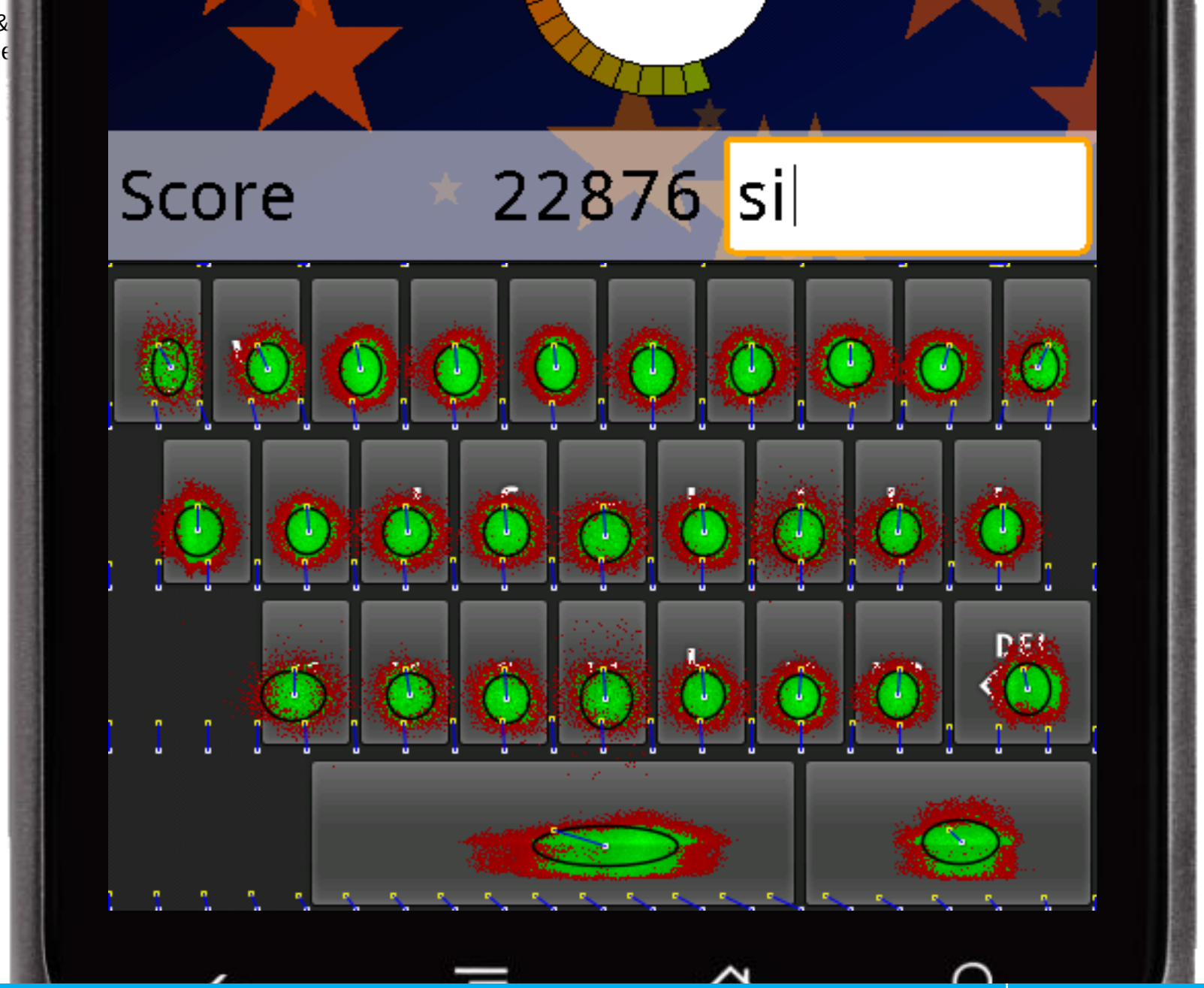

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