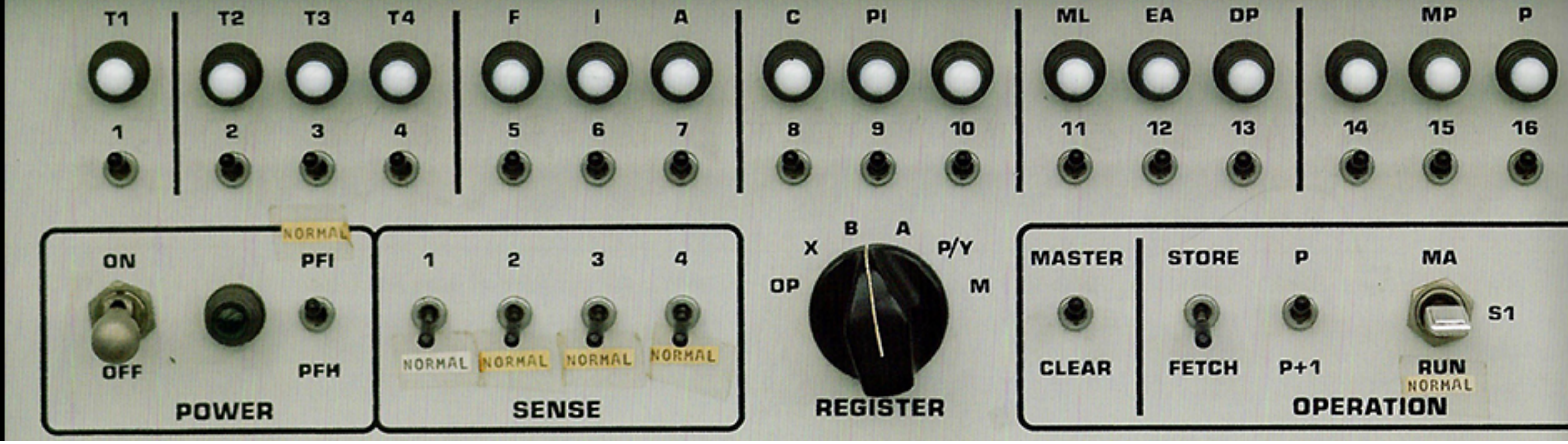
CS160

USER INTERFACE DESIGN

FALL 2018



HUMAN MODELS

19 SEP 2018

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www.paulos.net

UNIVERSITY OF CALIFORNIA Berkeley

ANNOUNCEMENTS

Airbnb has completely switched over to using Figma.

PROG 02A — Due BEFORE CLASS

PROG 02B — Due 5 OCT

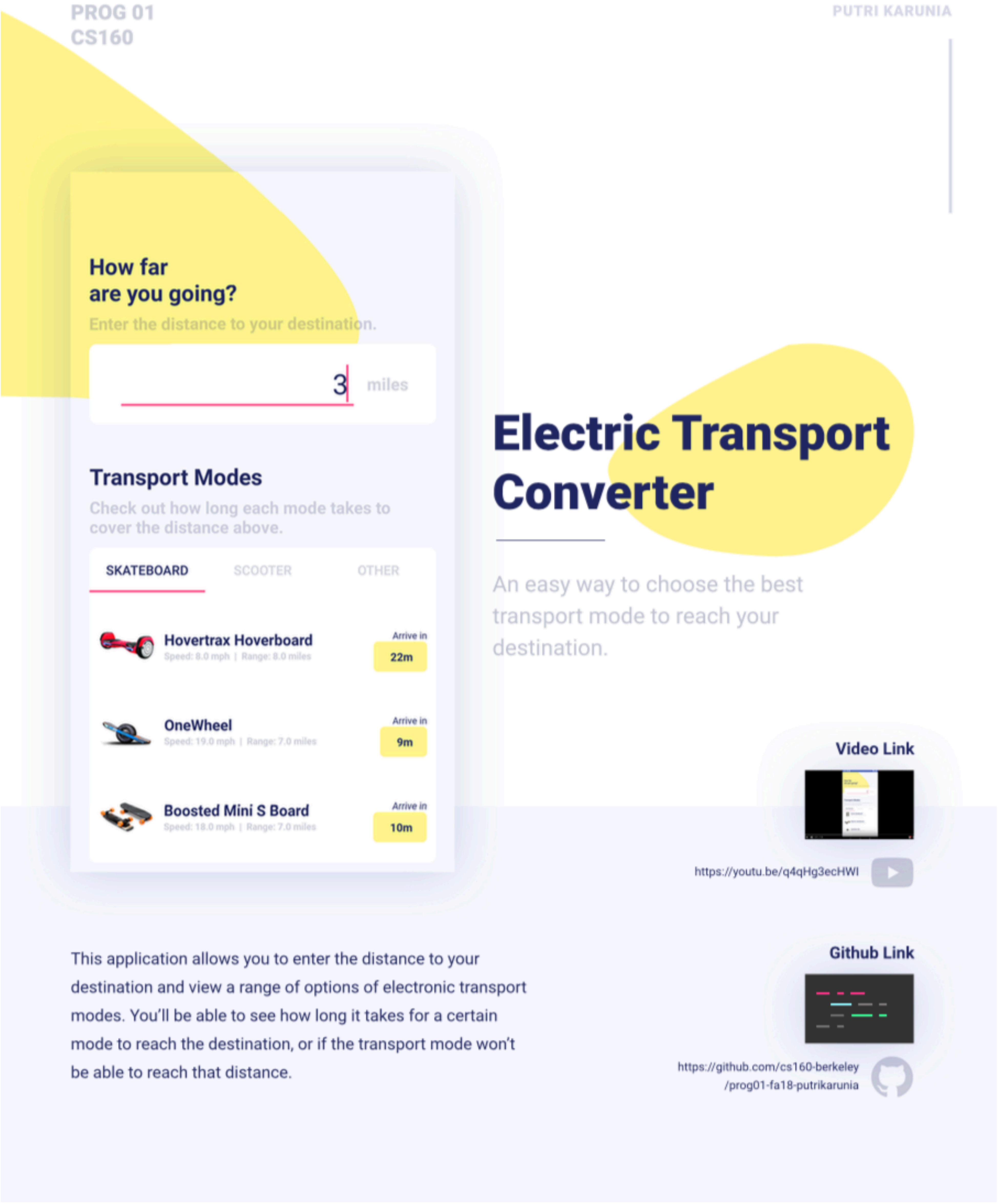
Required Class — 24 SEP

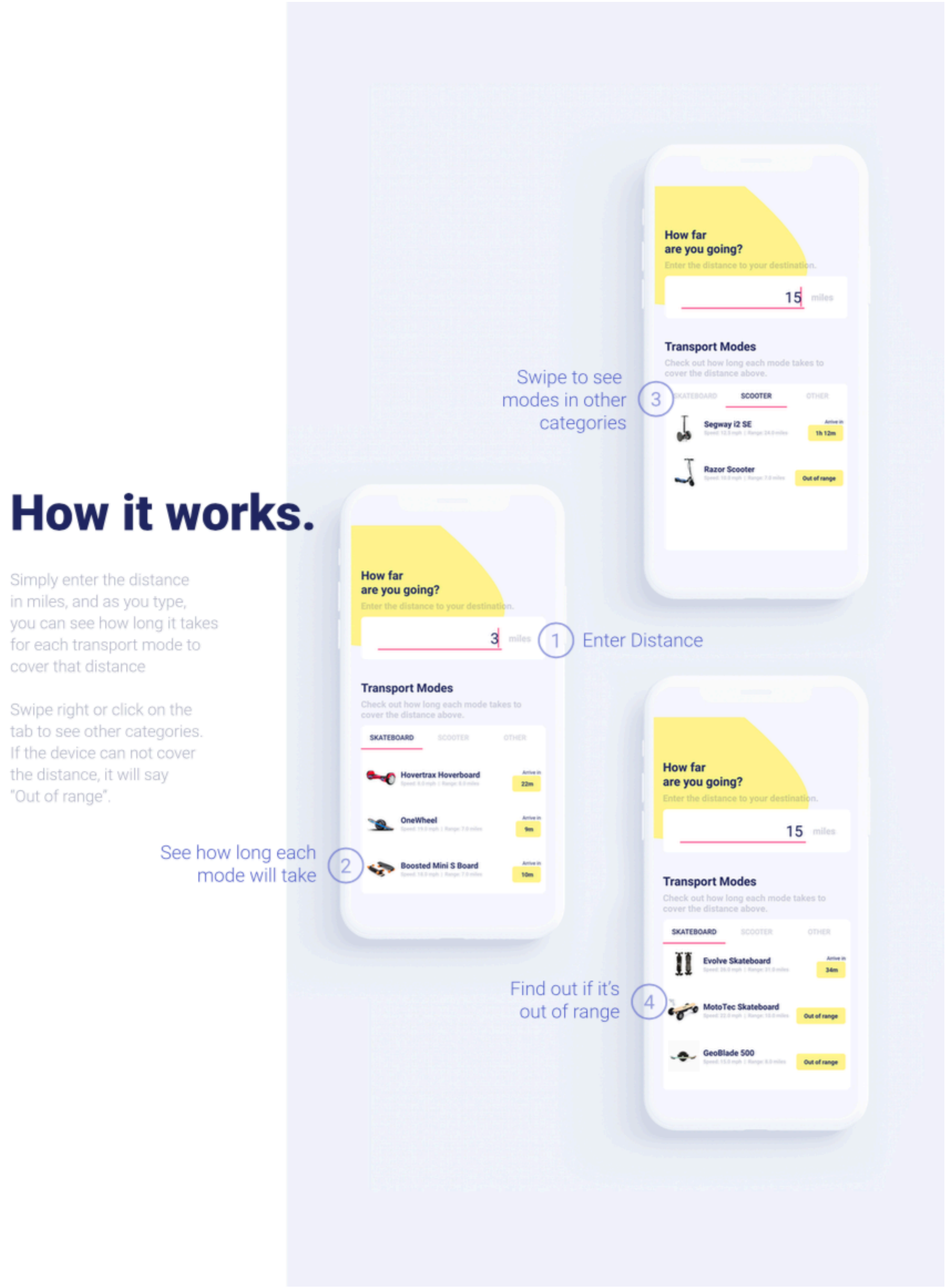
GROUPS ASSIGNED THIS WEEK

SECTION: APIs + Heuristic Evaluation

DESIGN 02 - Heuristic Evaluation (Due SEP 26)

PROG 01: PUTRI KARUNIA





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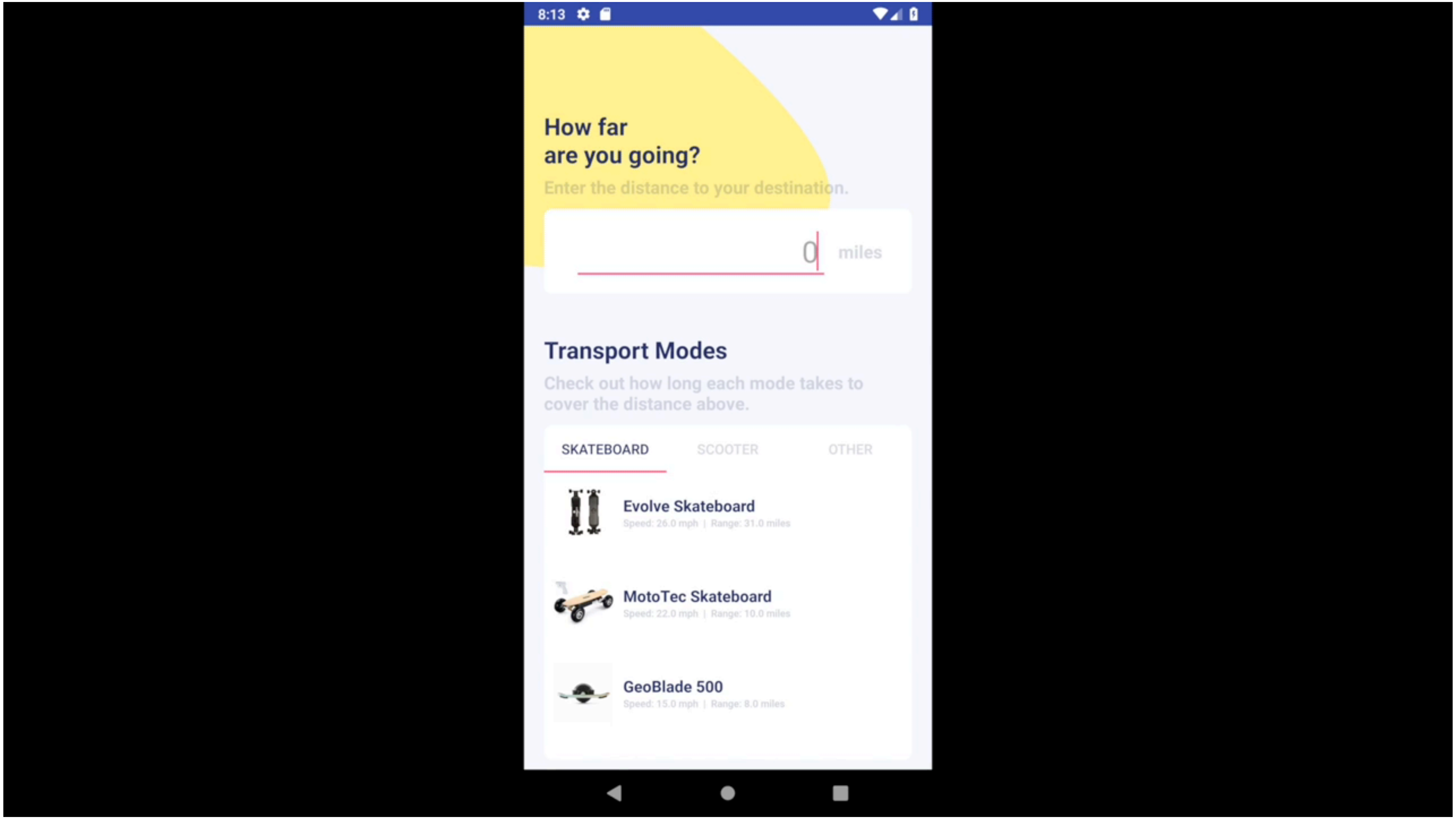
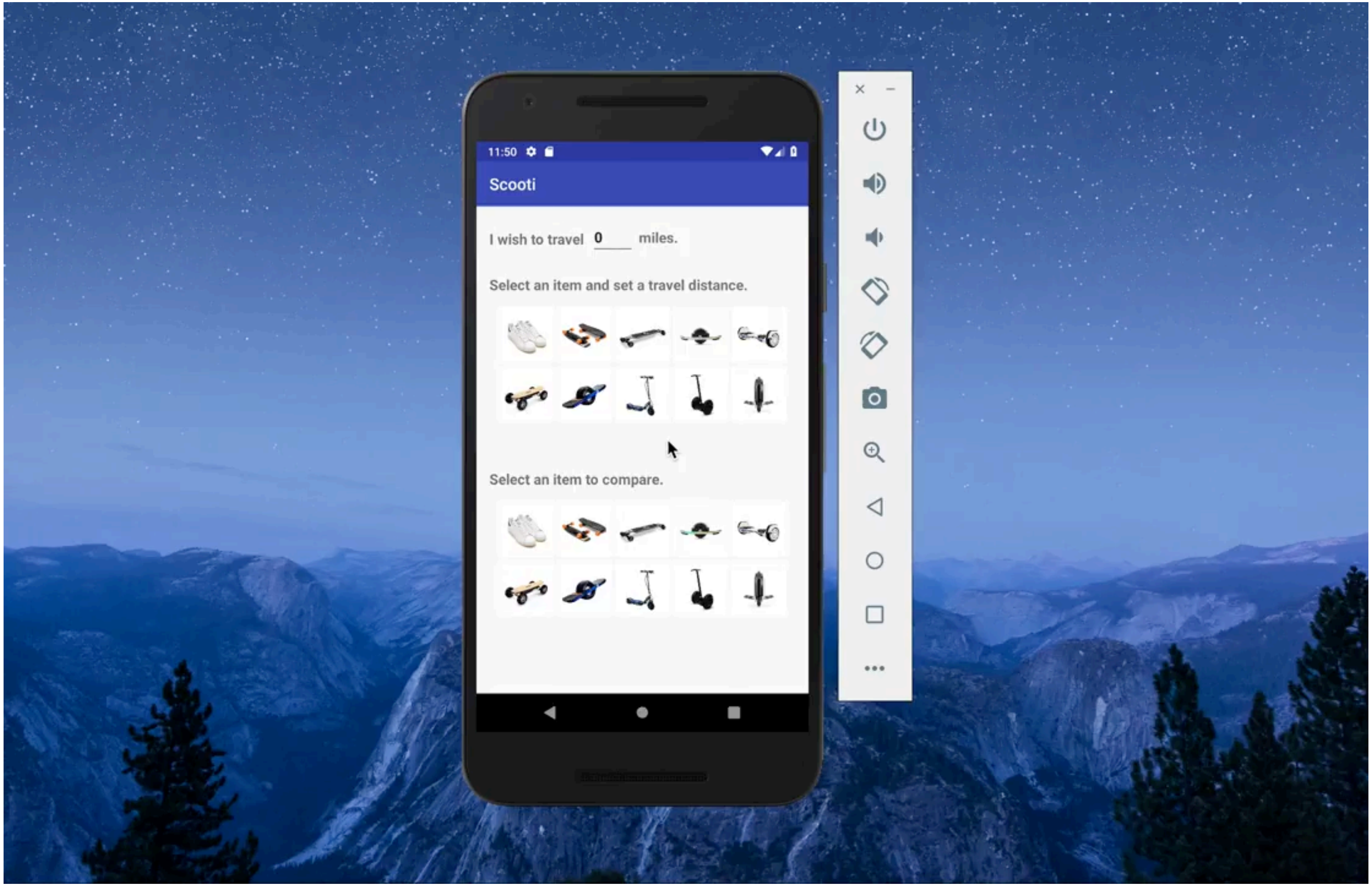


PROG 01: CANDICE YE



WHY MODEL HUMAN PERFORMANCE?

WHY MODEL HUMAN PERFORMANCE?

To predict impact of new technology/interface

Apply model to predict effectiveness

We could build a simulator to evaluate user interface designs

HUMAN INFO PROCESSOR

Processors:

- Perceptual
- Cognitive
- Motor

Memory:

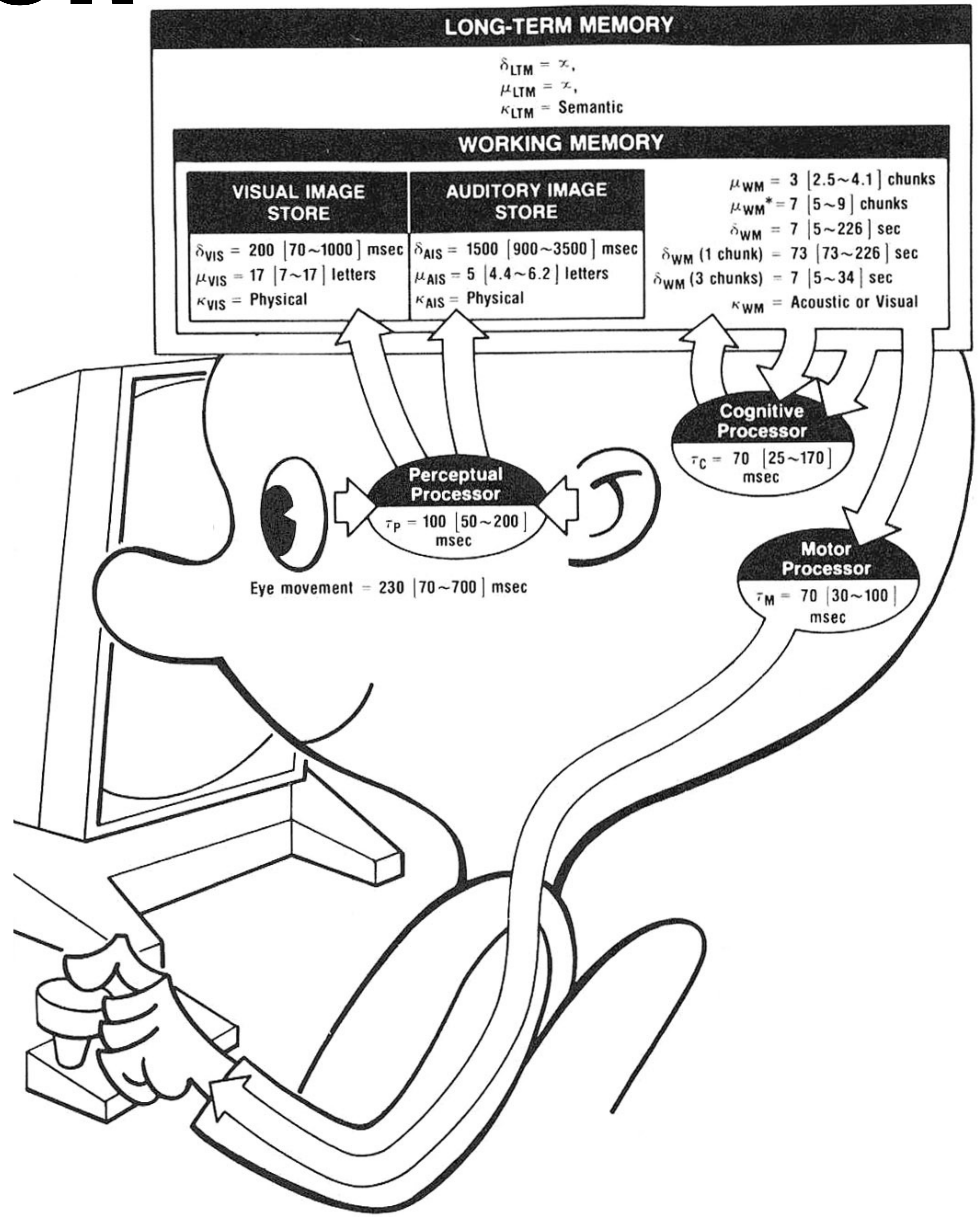
- Working memory
- Long-term memory

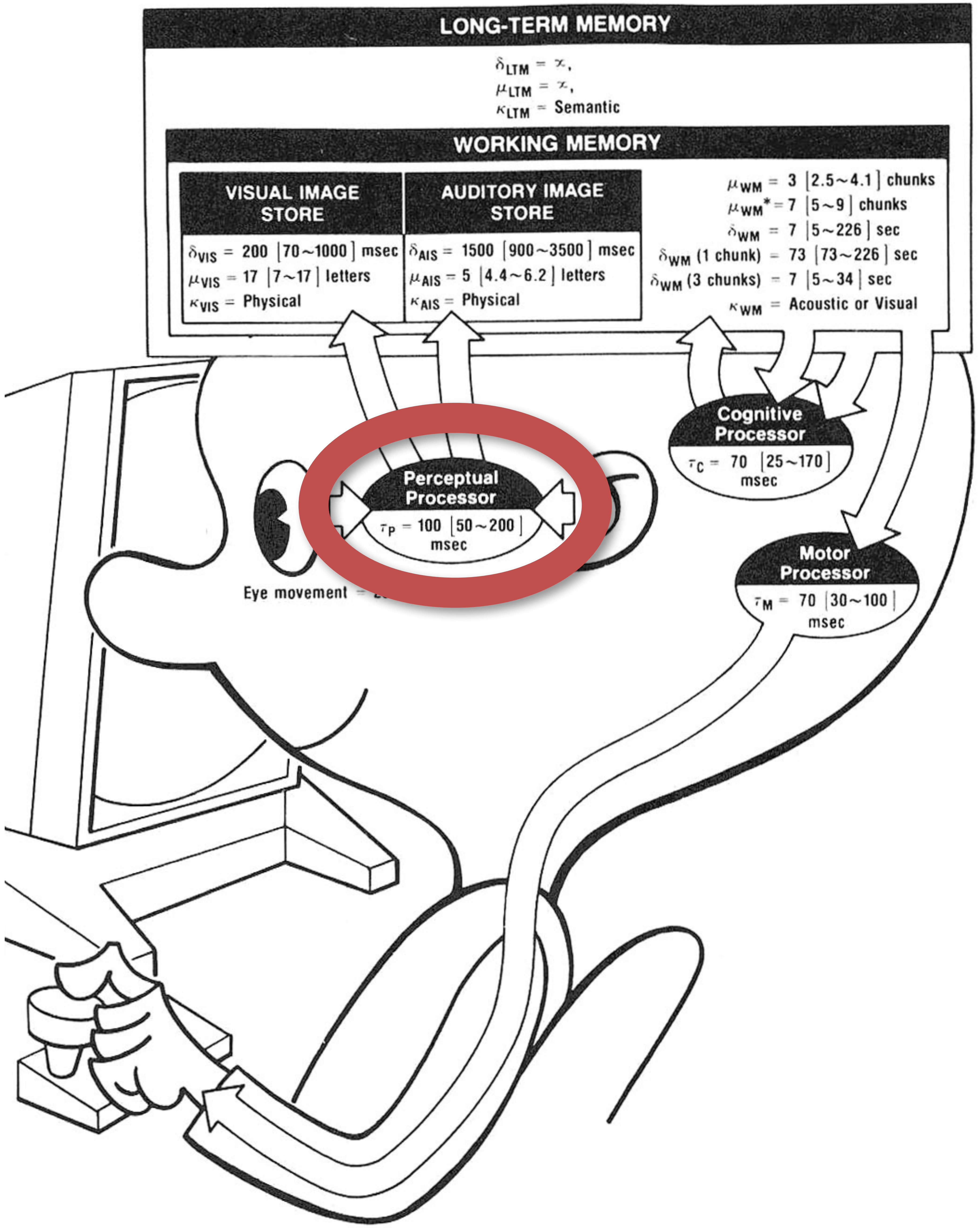
Unified model

Probably inaccurate

Predicts performance well

Very influential





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
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τ_P = 100 [50~200] msec
Motor Processor
τ_M = 70 [30~100] msec
Eye movement =

PERCEPTUAL PROCESSOR

Physical store from our senses: sight, sound, touch, ...

Code directly based on sense used

Visual, audio, haptic, ... features

Selective

Spatial

Pre-attentive: color, direction...

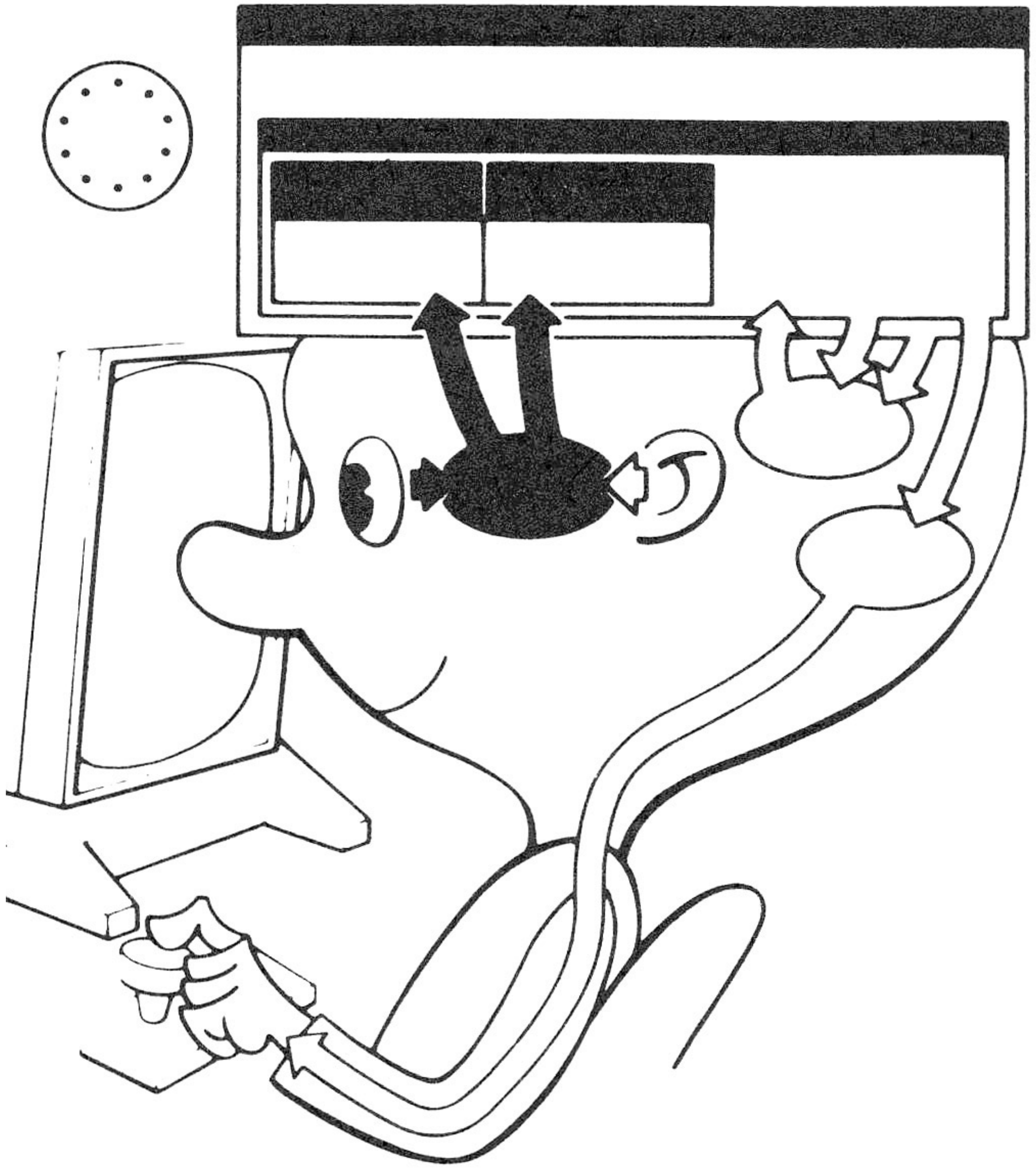
Capacity of visual store

Example: 17 letters

Decay time for working memory: 200ms

Recoded for transfer to working memory

Progressive: 10ms/letter



PRE-ATTENTIVE

Typically, tasks that can be performed on large multi-element displays in less than 200 to 250 milliseconds are considered preattentive.

HOW MANY 3'S

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686

HOW MANY 3'S

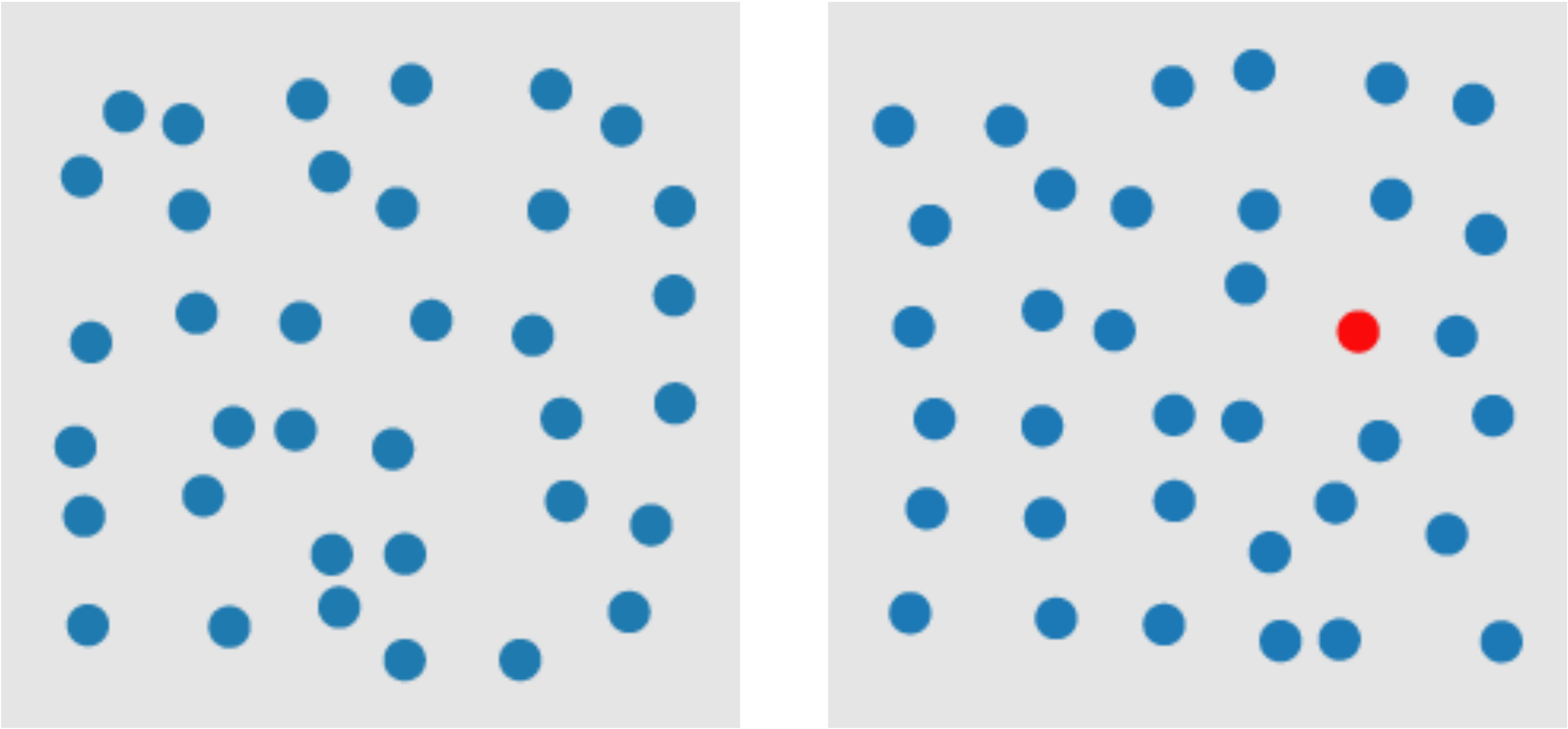
5690859068509681**3**89765469845069856082826
21120918209812098120984659690910**3**0209902
5**3**95959577256445689075469675050678904567
81894576**3**64669504405986812404**3**60912949686

HOW MANY 3'S

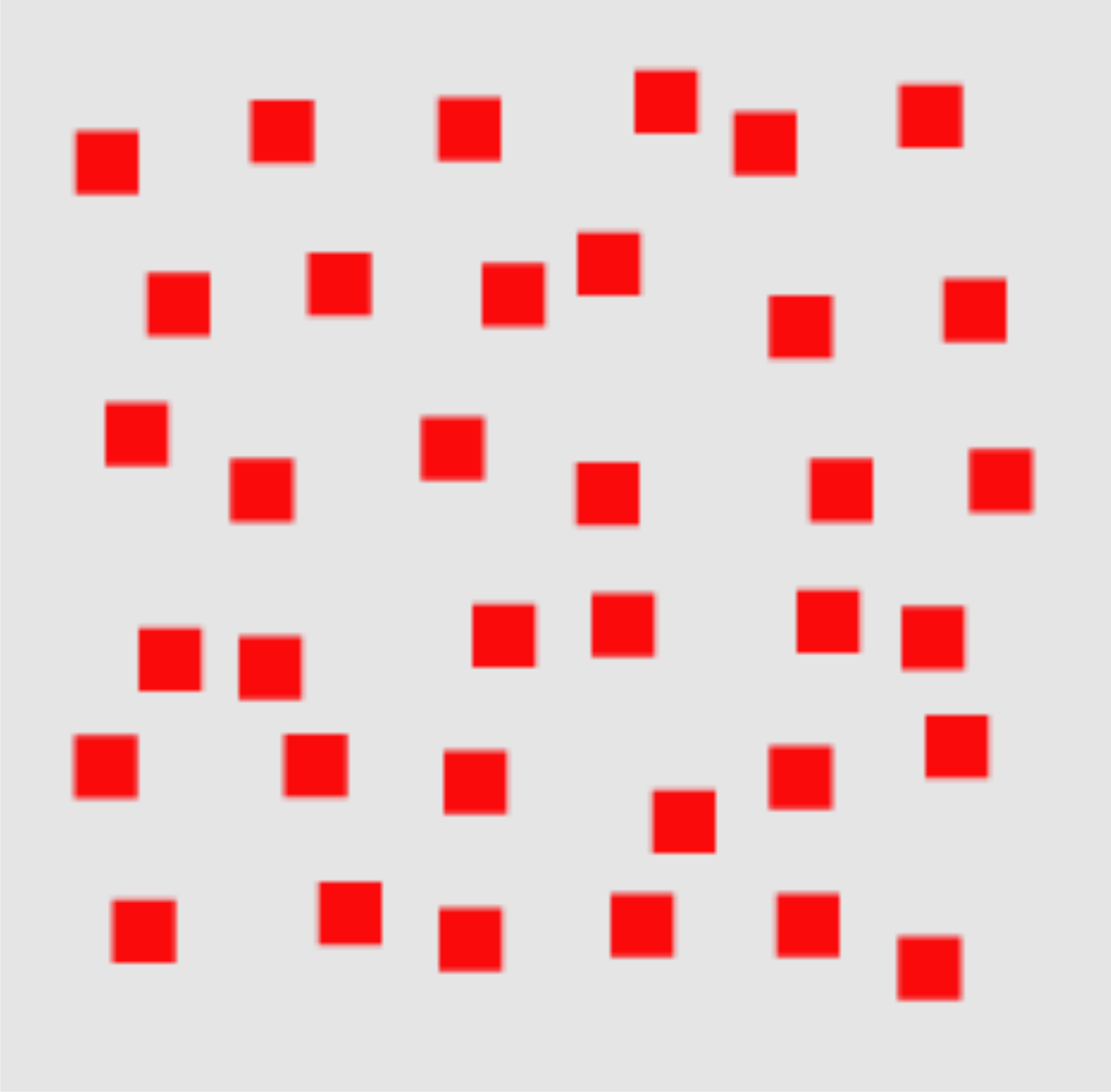
1281768756**3**8976546984506985604982826762
980985845822450985645894509845098094**3**585
909103**3**020990595959577256467505067890456 7
8845789809821677654876**3**64908560912949686

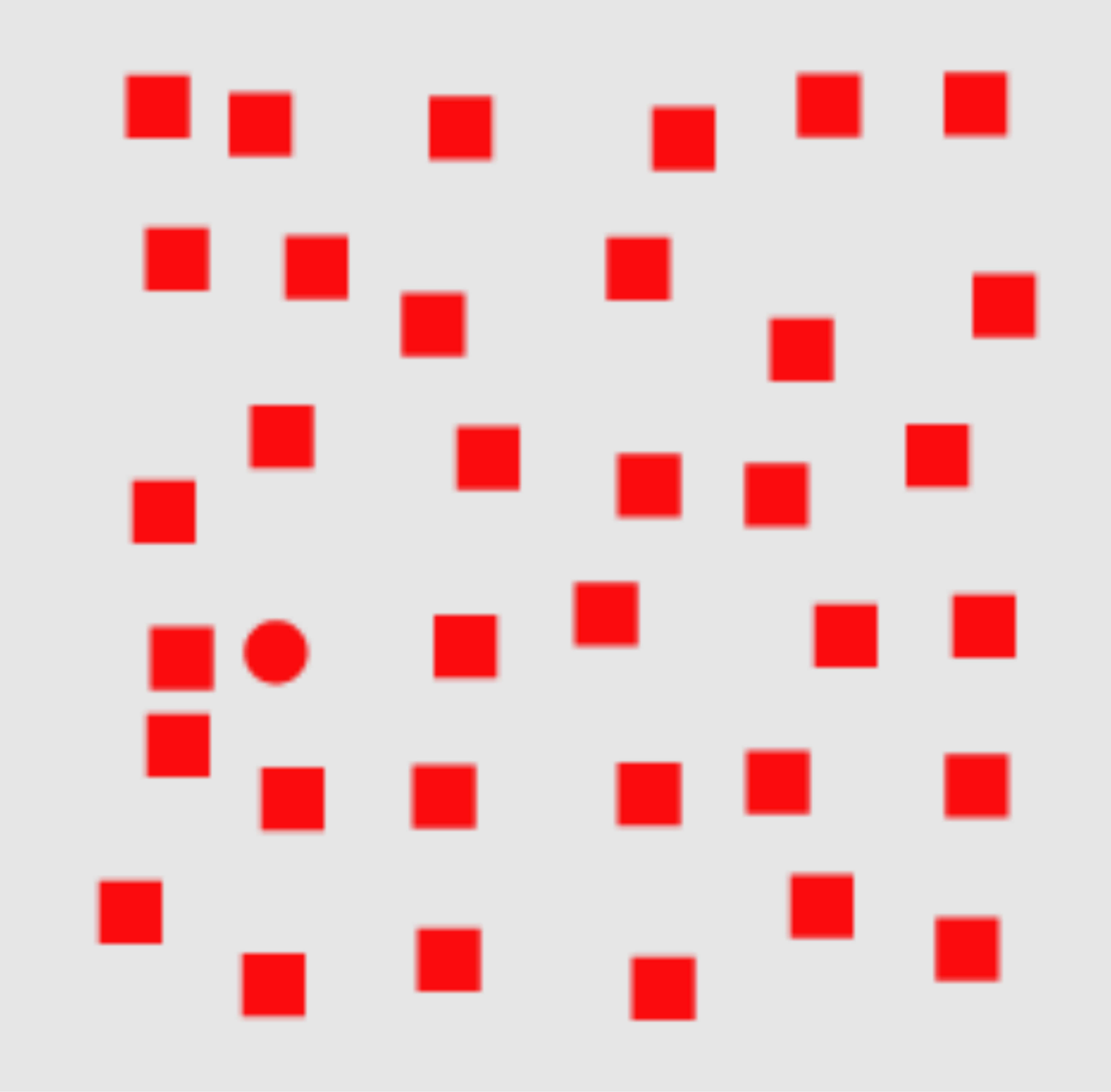
VISUAL POP-OUT: COLOR

http://www.csc.ncsu.edu/faculty/healey/PP/index.html



VISUAL POP-OUT: SHAPE





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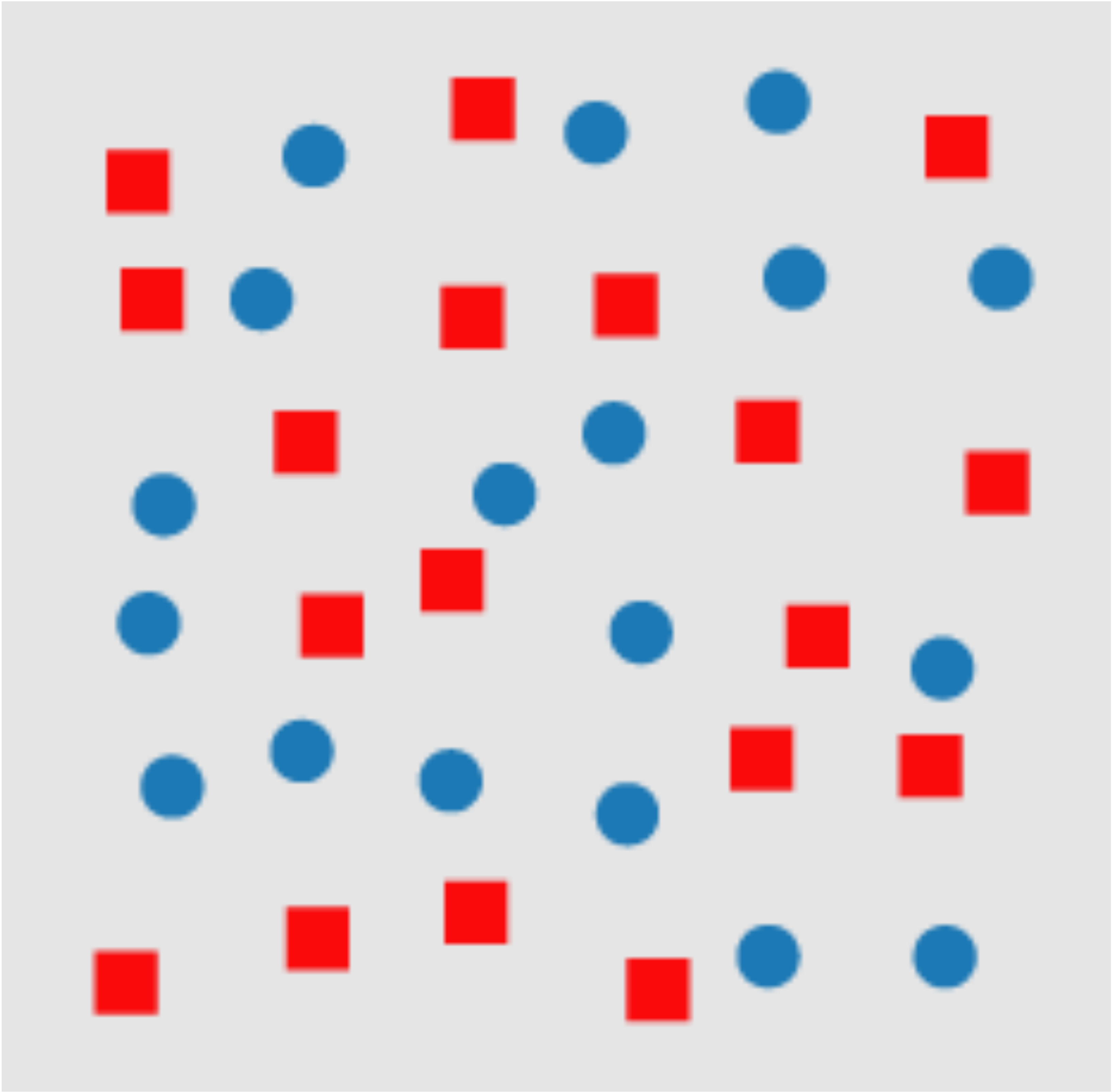
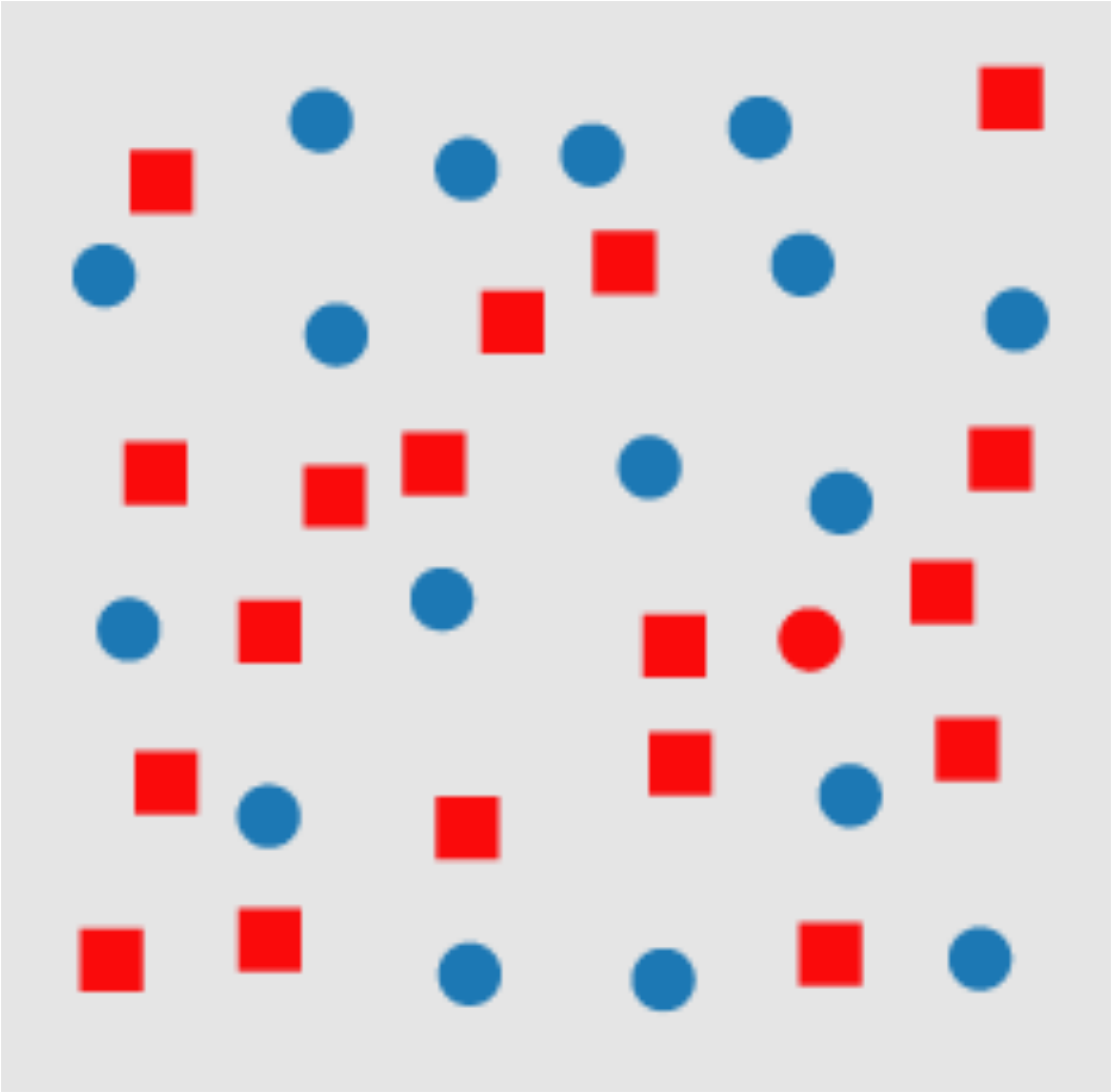
FEATURE CONJUNCTIONS





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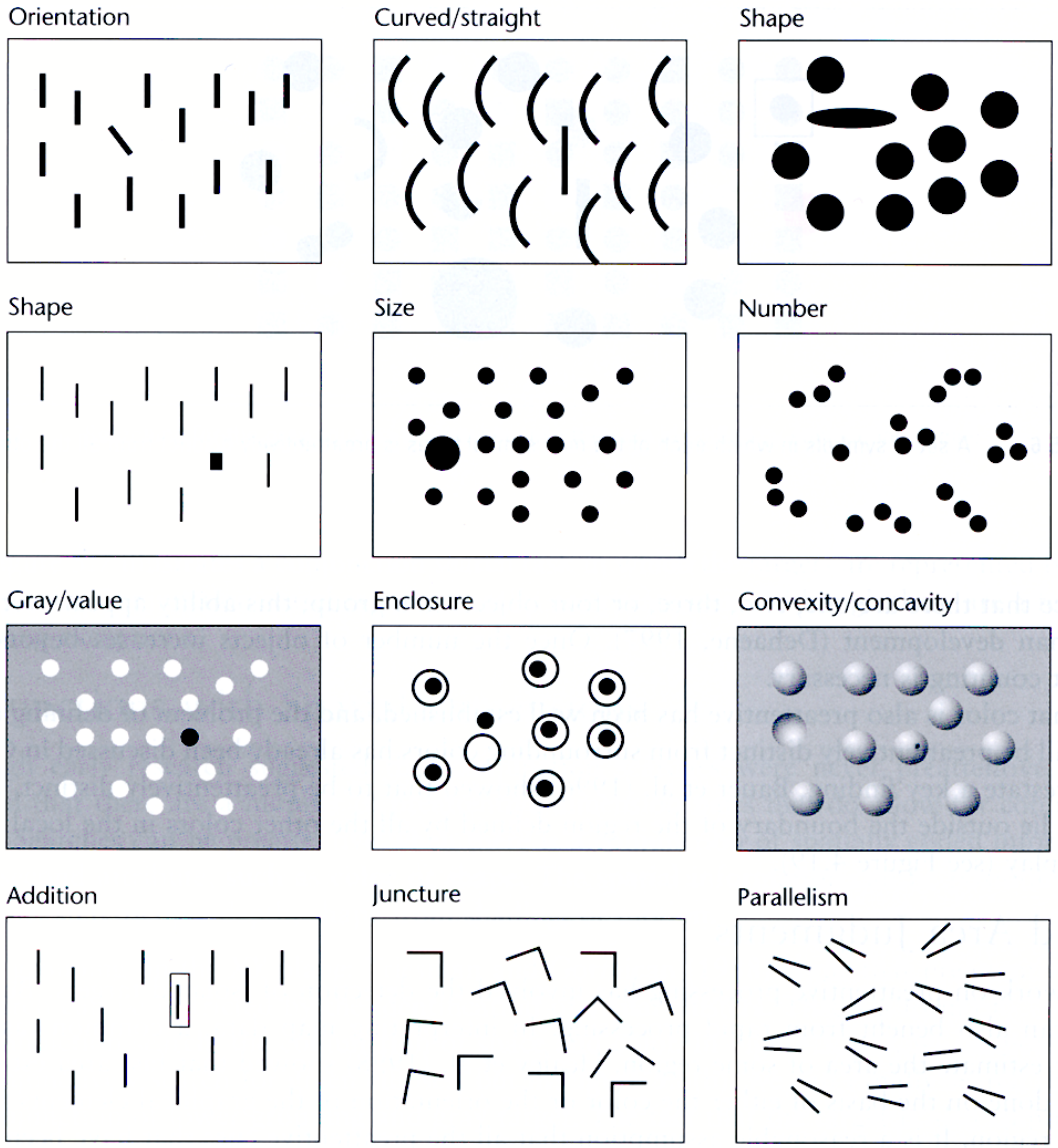
PRE-ATTENTIVE FEATURES



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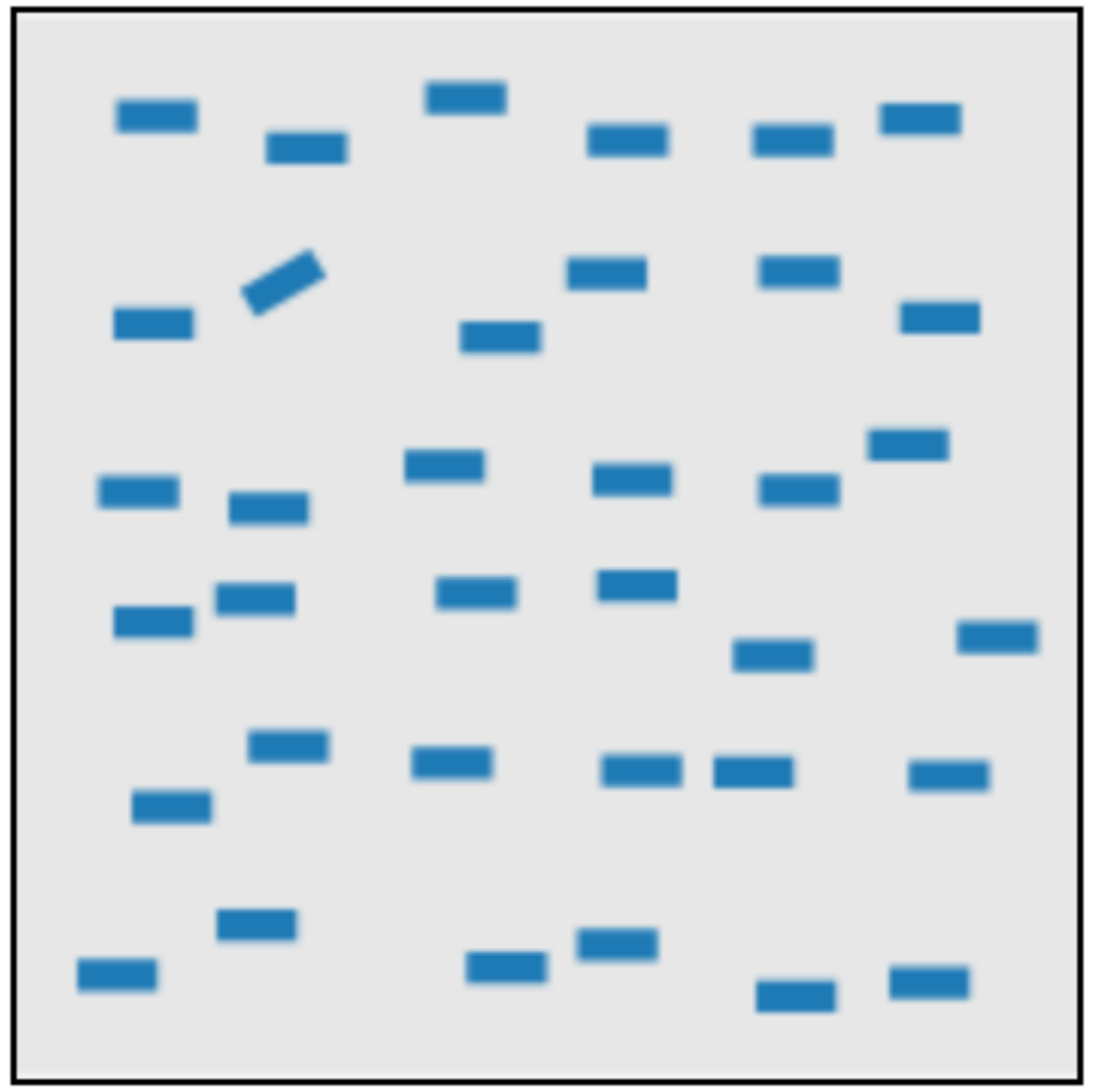
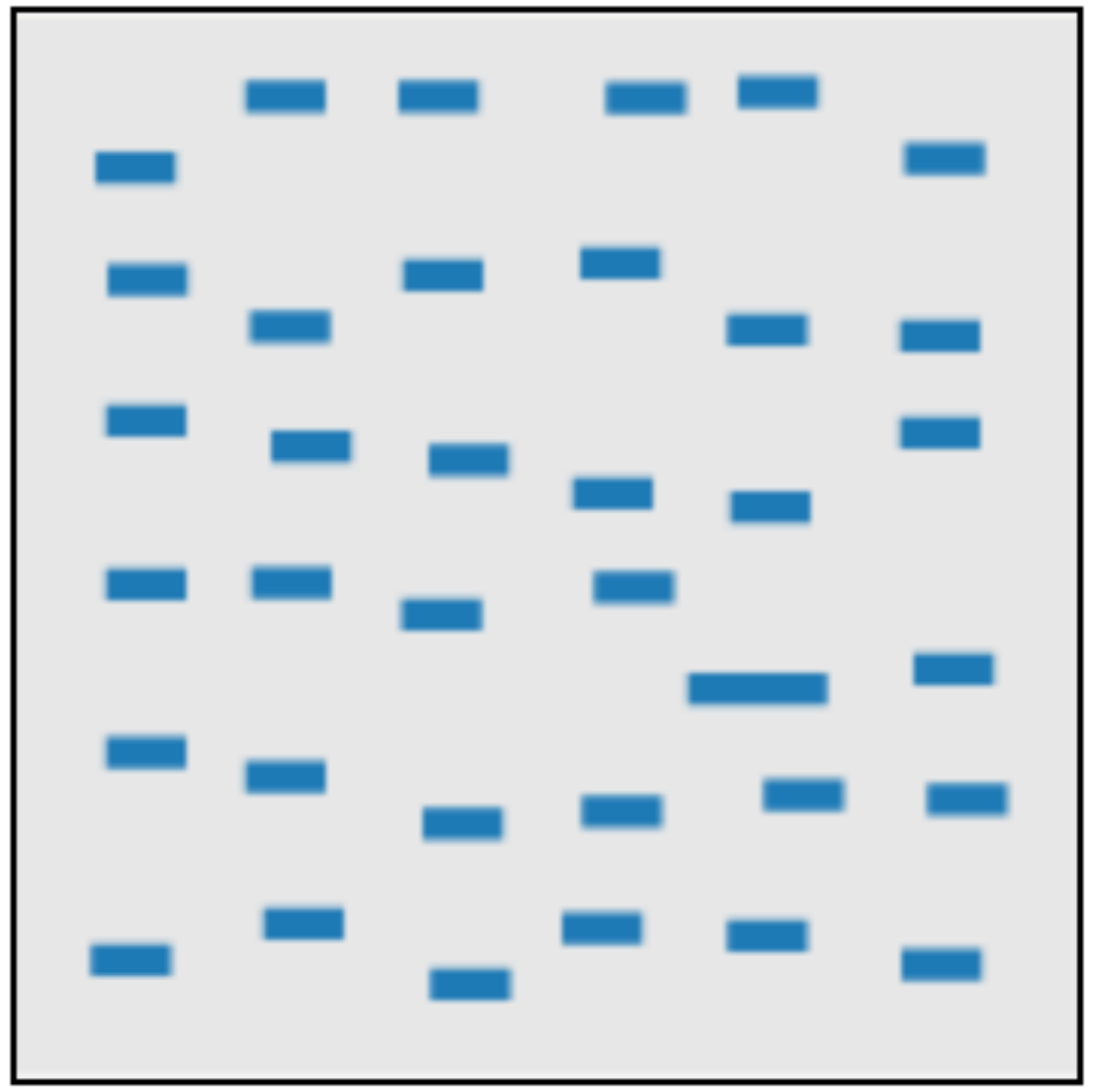
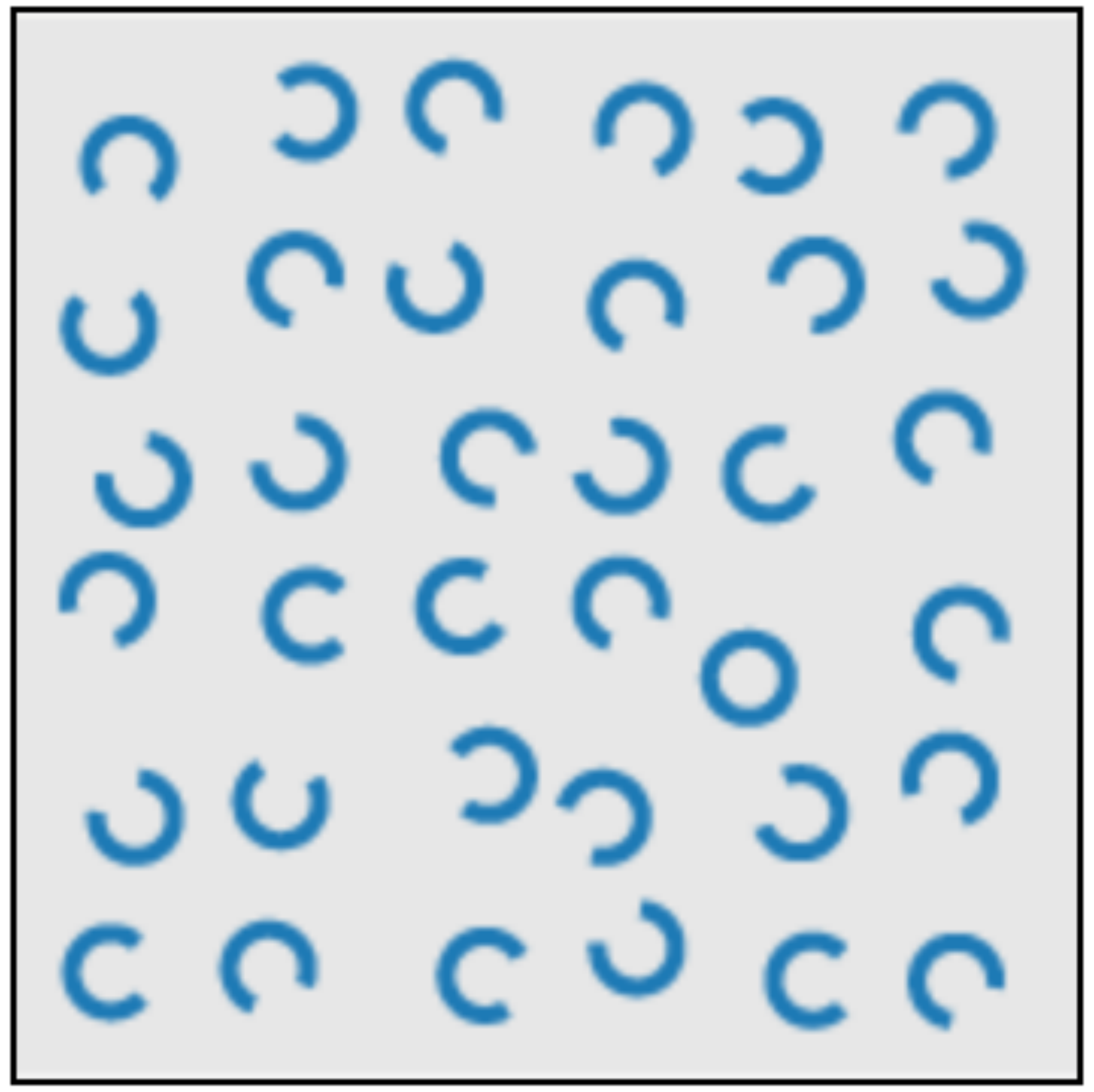


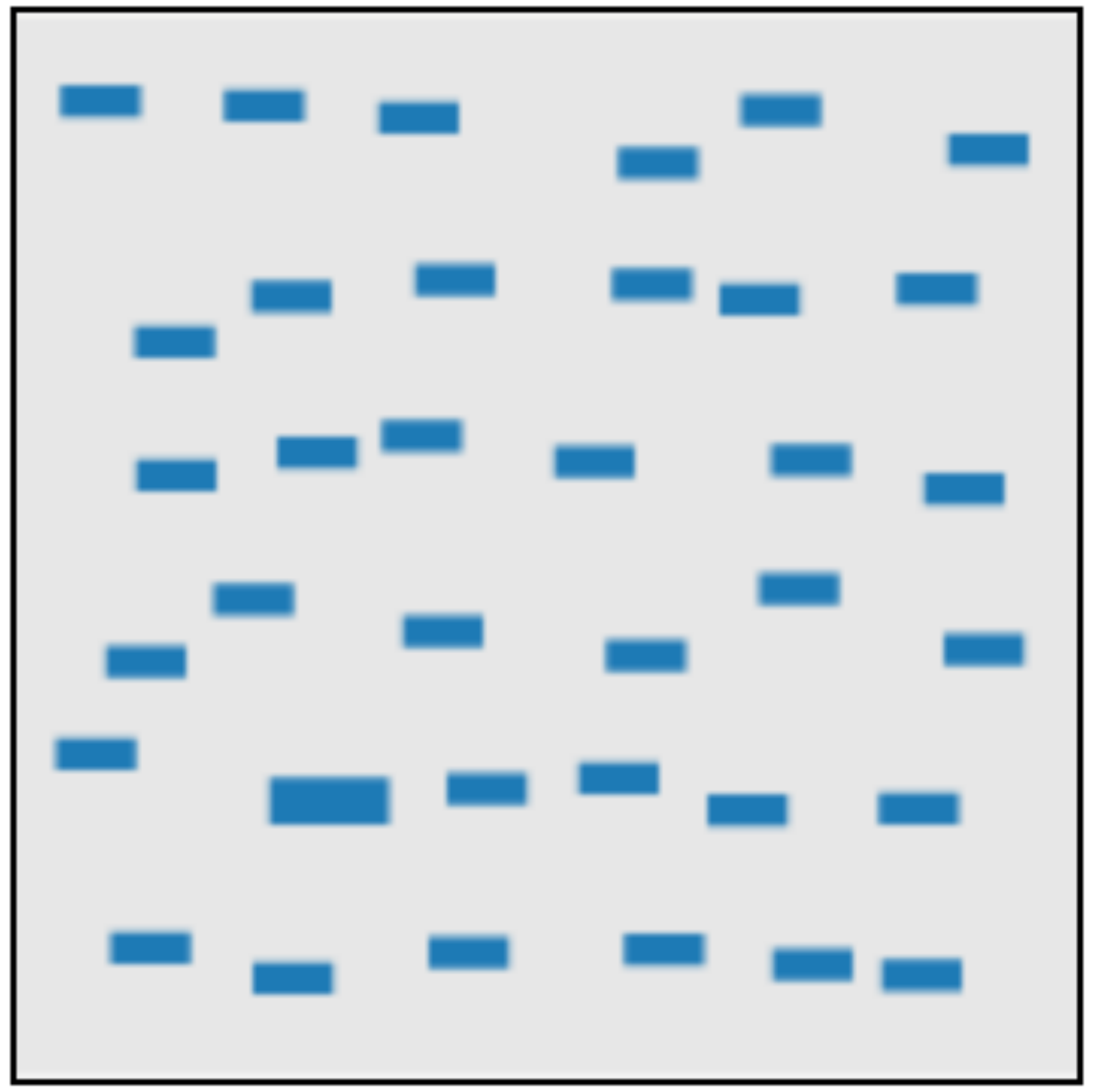
line (blob) orientation



length, width



closure



size

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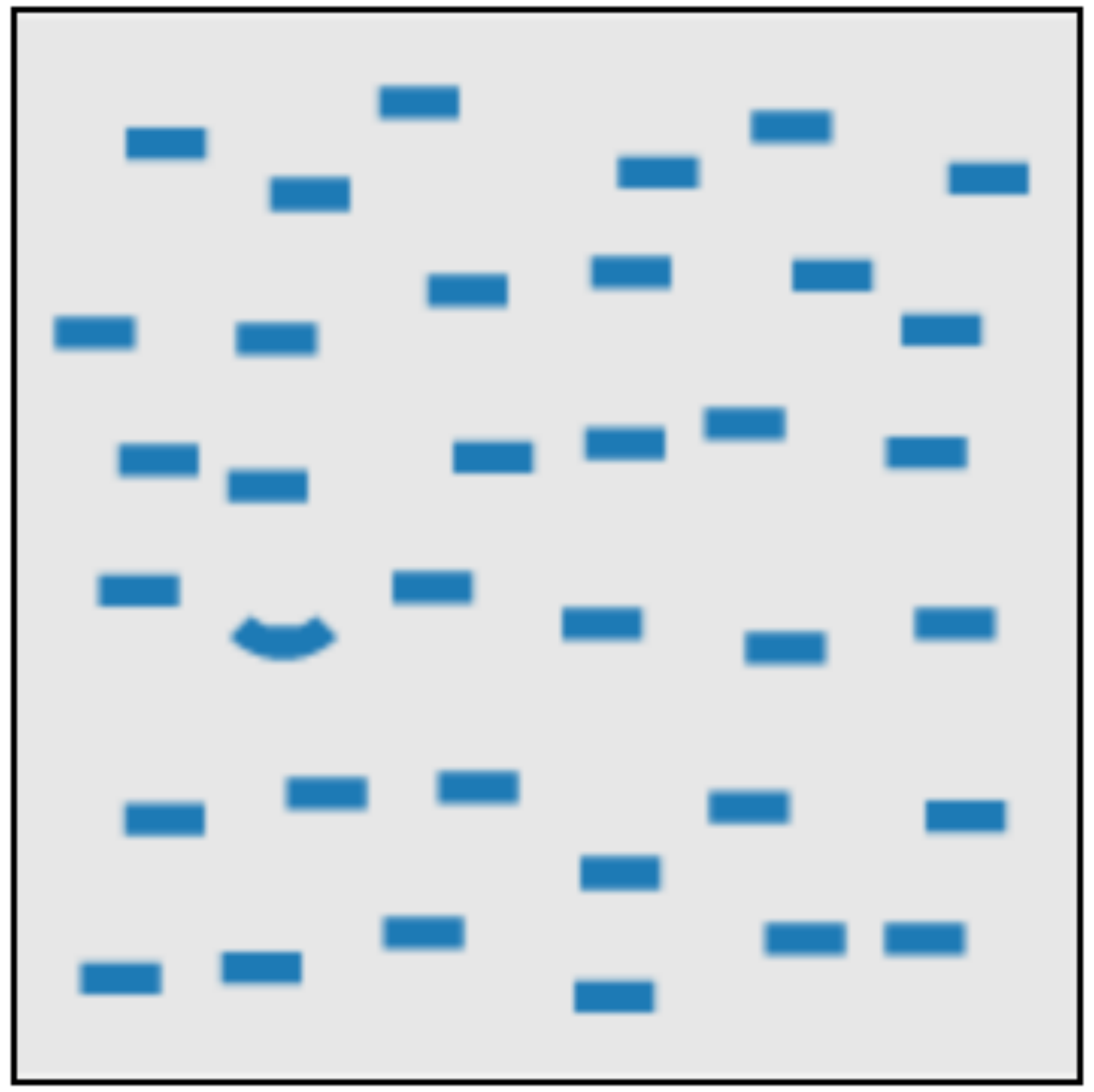
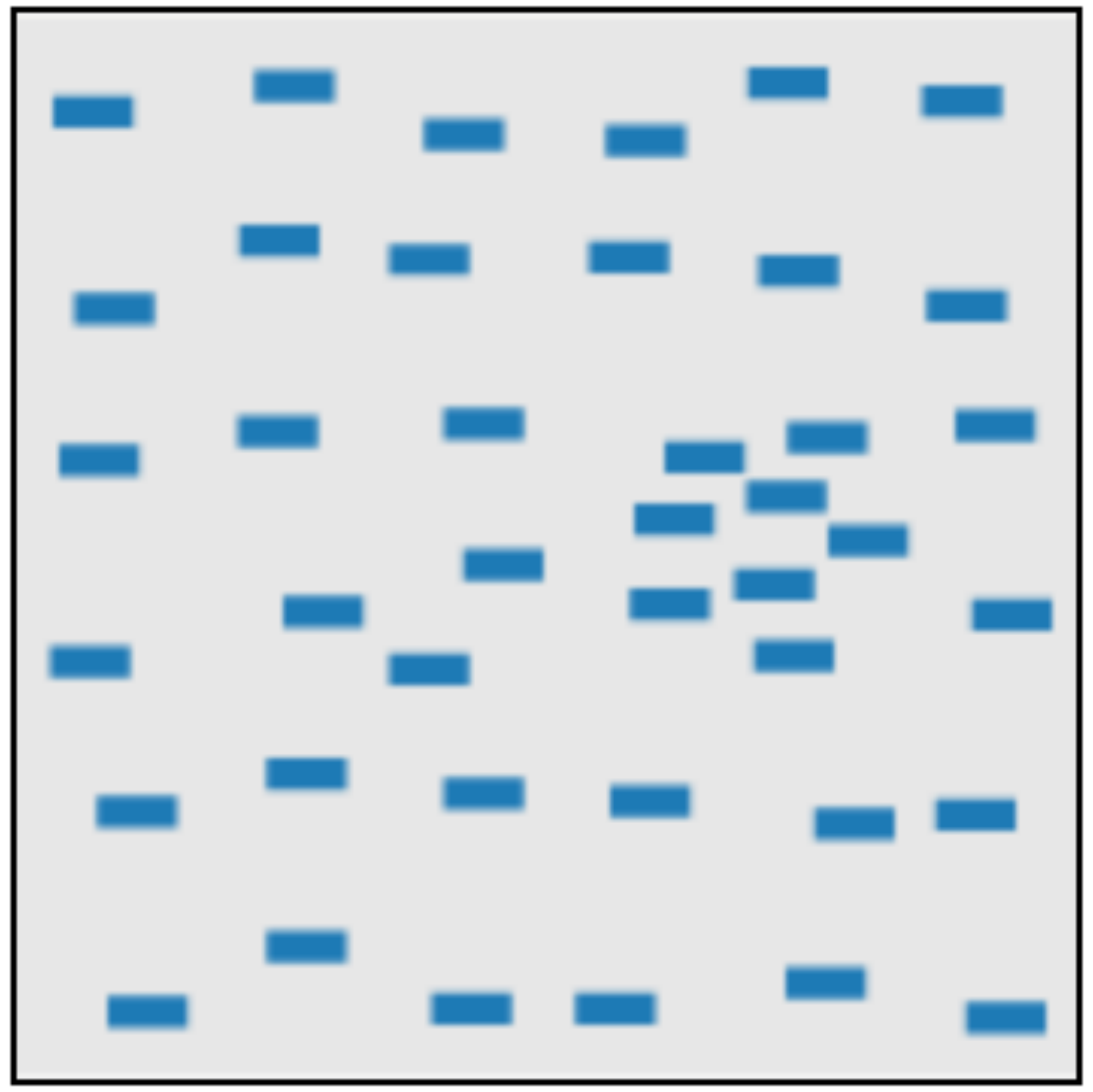
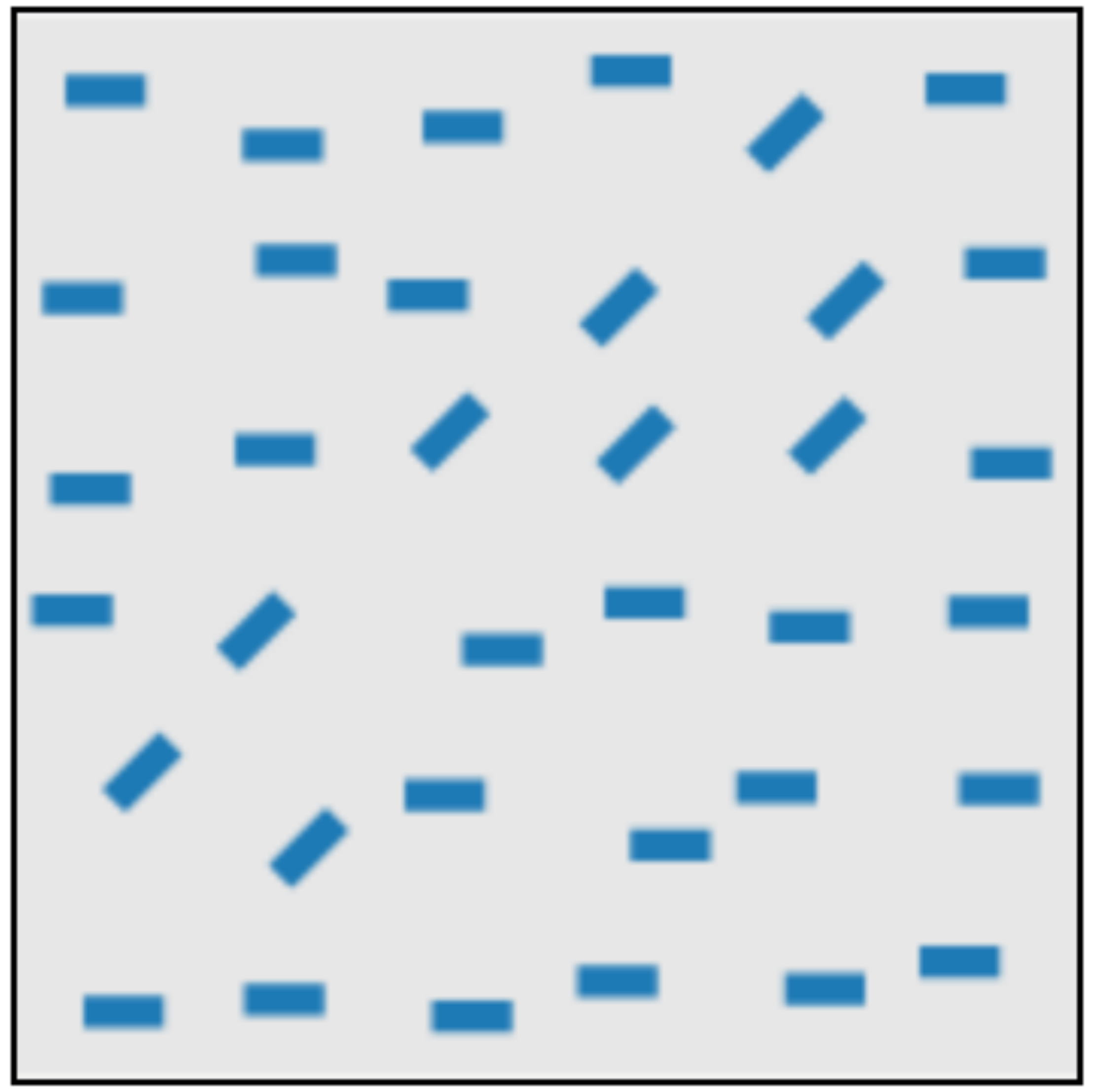


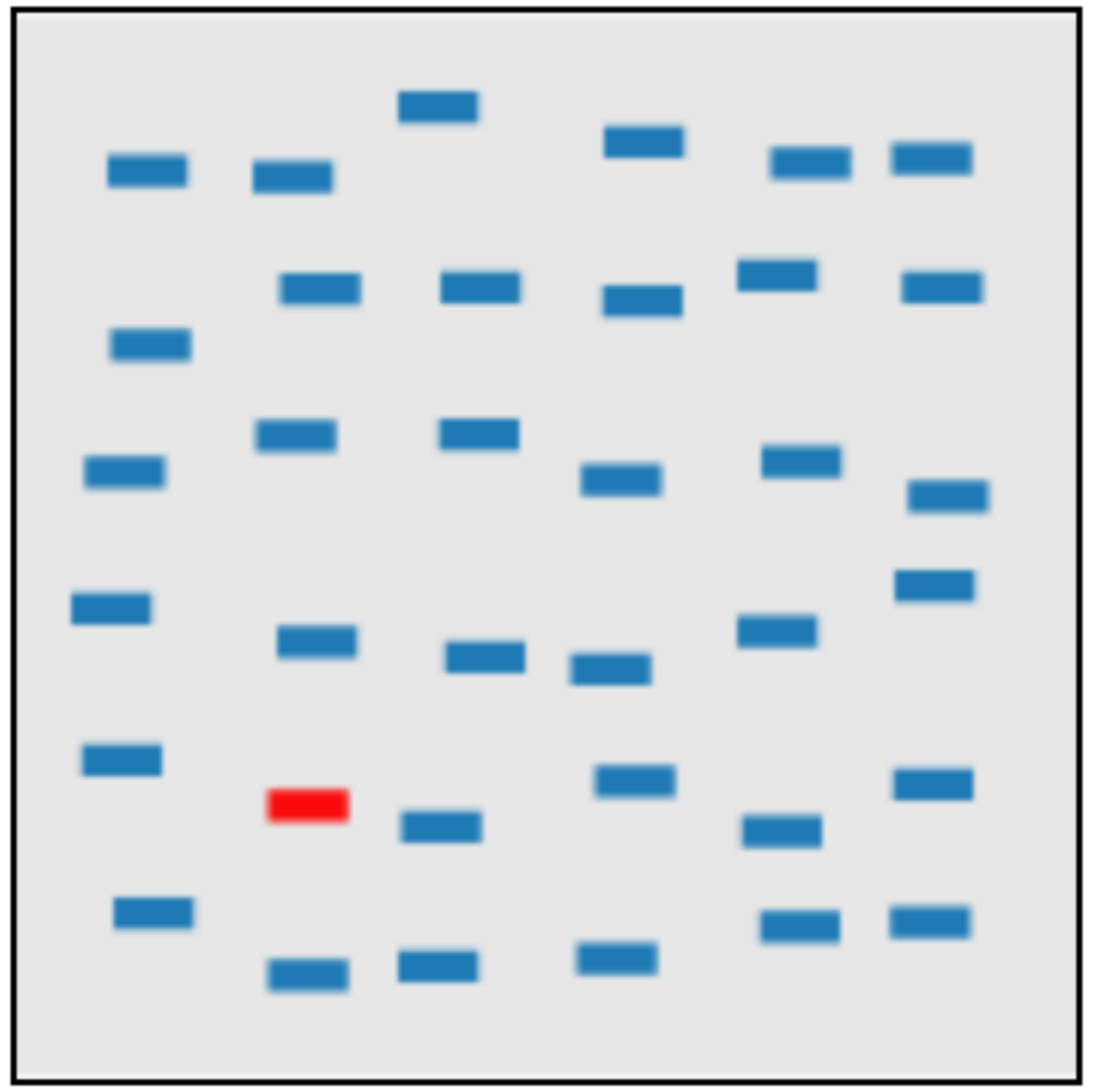
curvature



density, contrast

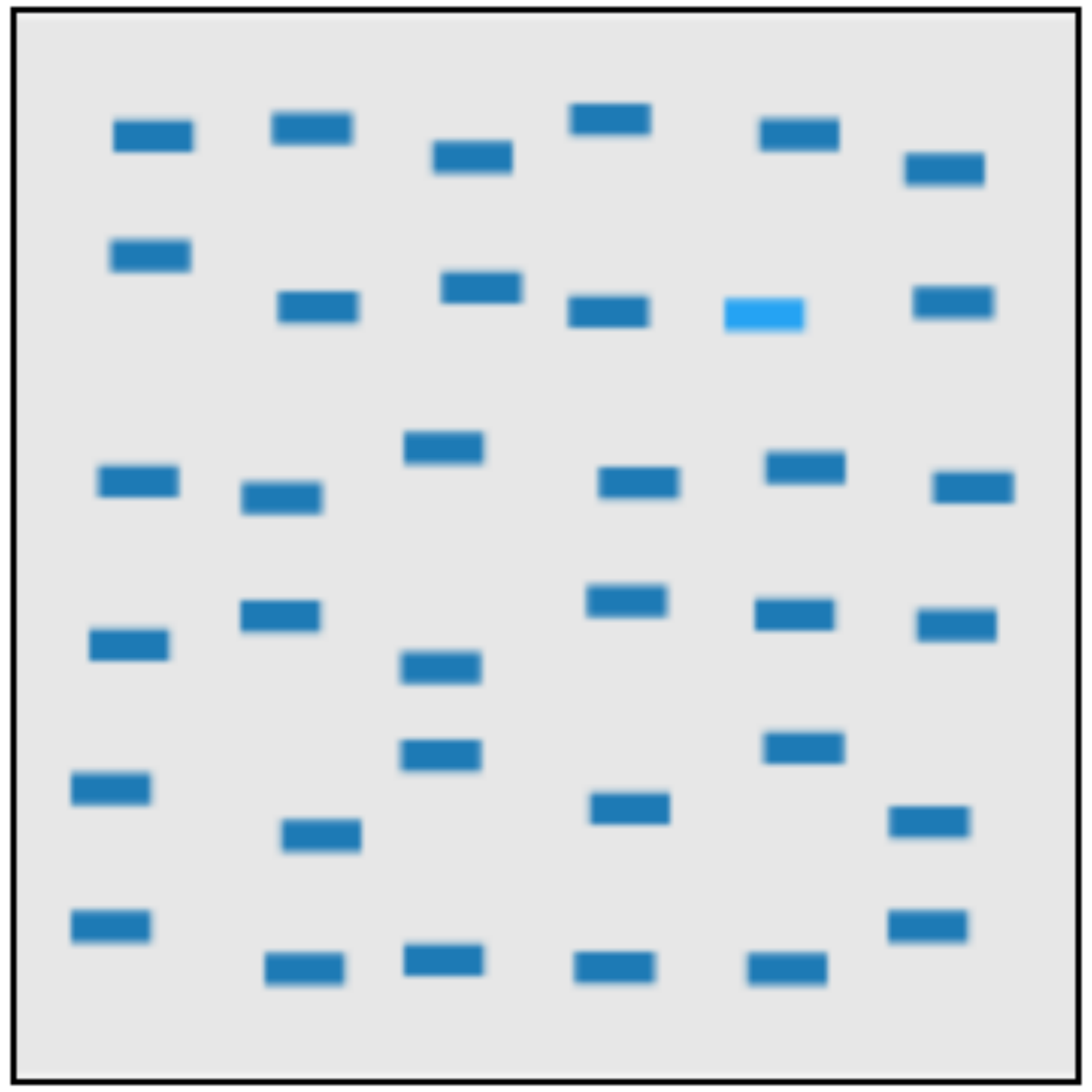


number, estimation

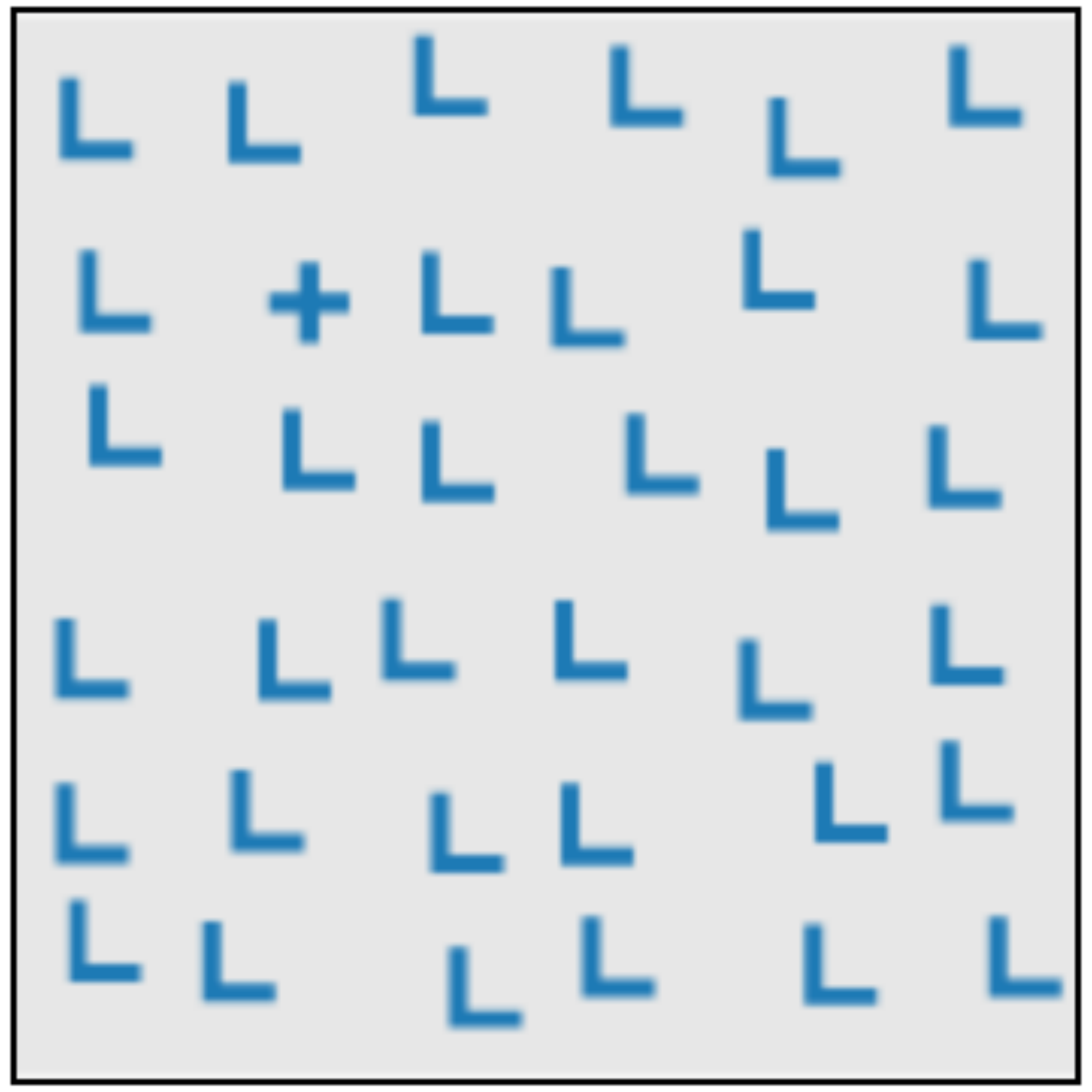


colour (hue)

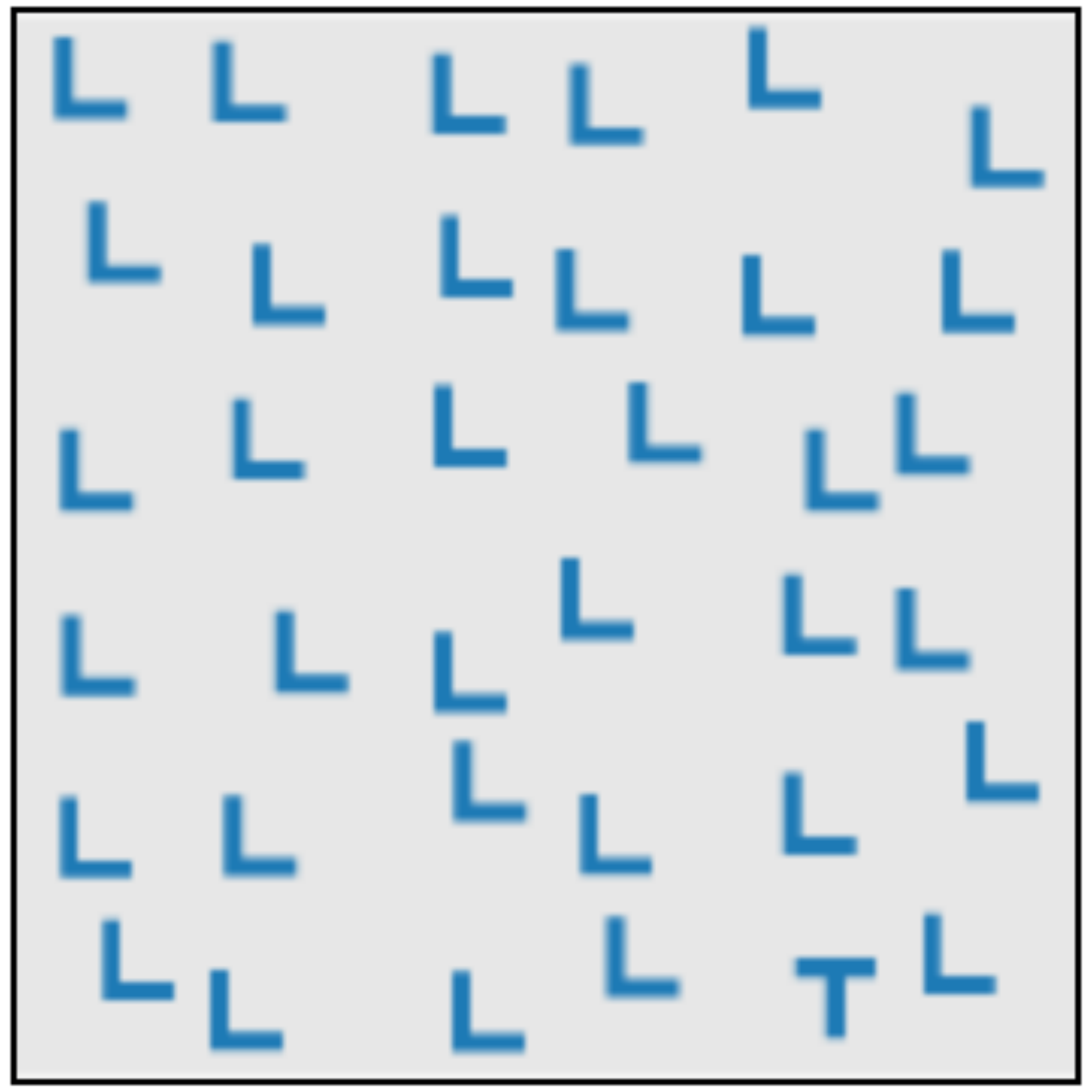
PRE-ATTENTIVE FEATURES



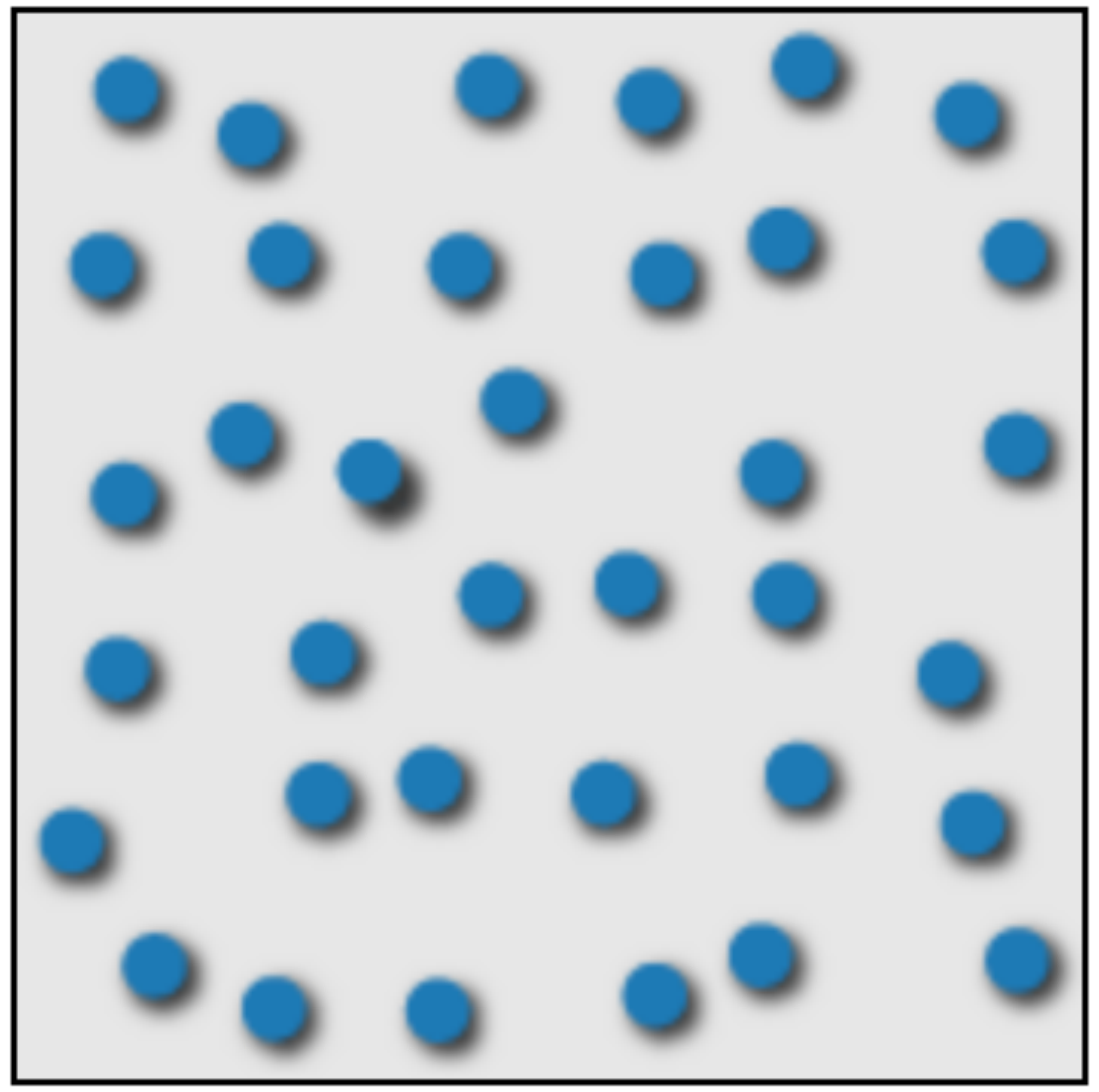
intensity, binocular lustre



intersection



terminators



3D depth cues

http://www.csc.ncsu.edu/faculty/healey/PP/

CHANGE BLINDNESS

Change blindness is a surprising perceptual phenomenon that occurs when a change in a visual stimulus is introduced and the observer does not notice it. For example, observers often fail to notice major differences introduced into an image while it flickers off and on again.

Instructions

Count how many times the players wearing white pass the basketball.

SELECTIVE ATTENTION

Selective attention is simply the act of focusing on a particular object for a period of time while simultaneously ignoring irrelevant information that is also occurring. This occurs on a daily basis and can be seen in basically any of your interactions. Because it is impossible to give attention to every stimulus in our environment, we use selective attention to select what stimuli are important as events occur.

PERCEPTUAL PROCESSOR

Cycle time

Quantum experience: 100ms

Percept fusion

Frame rate necessary for movies to look continuous?

time for 1 frame < Tp (100 msec) -> 10 frame/sec.

Max. morse code rate can be similarly calculated

Perceptual causality

Two distinct stimuli can fuse if the first event appears to *cause* the other

Events must occur in the same cycle

Michotte demonstration

What do you see? Most observers report that the red ball hit the blue ball. The blue ball moved “**because the red ball hit it**.” Thus, the red ball is perceived to “**cause**” the blue ball to move, even though the balls are nothing more than color disks on your screen that move according to a program.

http://cogweb.ucla.edu/Discourse/Narrative/Heider_45.html

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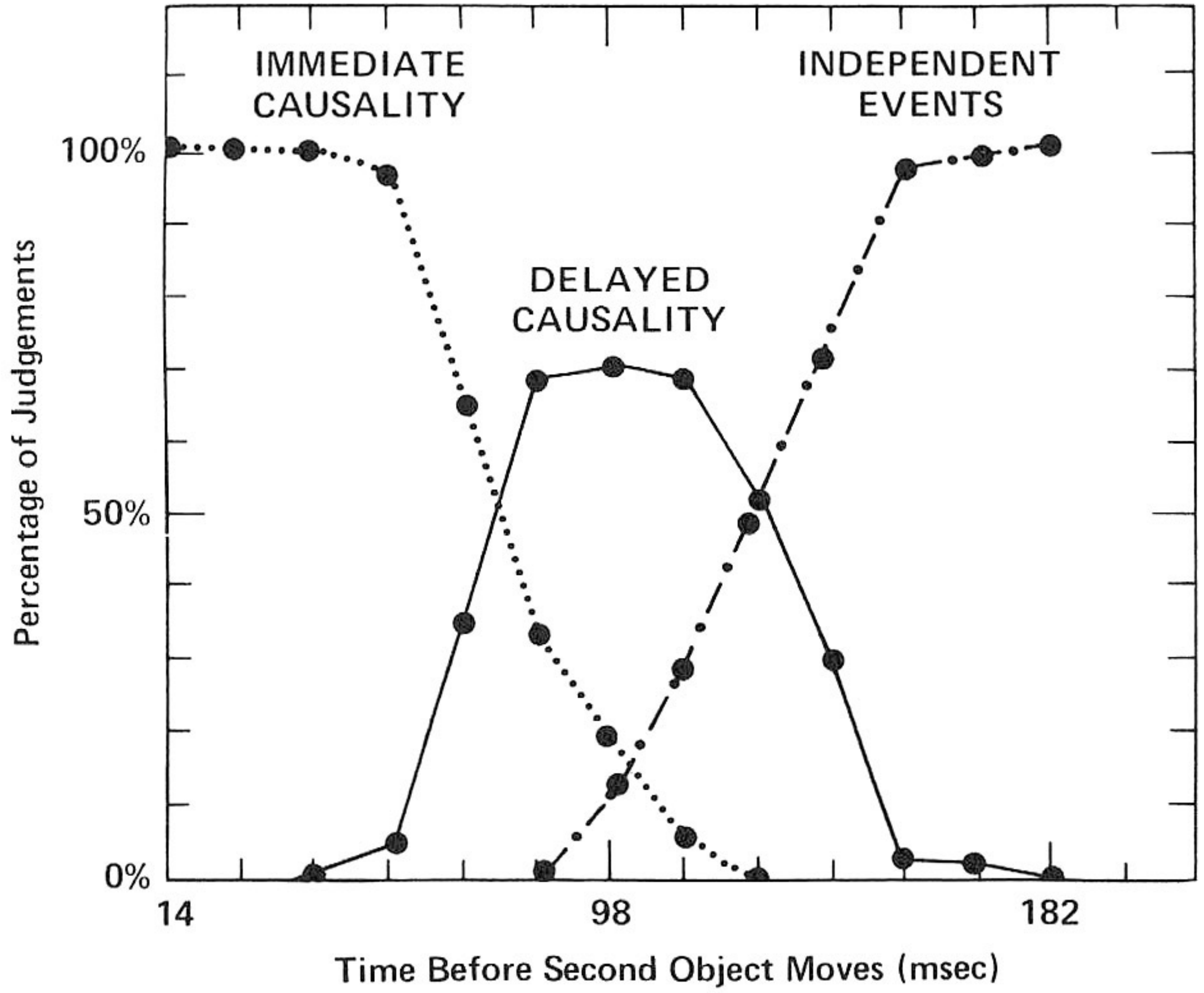


NewScientist

Progress bar illusion

WORKING MEMORY

Access in chunks

Task dependent construct

7 ±2 (Miller)

Decay

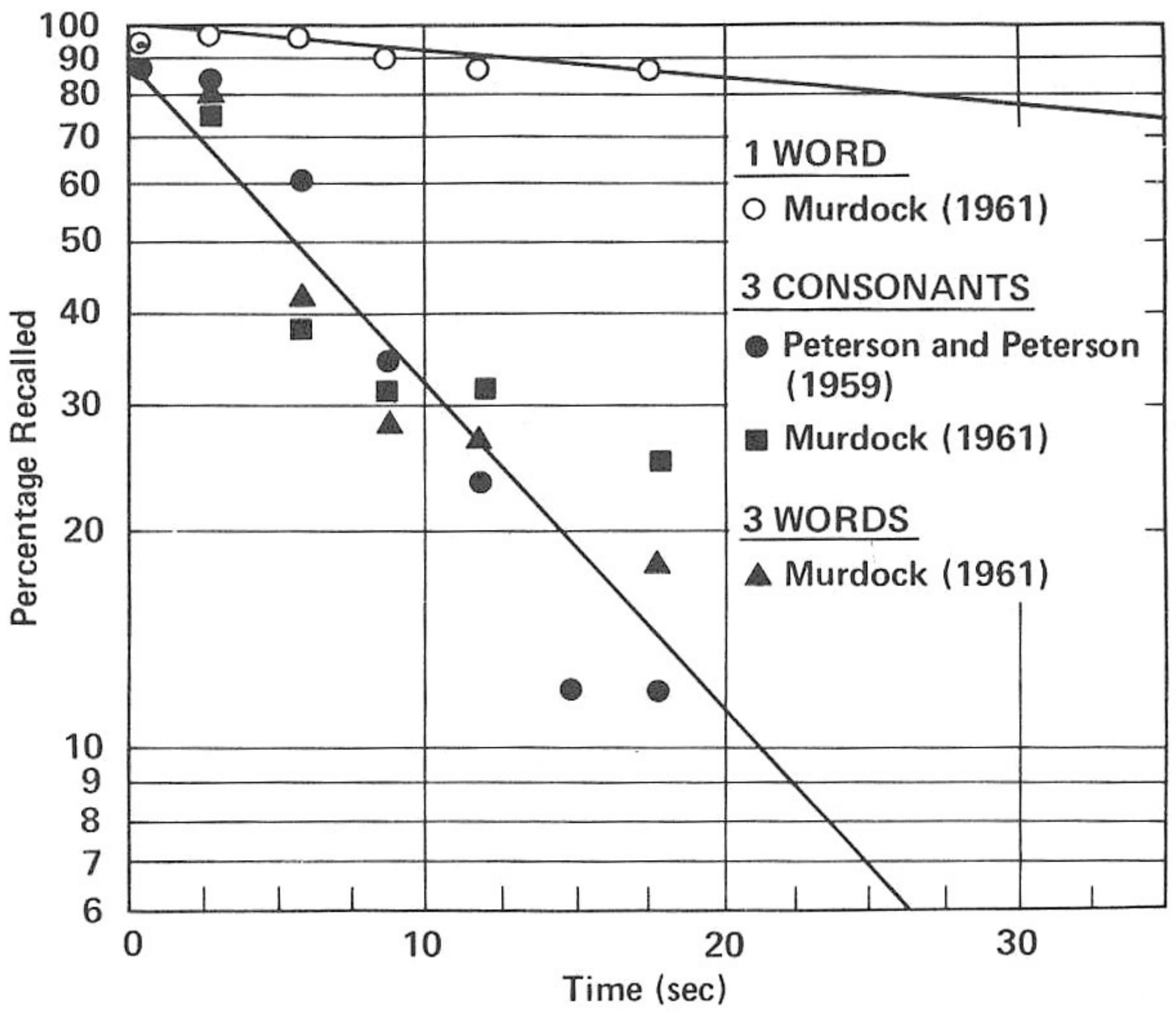
Content dependant

1 chunk 73 sec

3 chunks 7 sec

Attention span

Interruptions > decay time



LONG TERM MEMORY

Very large capacity

Semantic encoding

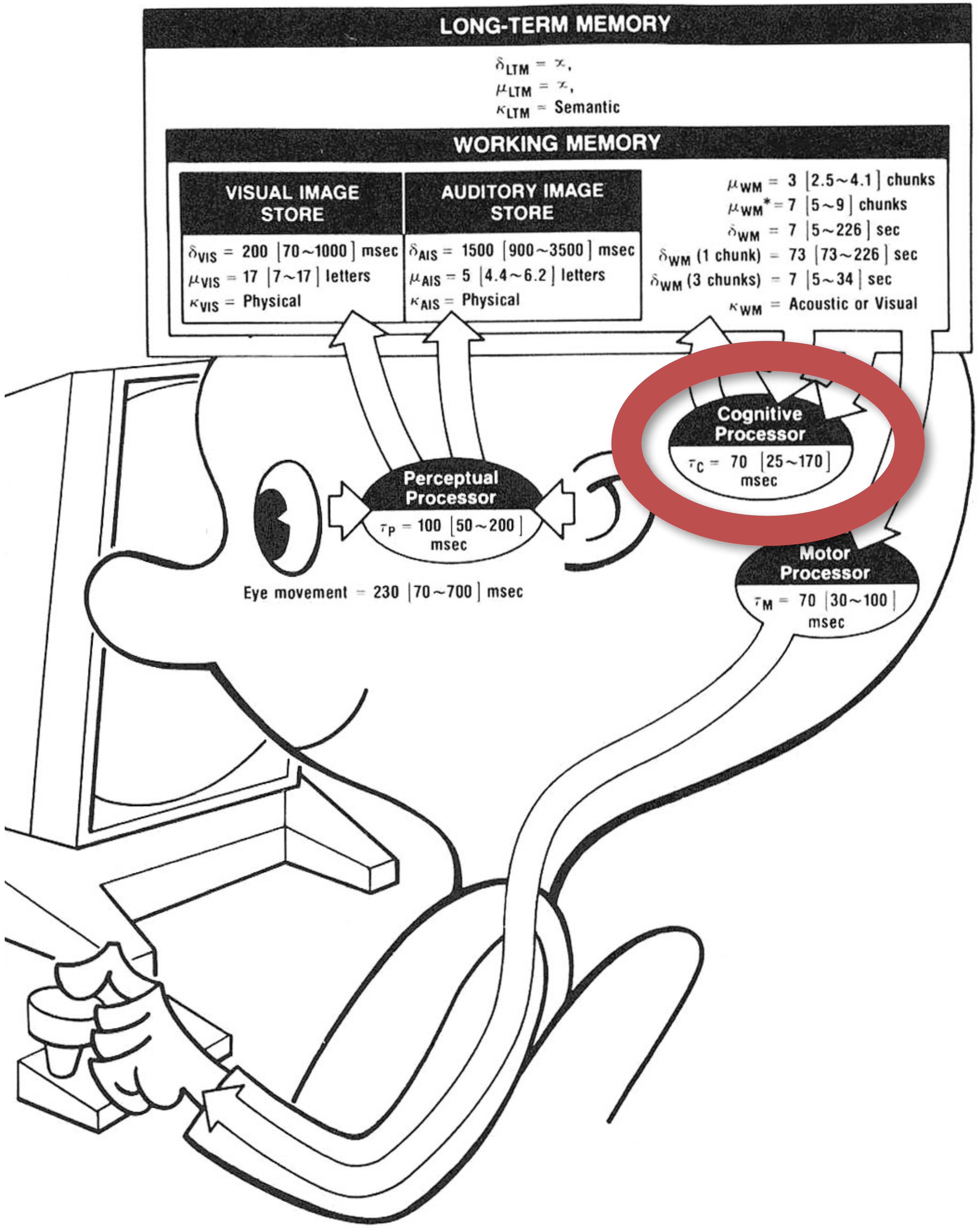
Associative access

Fast read: 70ms

Expensive write: 10s

Can also move from WM to LTM via rehearsal

Context at the time of acquisition key for retrieval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Motor Processor
τM = 70 [30~100] msec
Eye movement = 230 [70~700] msec

COGNITIVE PROCESSOR

Cycle time: 70ms

Can be modulated

Typical matching time

Digits: 33ms

Colors: 38ms

Geometry: 50ms...

Fundamentally serial

One locus of attention at a time

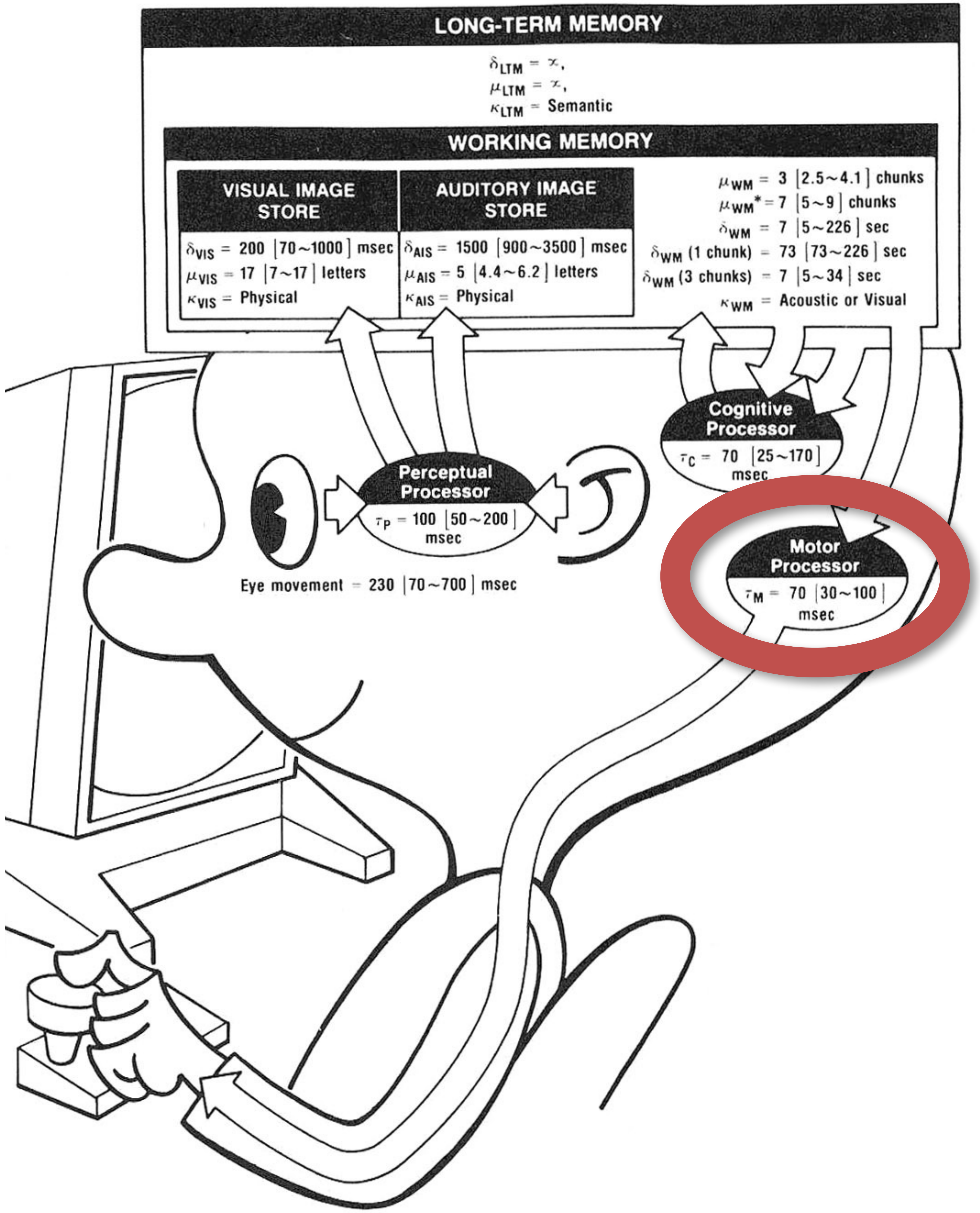
Eastern 401, December 1972

Crew focused on landing gear indicator bulb,

Aircraft is loosing altitude (horn, warning indicator...),

Aircraft crashed in the Everglades

see “The Human Interface” by Raskin, p25



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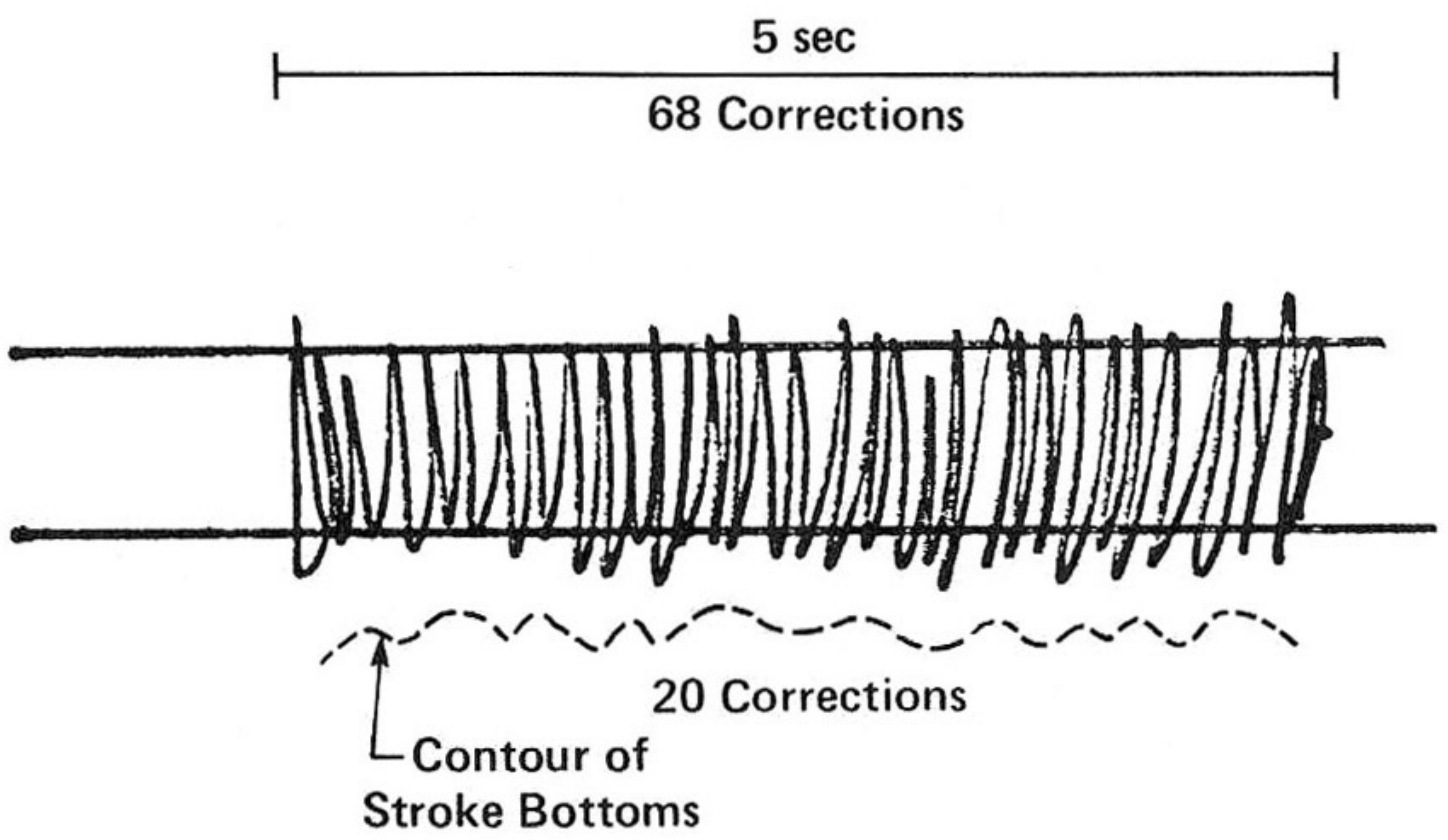
MOTOR PROCESSOR

Receive input from the cognitive processor

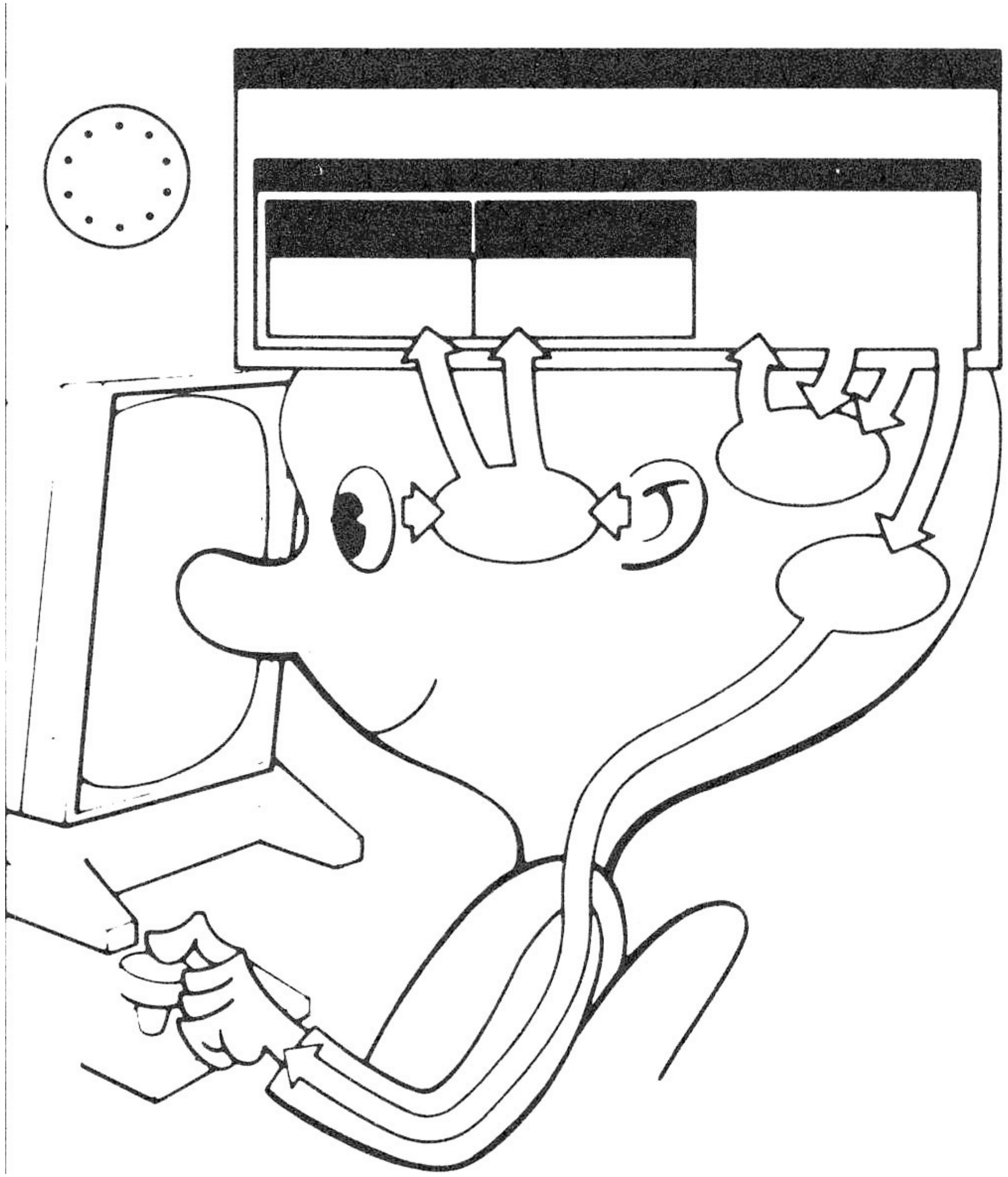
Execute motor programs

Pianist: up to 16 finger movements per second

Point of no-return for muscle action



HIT SPACE WHEN CHARACTER APPEARS



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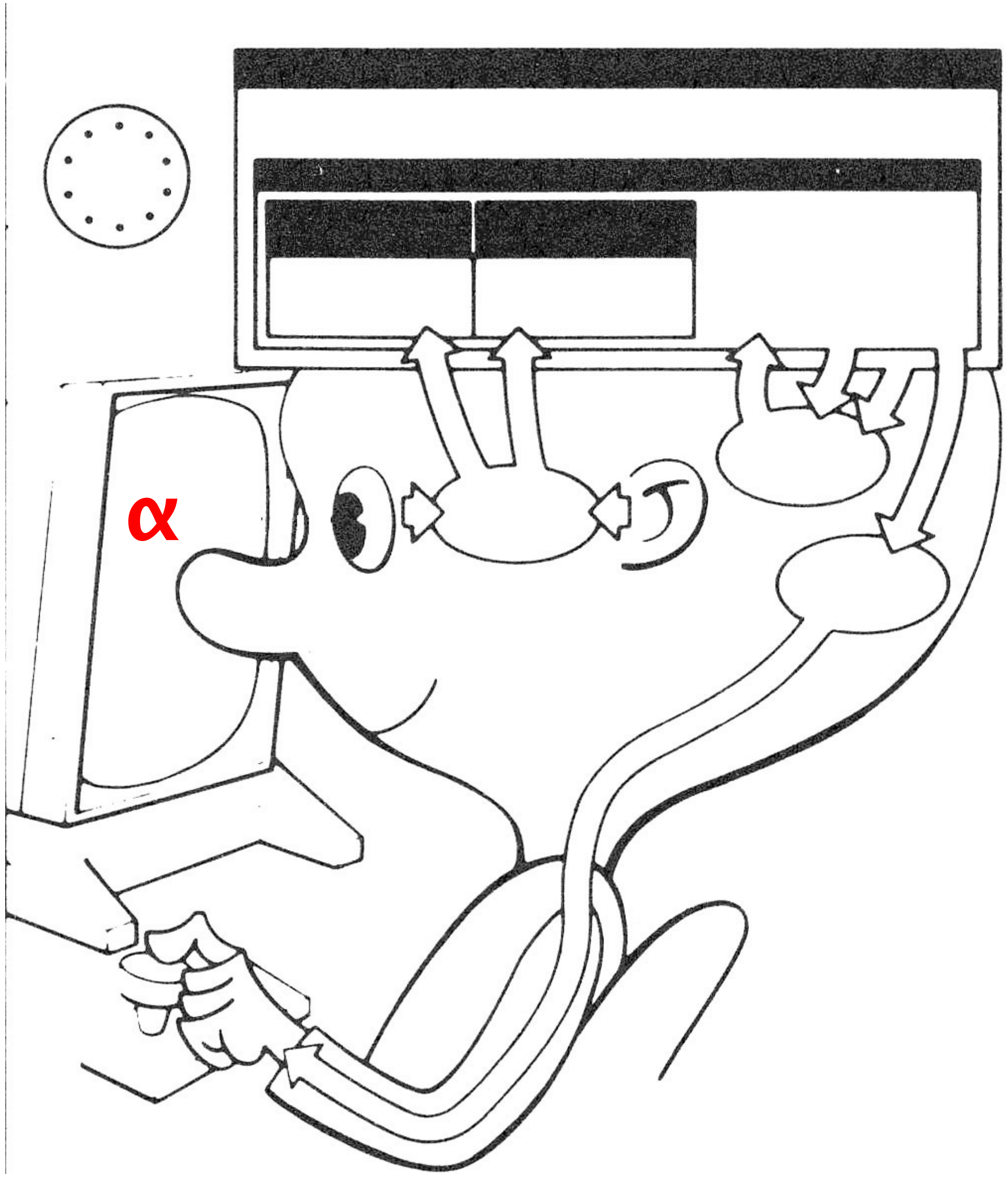

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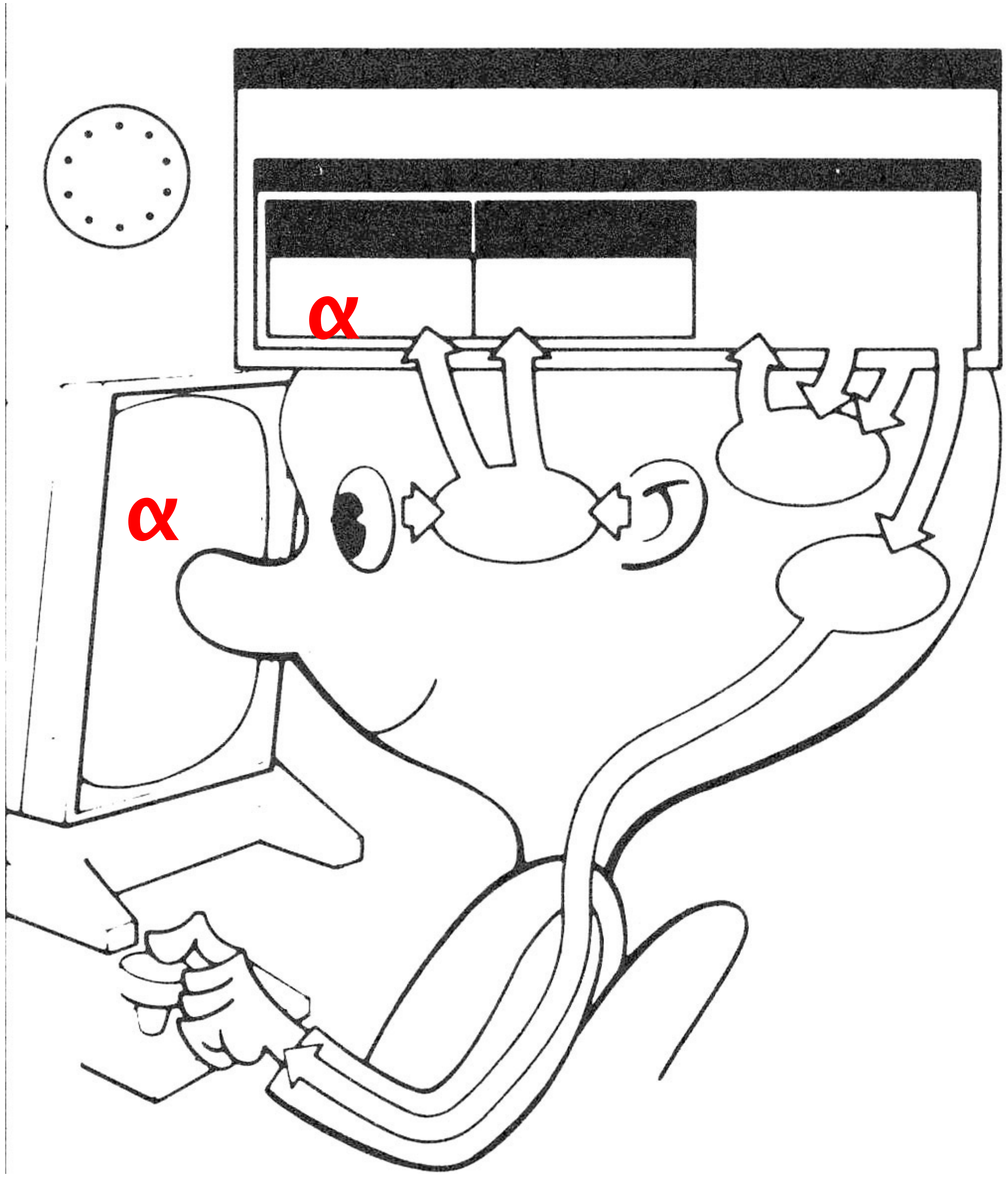

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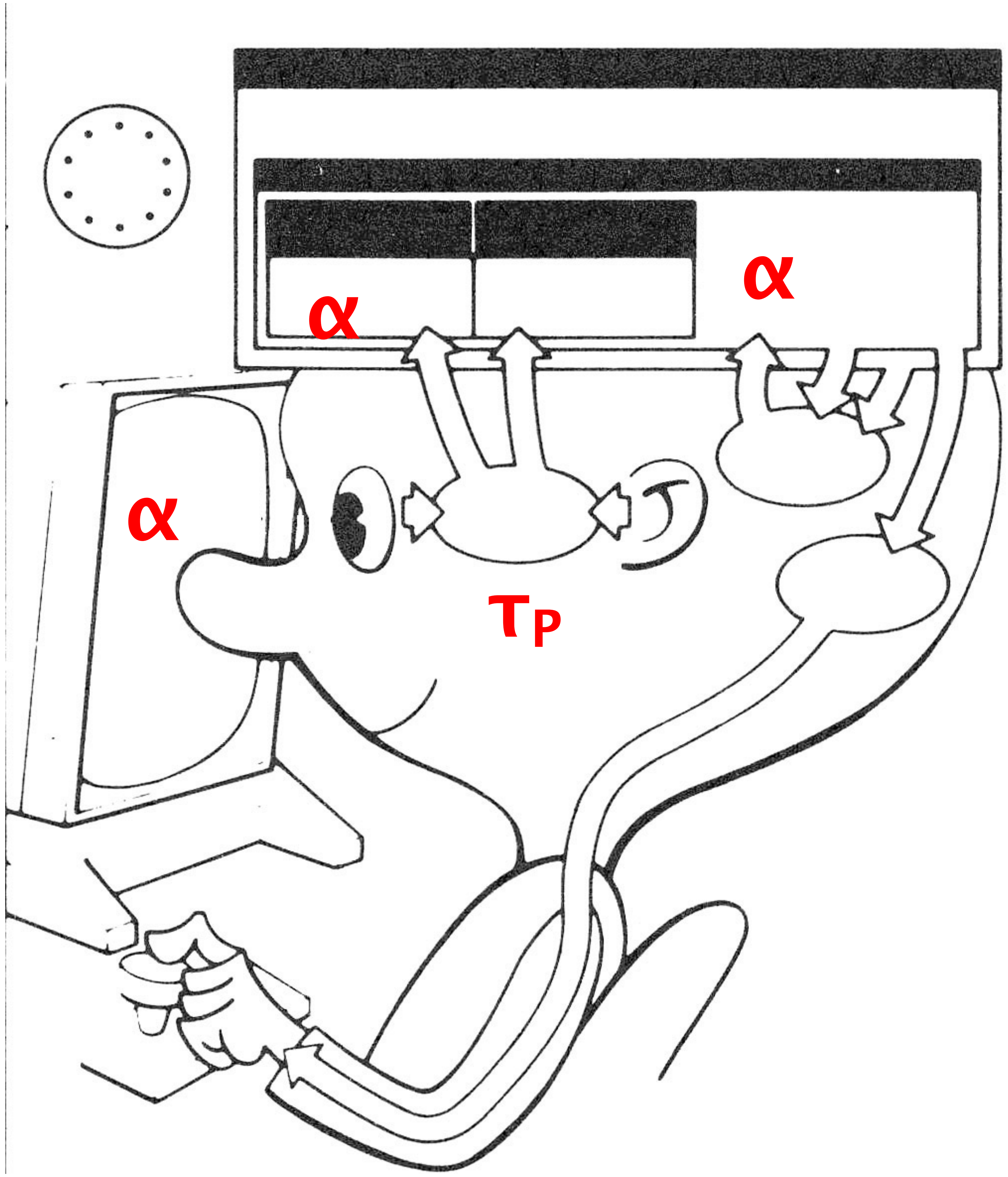

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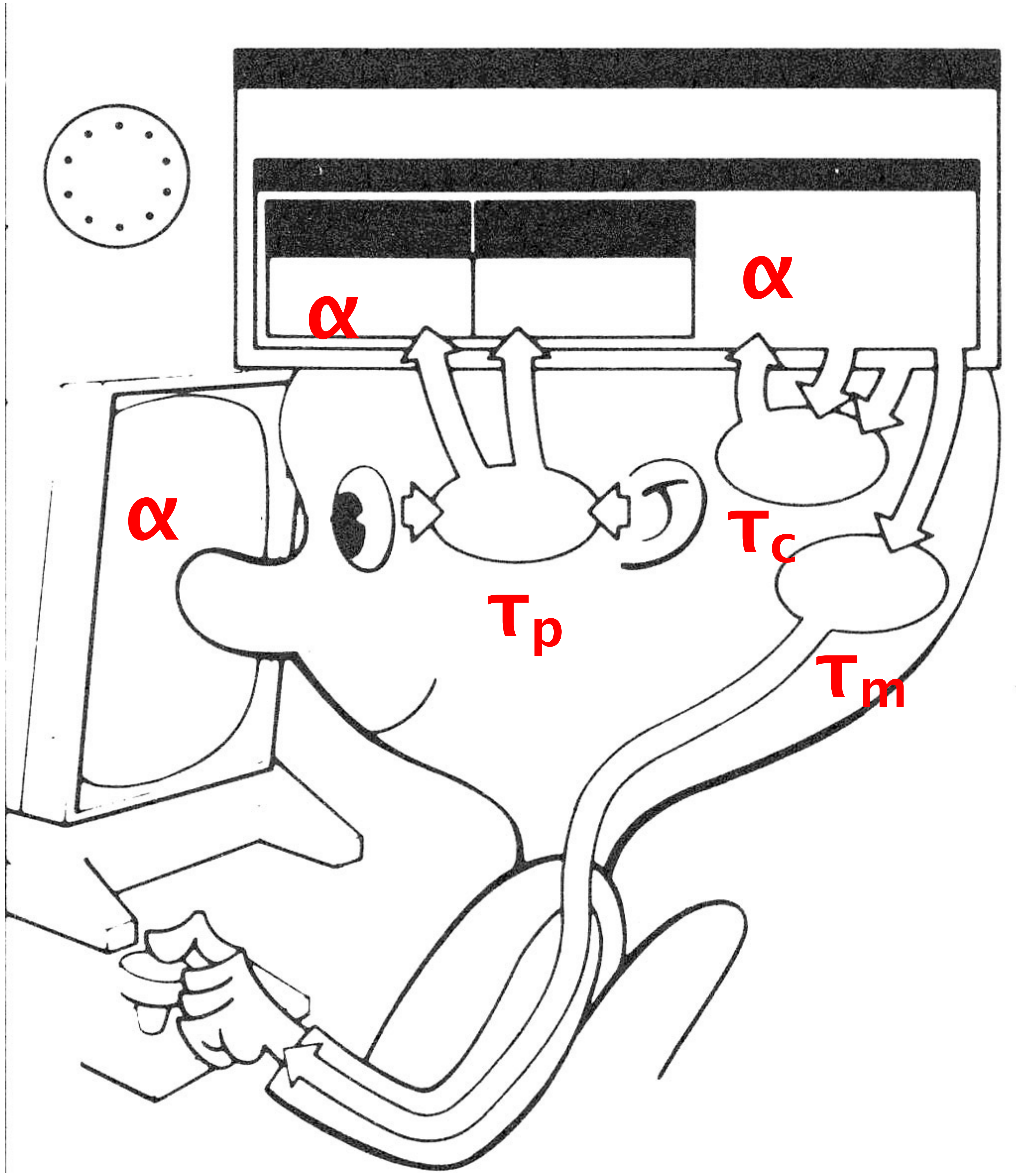

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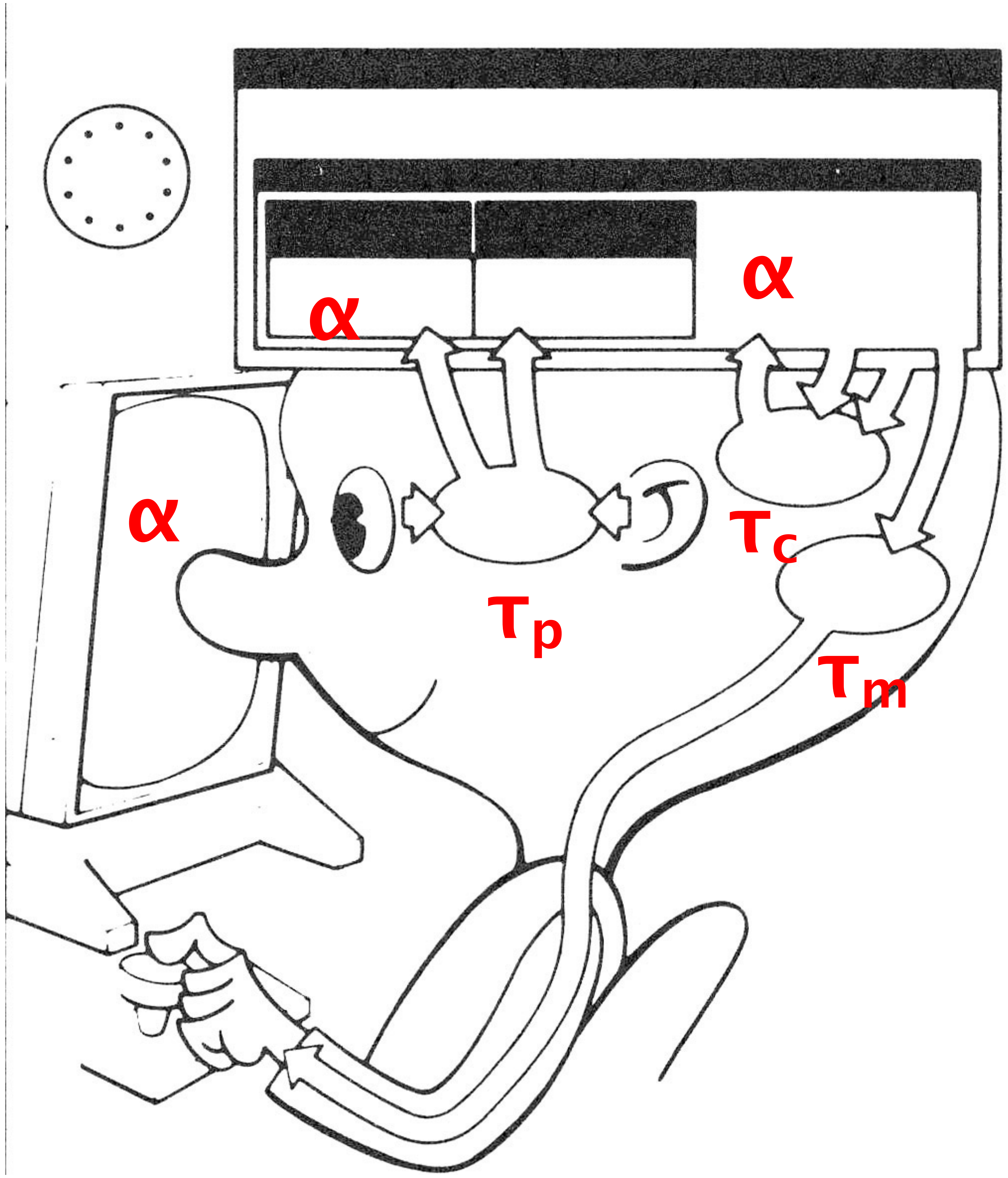
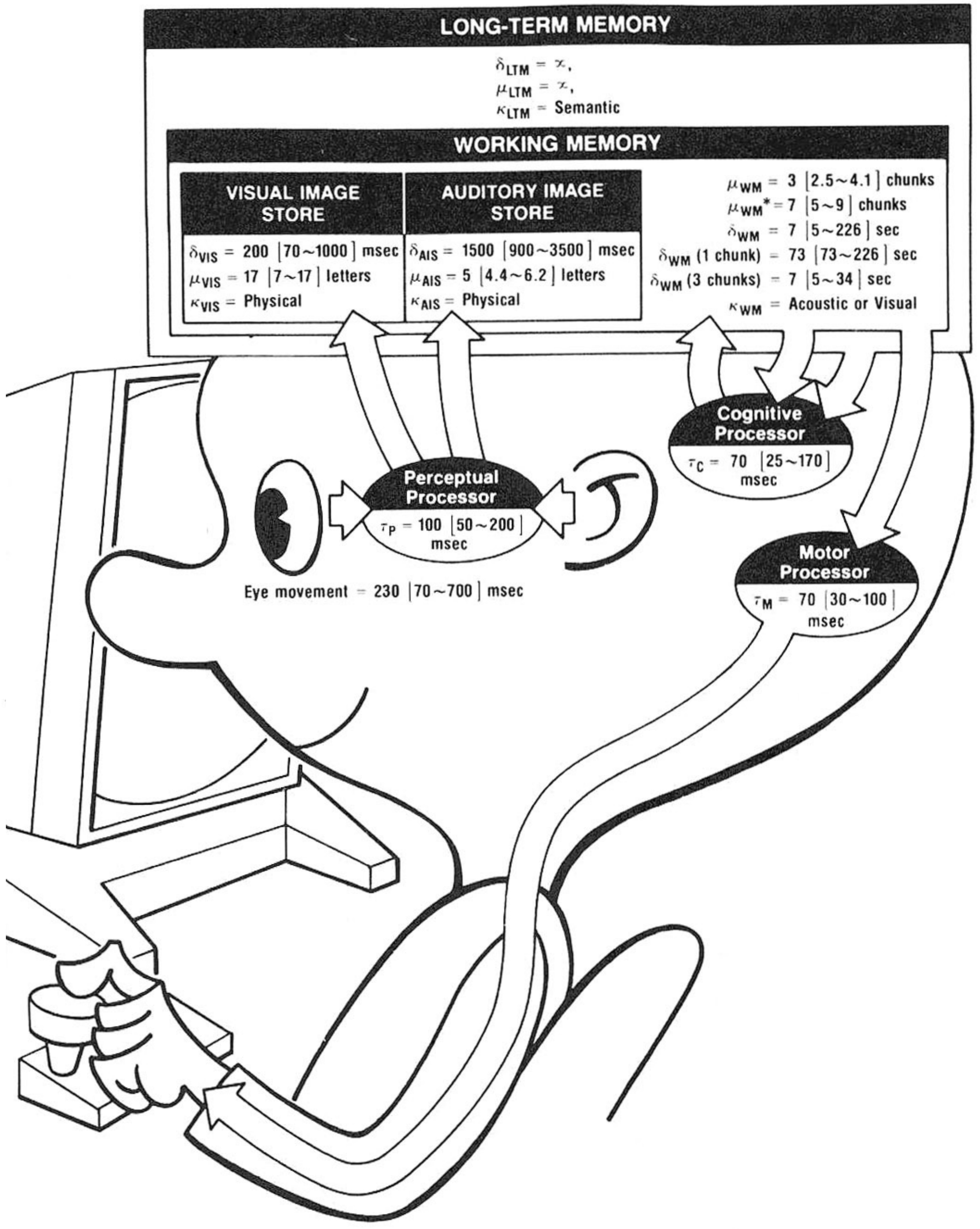
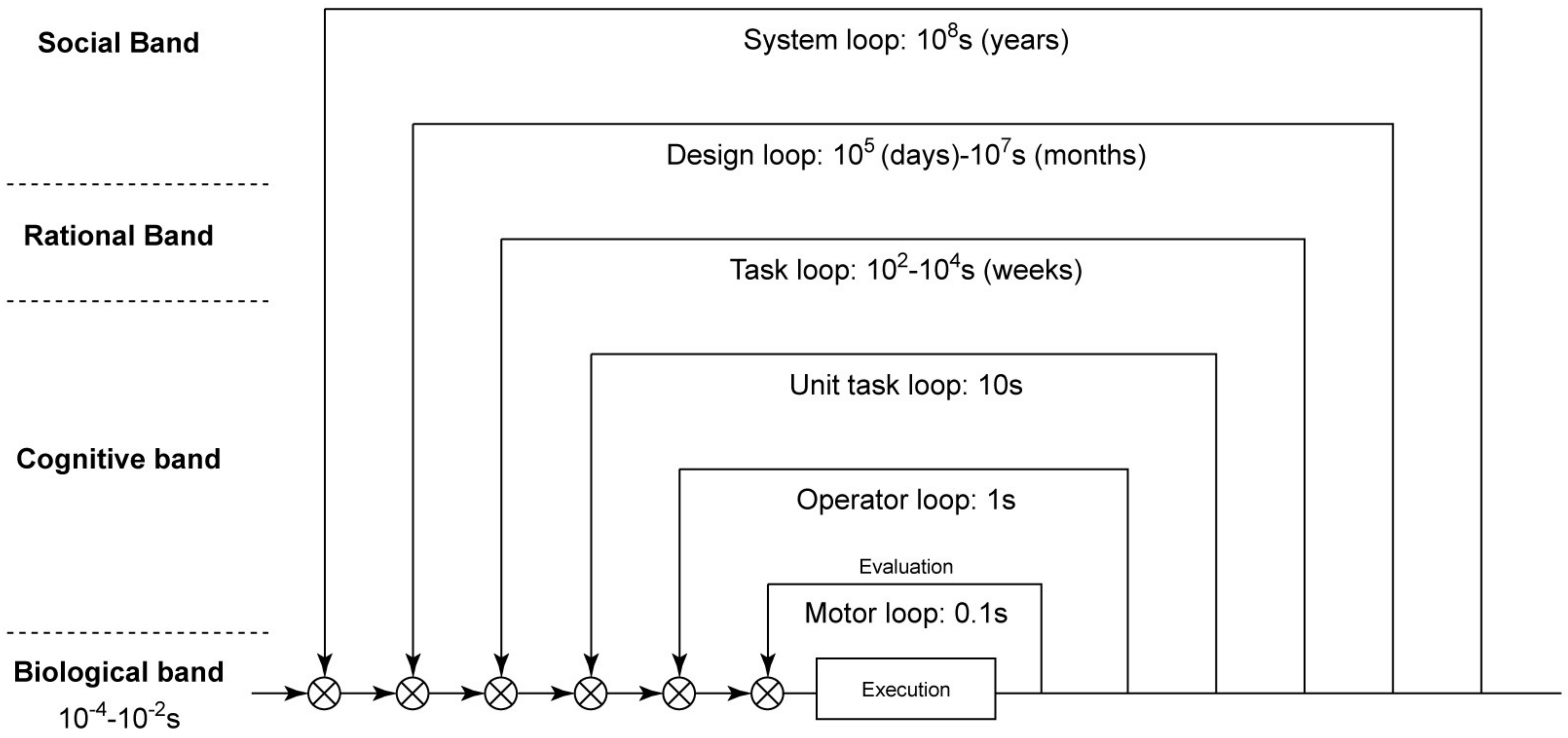




HUMAN INTERACTION LOOPS

(NEWELL)



PRINCIPLES OF OPERATION

Interface should respect limits of human performance

Pre-attentive features pop-out

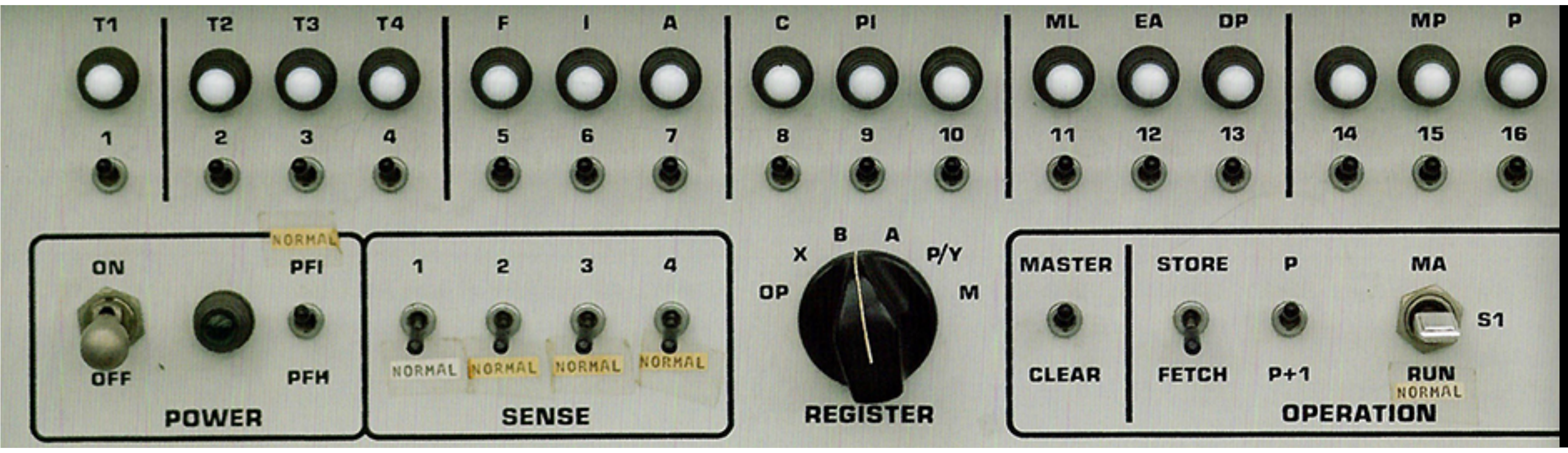
Events within cycle time fuse together

Causality

Recognize-Act Cycle of the cognitive processor

On each cycle contents in Working Memory initiate cognitive actions

Cognitive actions modify the contents of Working Memory


T1 T2 T3 T4 F I A C PI ML EA DP MP P
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
ON
OFF
PFI
PFM
POWER
1 2 3 4
NORMAL
SENSE
X B A P/Y
OP M
REGISTER
MASTER
CLEAR
STORE
FETCH
P
P+1
MA
S1
RUN
OPERATION

MEMORY

SIMPLE EXPERIMENT

Volunteer

Start saying colors you see in list of words

When slide comes up

As fast as you can

Say “done” when finished

Schedule

Paper

Page

Back

Change

Home

SIMPLE EXPERIMENT

Do it again

Say “done” when finished

Blue

Red

Black

White

Green

Yellow

INTERFERENCE

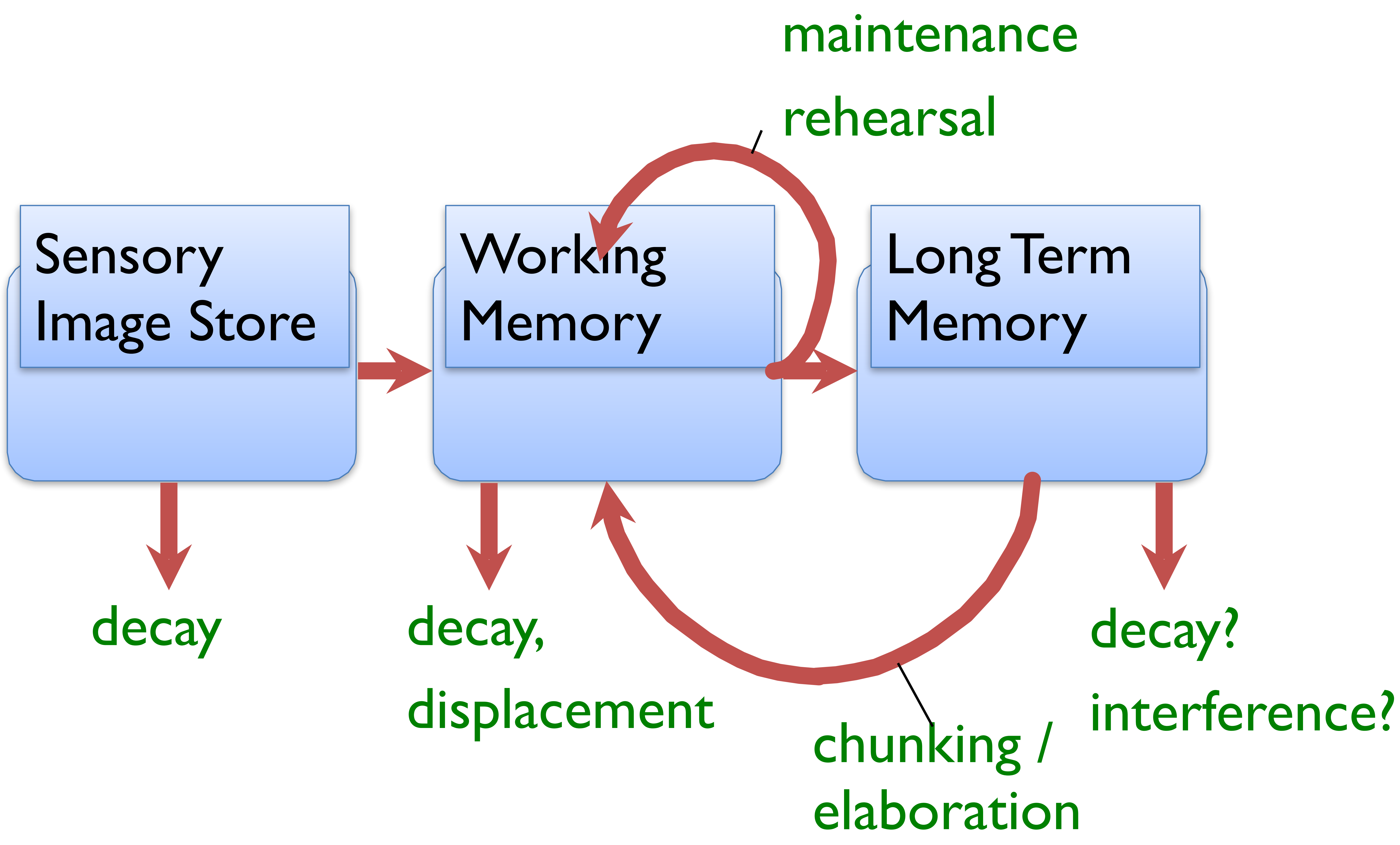
Stroop Effect

When the color spelled out by a word is incongruent with the color used to show that word, naming the word color is slower and more error prone.

Explanation:

Relationship between meaning and physical form of stimulus are in conflict.

STAGE THEORY



STAGE THEORY

Working memory is small

Temporary storage

decay

displacement

Maintenance rehearsal

Rote repetition

Not enough to learn information well

LTM AND ELABORATION

Recodes information

Organize (chunking)

Relate new material to already learned material

Link to existing knowledge, categories

Attach meaning

Make a story

RECOGNITION OVER RECALL

Recall

Info reproduced from memory

Recognition

Presentation of info helps retrieve info (helps remember it was seen before)

Easier because of cues to retrieval

We want to design UIs that rely on recognition!

FACILITATING RETRIEVAL: CUES

Any stimulus that improves retrieval

Example: giving hints

Other examples in software?

icons, labels, menu names, etc.

Anything related to

Item or situation where it was learned

SUMMARY

Model human processor

5 parts

Perceptual processor

Working memory

Long term memory

Cognitive processor

Motor processor

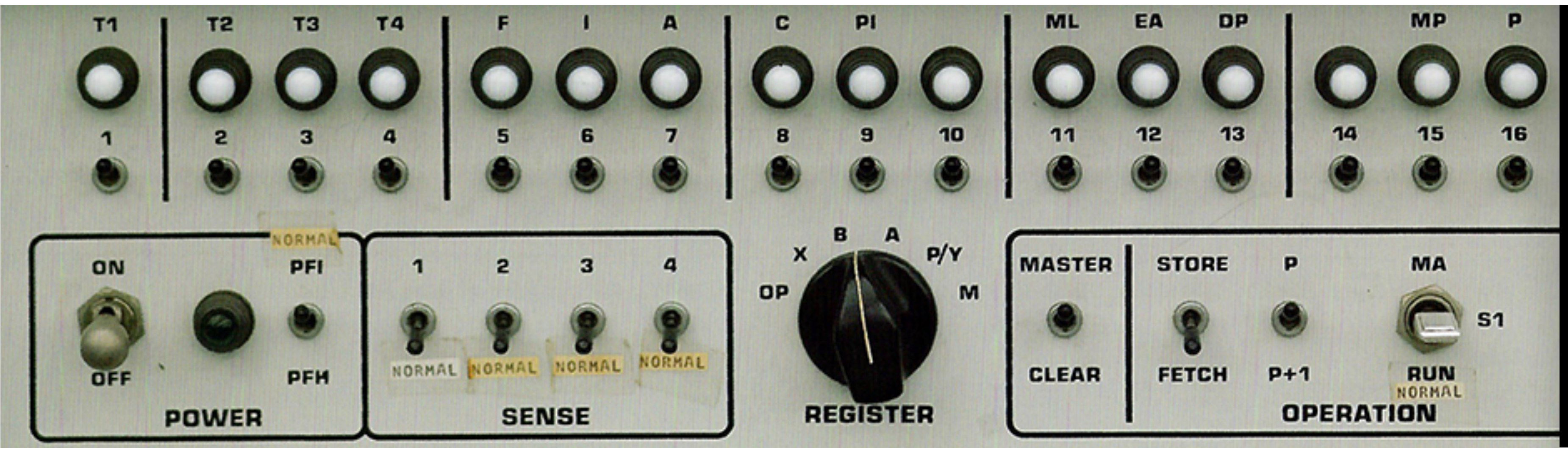
May not be biologically accurate

But …

Provides rough estimate of performance

Can help us compare and evaluate interfaces

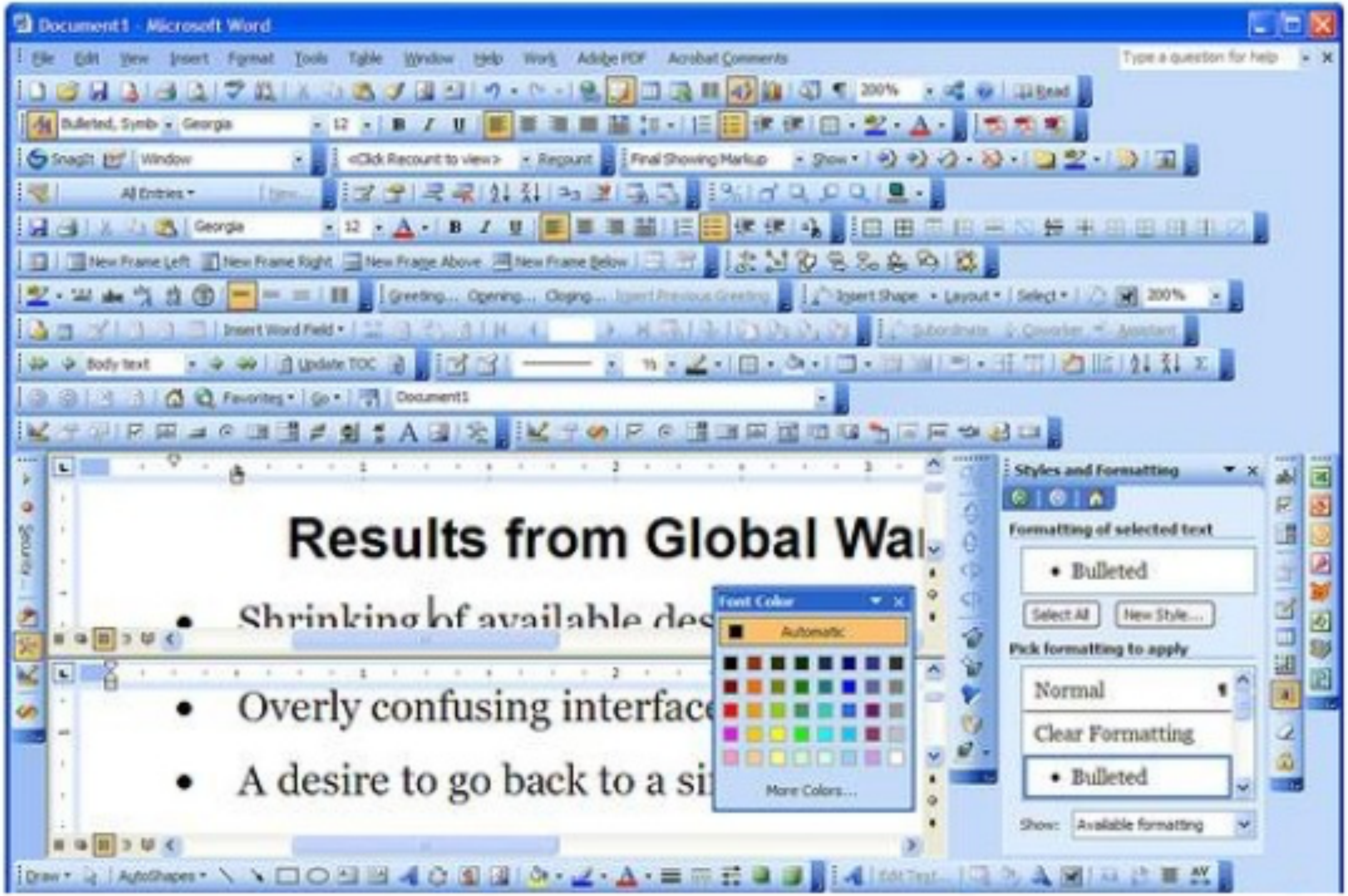
Interfaces should both aid and exploit human capabilities

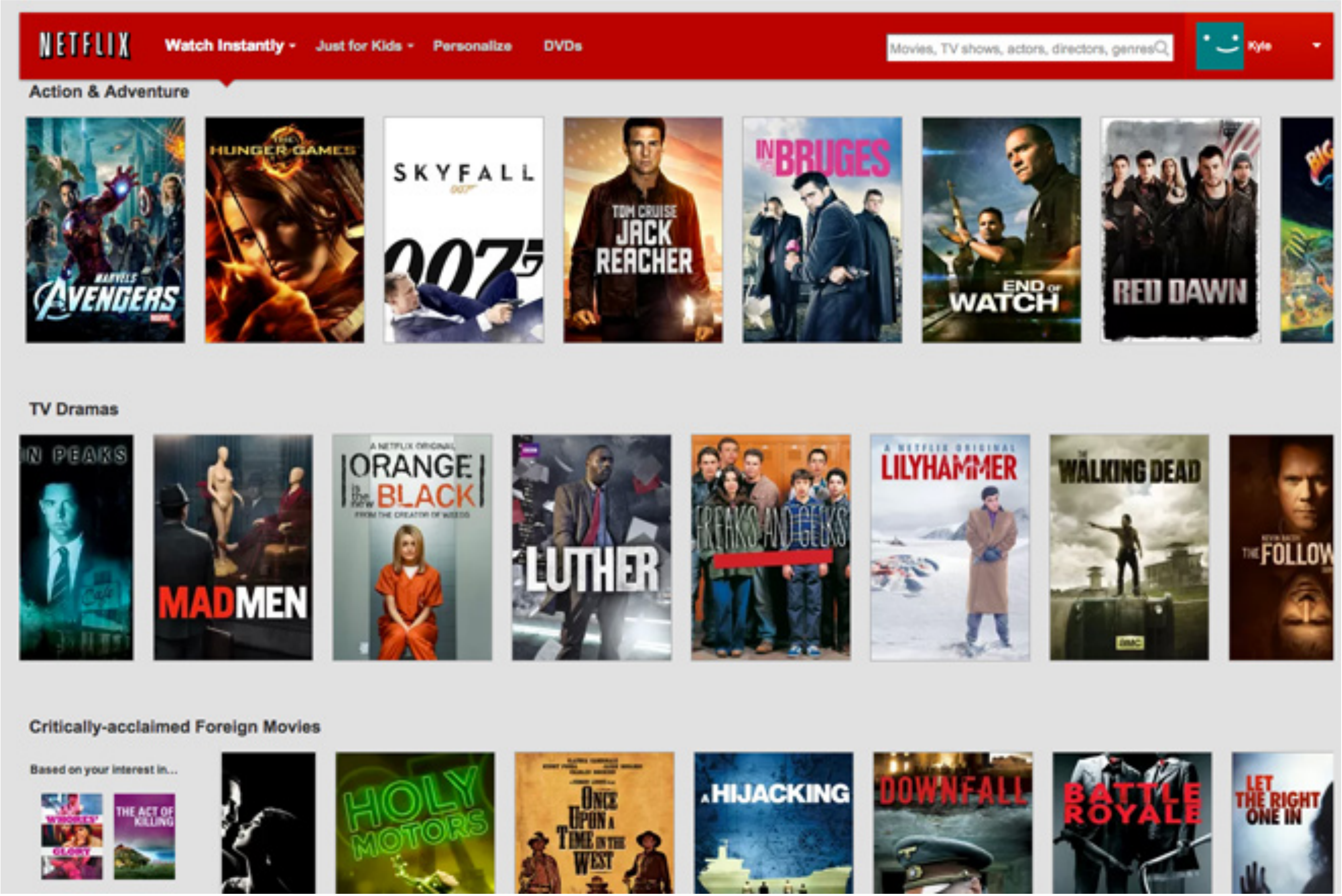


DECISION MAKING AND LEARNING


Crest PRO-HEALTH
Colgate Total
Colgate Max Fresh
Colgate MaxWhite
Colgate MaxClean
Colgate Cavity Protection
Colgate Tartar Protection
Colgate Triple Action
Colgate Luminous
Advance White
PeroxiCare
Close-Up
Ultrabrite
Aim
Aquafresh
Fixodent
bonus! Save even more on gas.
$4.99

Too Many Options

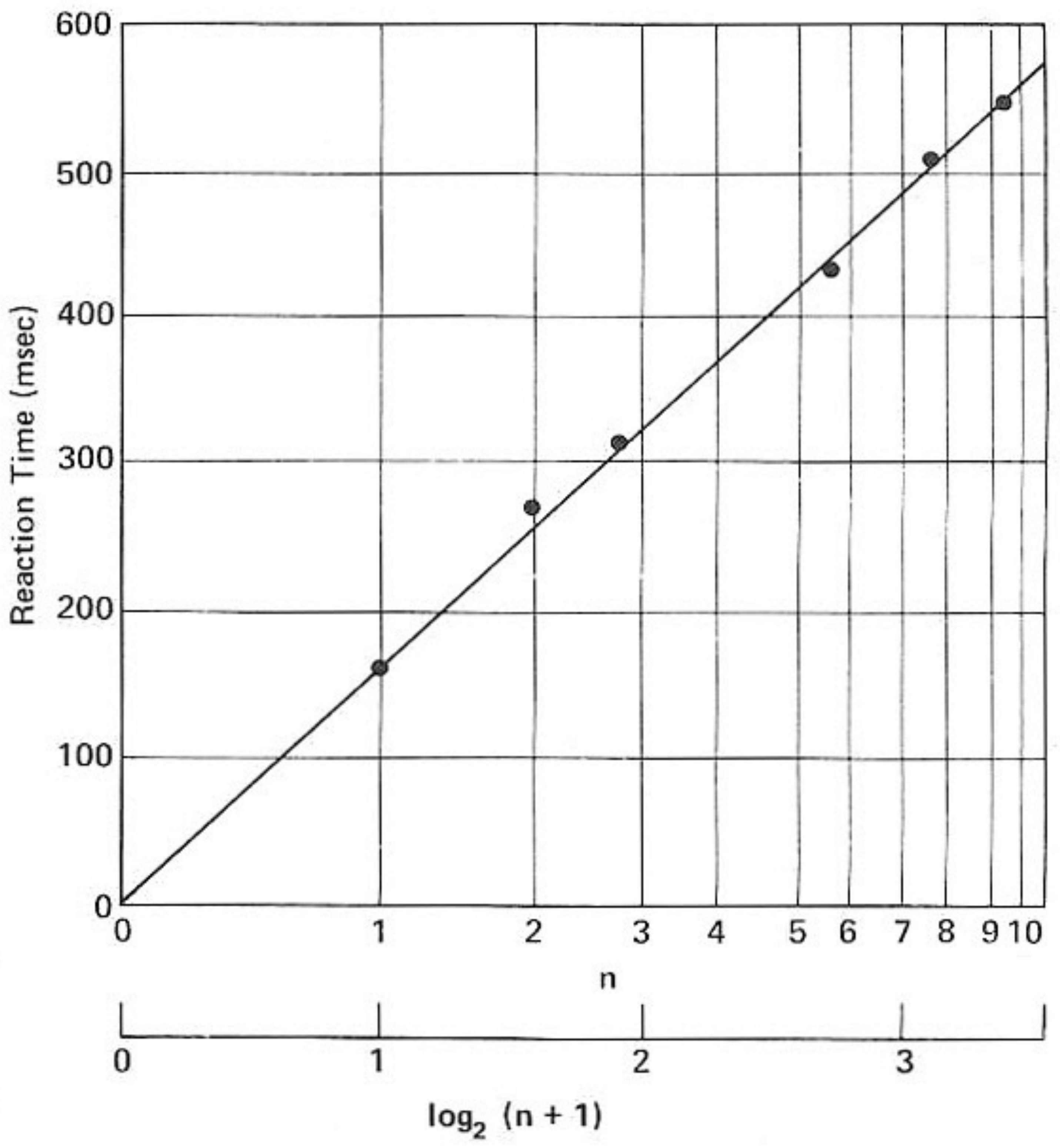


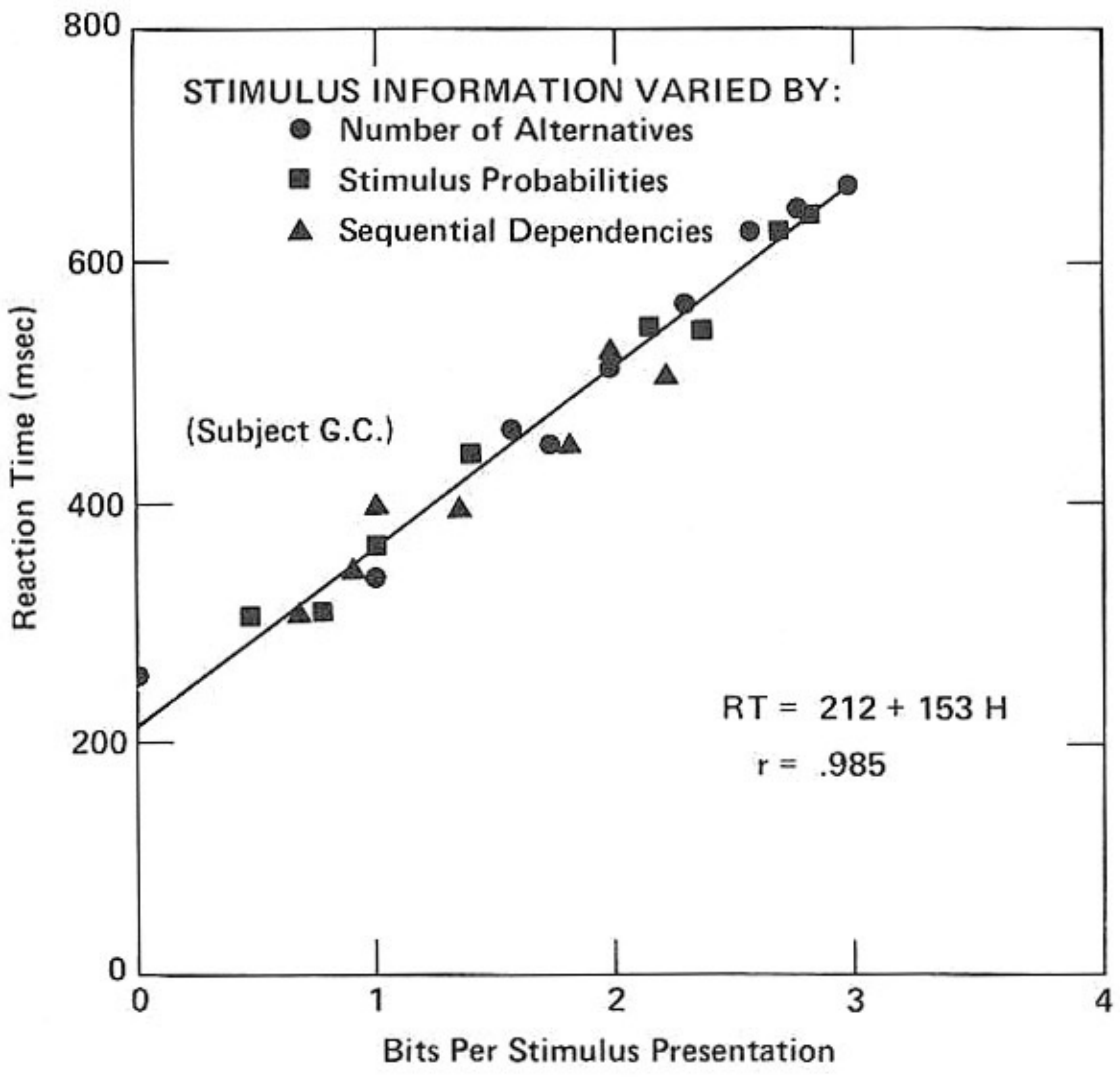

NETFLIX
Watch Instantly
Just for Kids
Personalize
DVDs
Movies, TV shows, actors, directors, genres
Kyle
Action & Adventure
AVENGERS
THE HUNGER GAMES
SKYFALL
007
TOM CRUISE
JACK REACHER
IN BRUGES
END OF WATCH
RED DAWN
TV Dramas
MAD MEN
A NETFLIX ORIGINAL
ORANGE is the new BLACK
LUTHER
FREAKS AND GEEKS
A NETFLIX ORIGINAL
LILYHAMMER
THE WALKING DEAD
THE FOLLOW
Critically-acclaimed Foreign Movies
Based on your interest in...
THE ACT OF KILLING
HOLY MOTORS
ONCE UPON A TIME IN THE WEST
A HIJACKING
DOWNFALL
BATTLE ROYALE
LET THE RIGHT ONE IN

HICK'S LAW

Cost of taking a decision:
n = number of choices

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





POWER LAW OF PRACTICE

Task time on the nth trial follows a power law

$$T_n = T_1 n^{-a} + c$$

where a = .4, c = limiting constant

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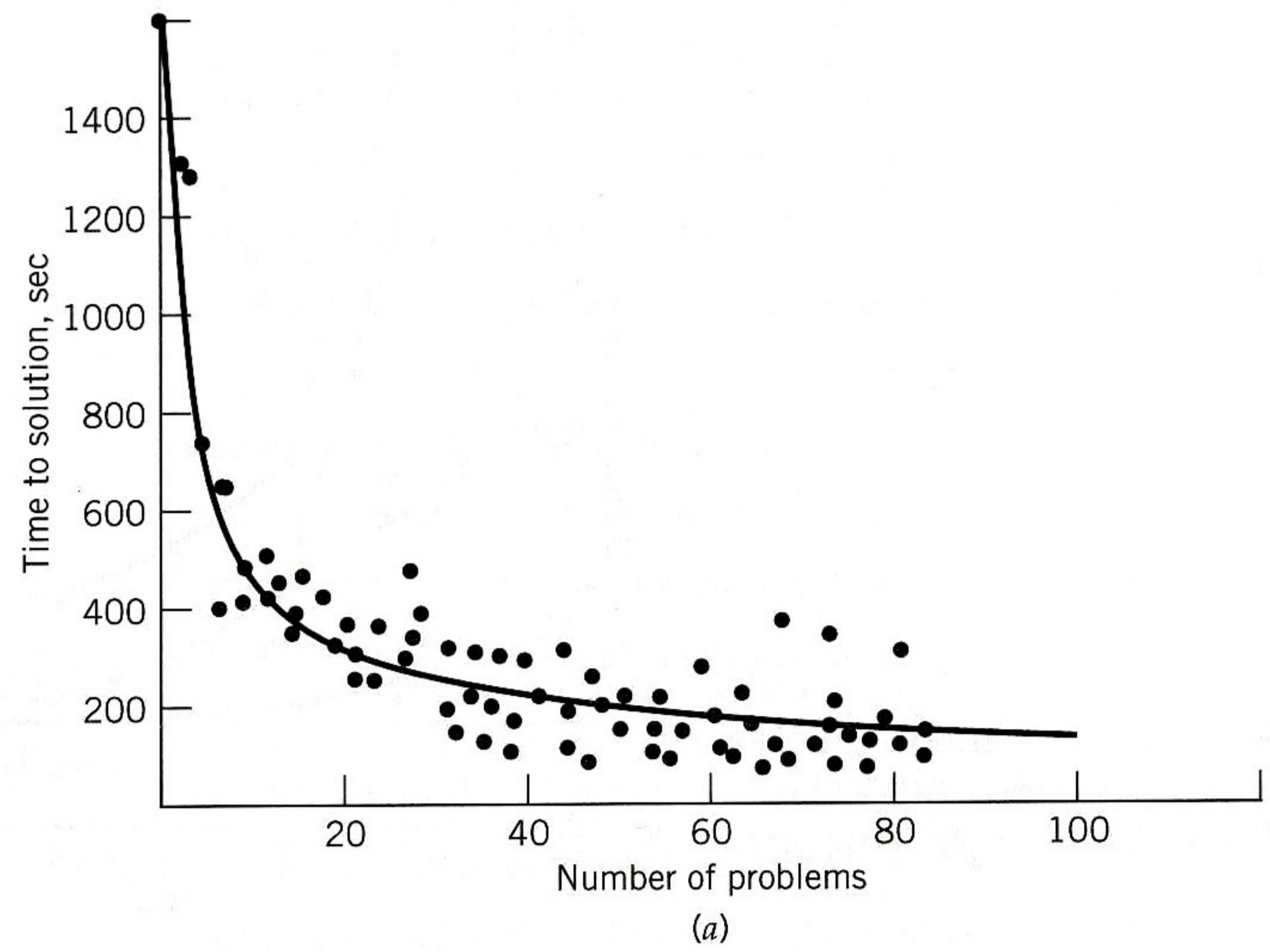


POWER LAW OF PRACTICE

Task time on the nth trial follows a power law

$$T_n = T_1 n^{-a} + c$$

where a = .4, c = limiting constant

You get faster the more times you do something!

Applies to skilled behavior (sensory & motor)

Does not apply to

Knowledge acquisition

Improving quality

SUMMARY

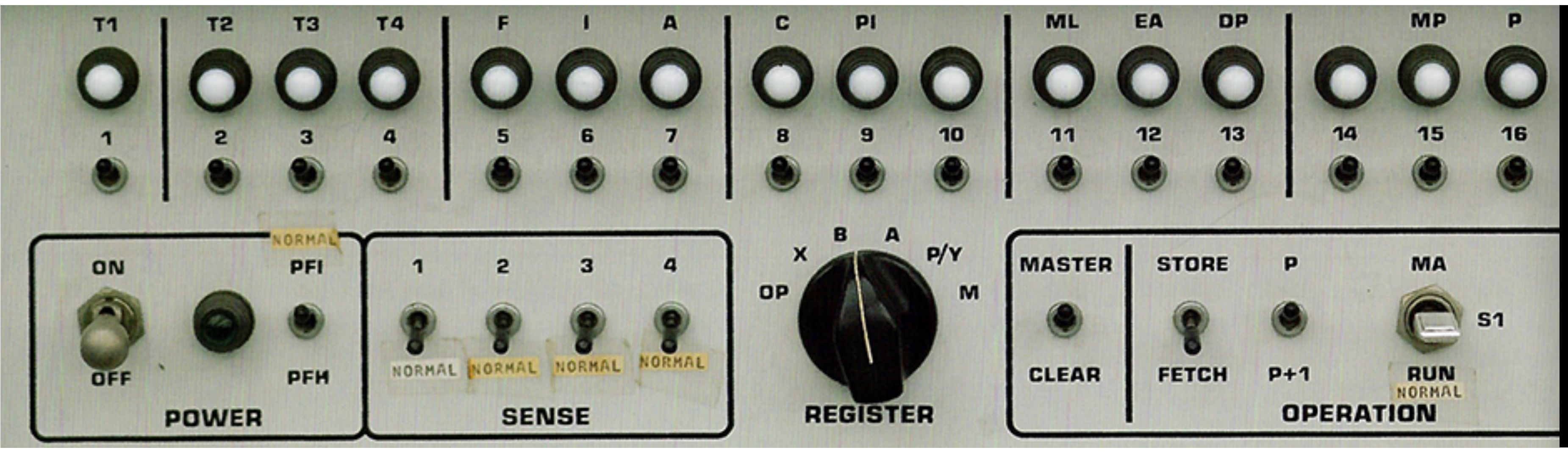
Decision Making and Learning

Time to make decisions depends on number of options

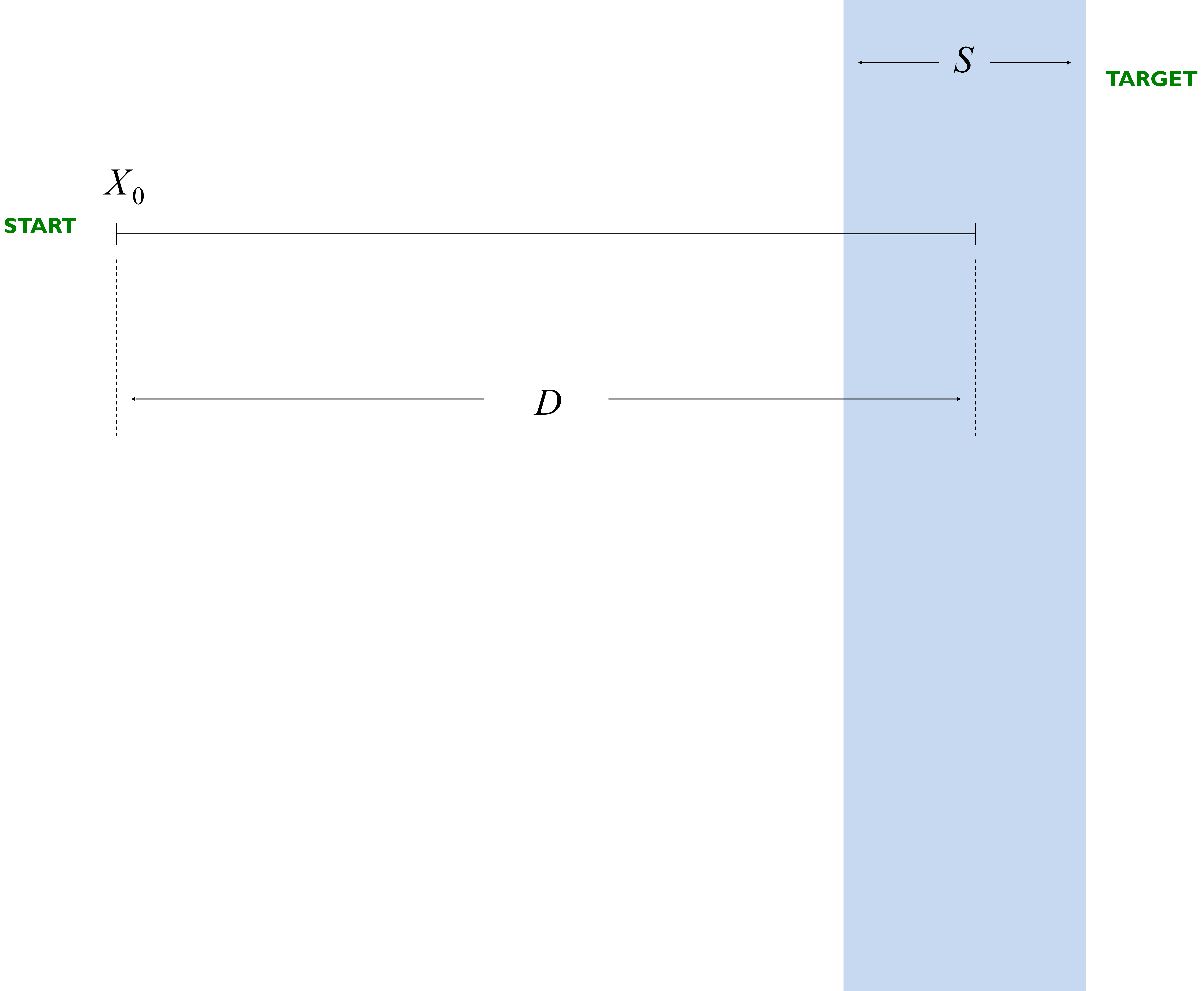
Choosing a movie on Netflix

Learning follows a power law

You get faster as you practice


T1 T2 T3 T4 F I A C PI ML EA DP MP P
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
ON
OFF
PFI
PFM
POWER
1 2 3 4
NORMAL NORMAL NORMAL NORMAL
SENSE
X B A P/Y
OP M
REGISTER
MASTER
CLEAR
STORE
FETCH
P
P+1
MA
S1
RUN
NORMAL
OPERATION

FITTS' LAW



S
TARGET
X_0
START
D

FITTS' LAW

Models well-rehearsed selection task

T increases as the ***distance*** to the target increases

T decreases as the ***size*** of the target increases

$$T = a + b\log_2(D/S + 1)$$

a, b = constants (empirically derived)

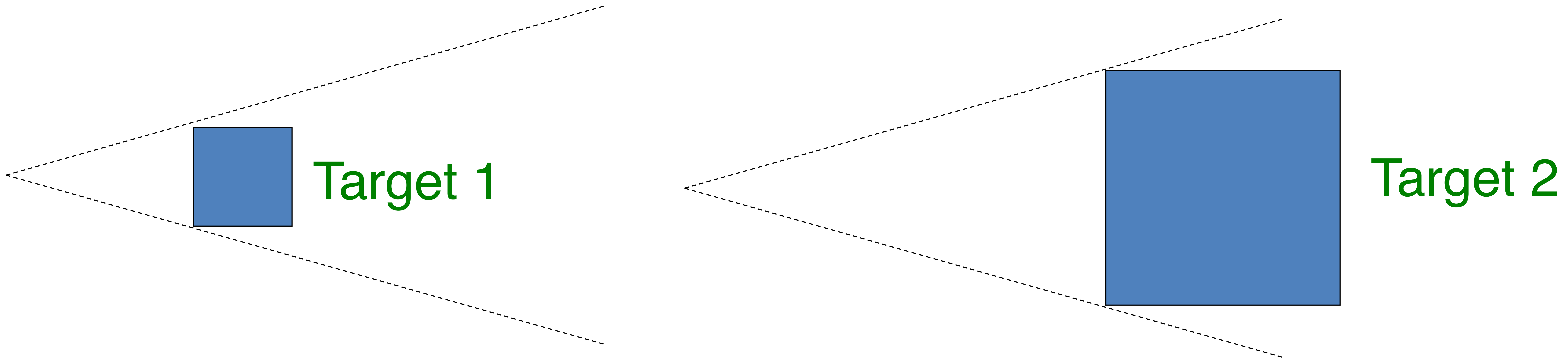
D = distance

S = size

ID is Index of Difficulty = $\log_2(D/S+1)$

CONSIDERS DISTANCE AND TARGET SIZE

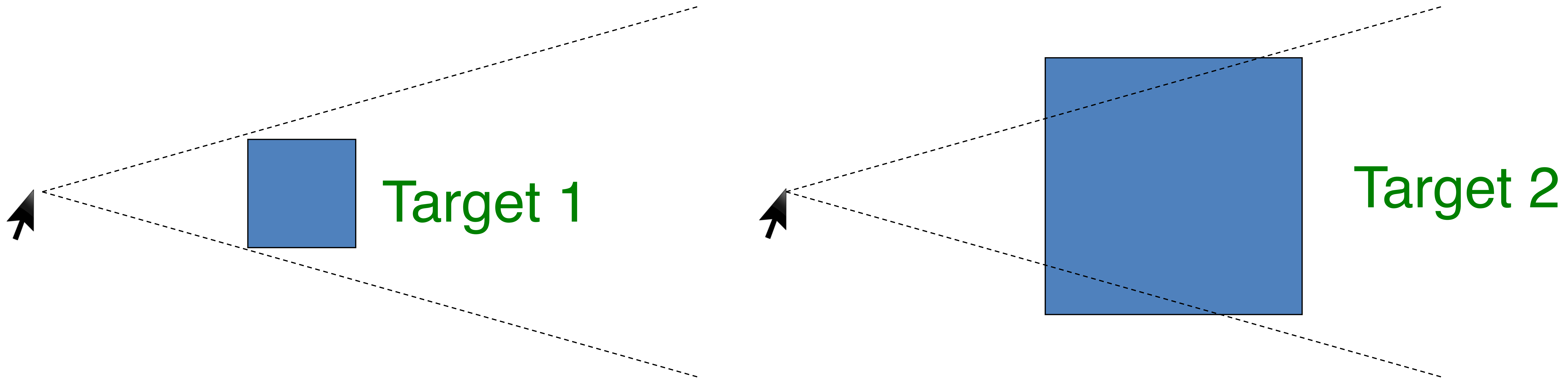
$$T = a + b\log_2(D/S + 1)$$



Same ID → Same Difficulty

CONSIDERS DISTANCE AND TARGET SIZE

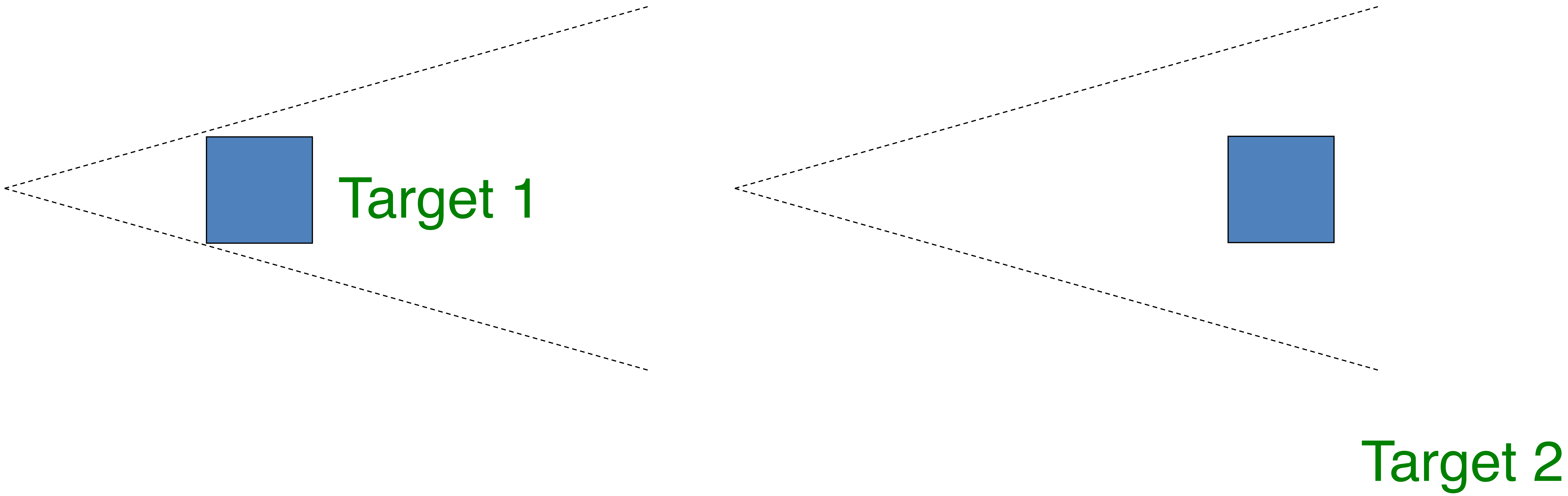
$$T = a + b\log_2(D/S + 1)$$



Smaller ID → Easier

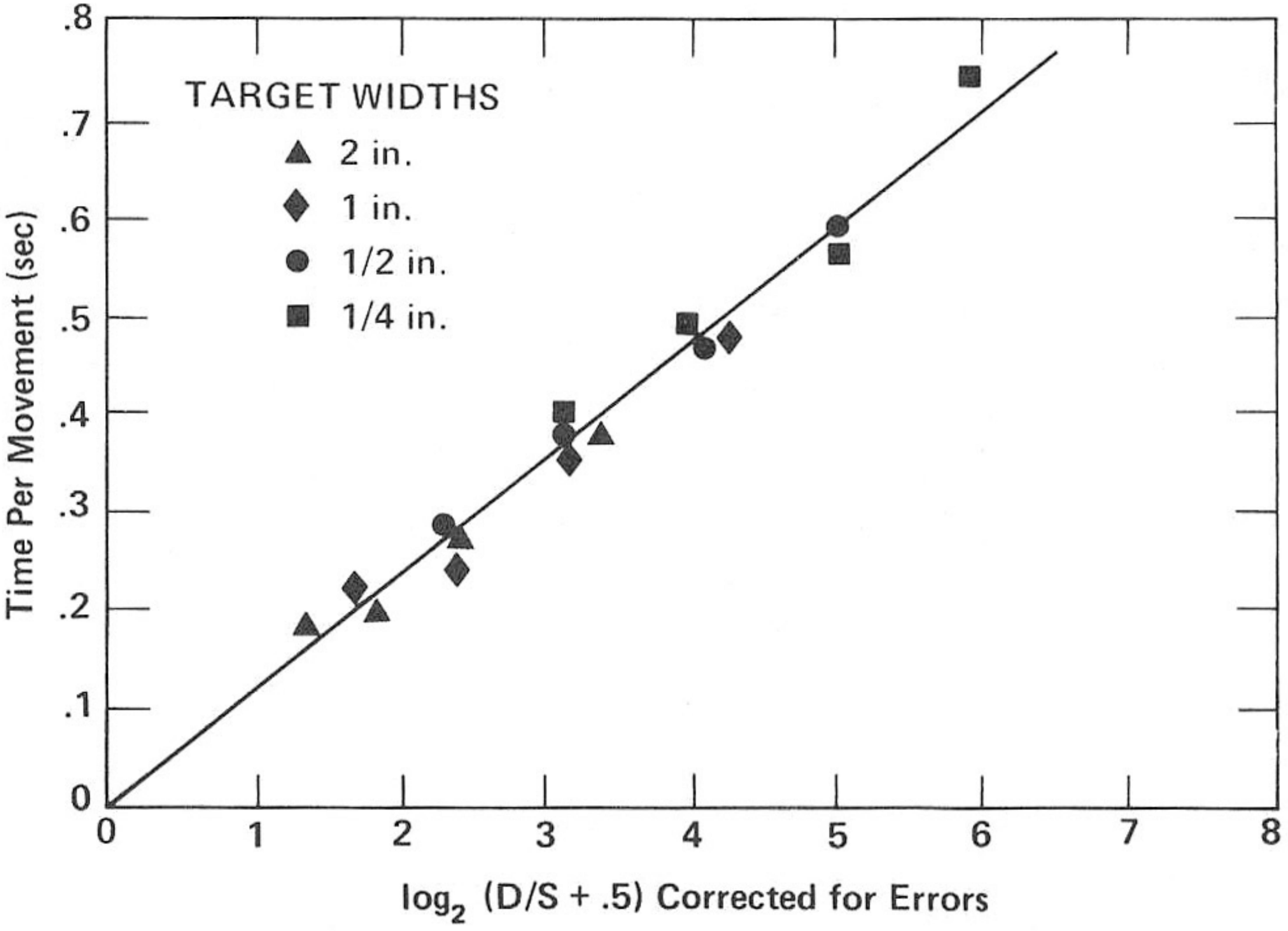
CONSIDERS DISTANCE AND TARGET SIZE

$$T = a + b\log_2(D/S + 1)$$



Larger ID → Harder

EXPERIMENTAL DATA

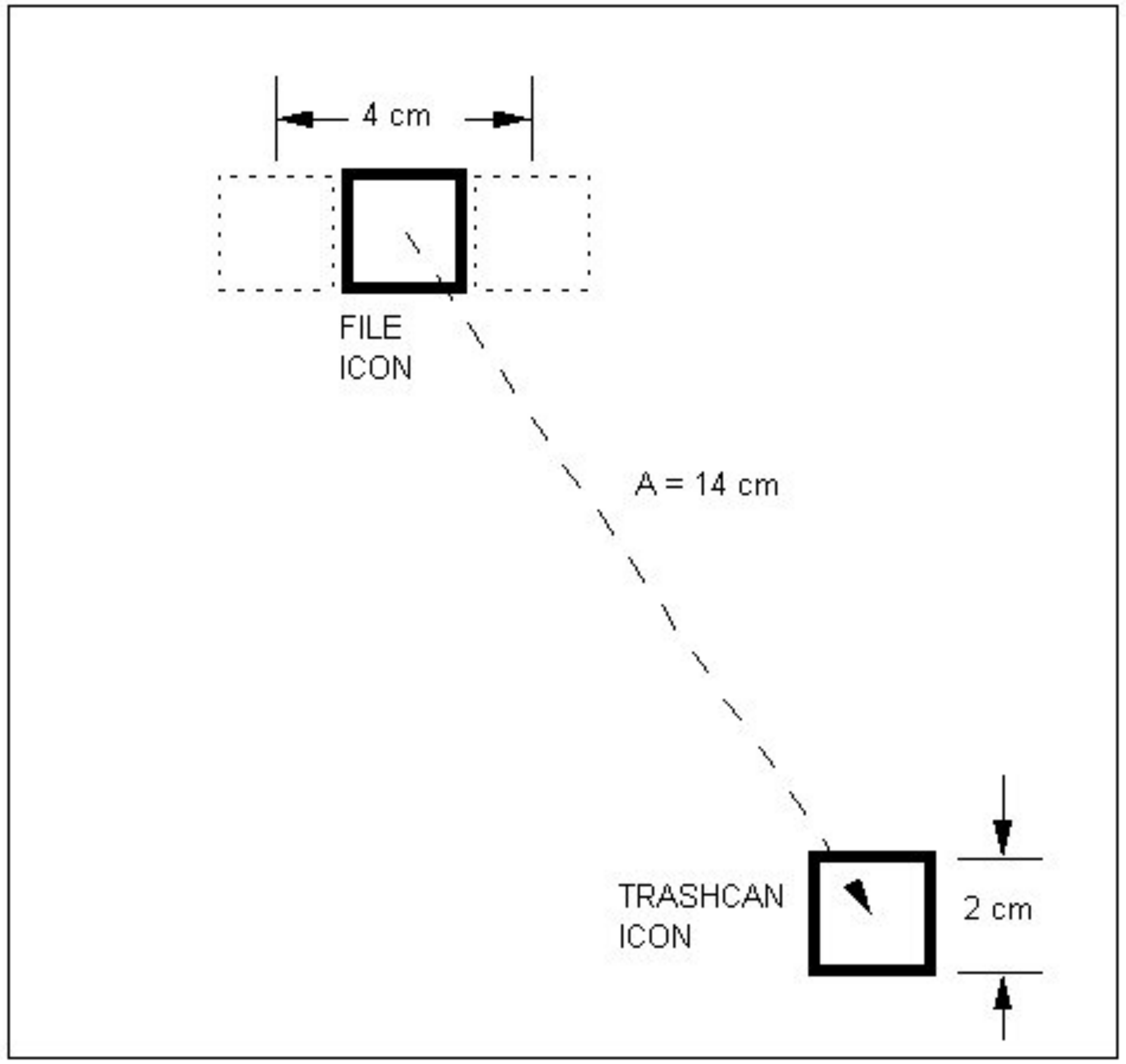


DESIGNING WITH FITTS' LAW

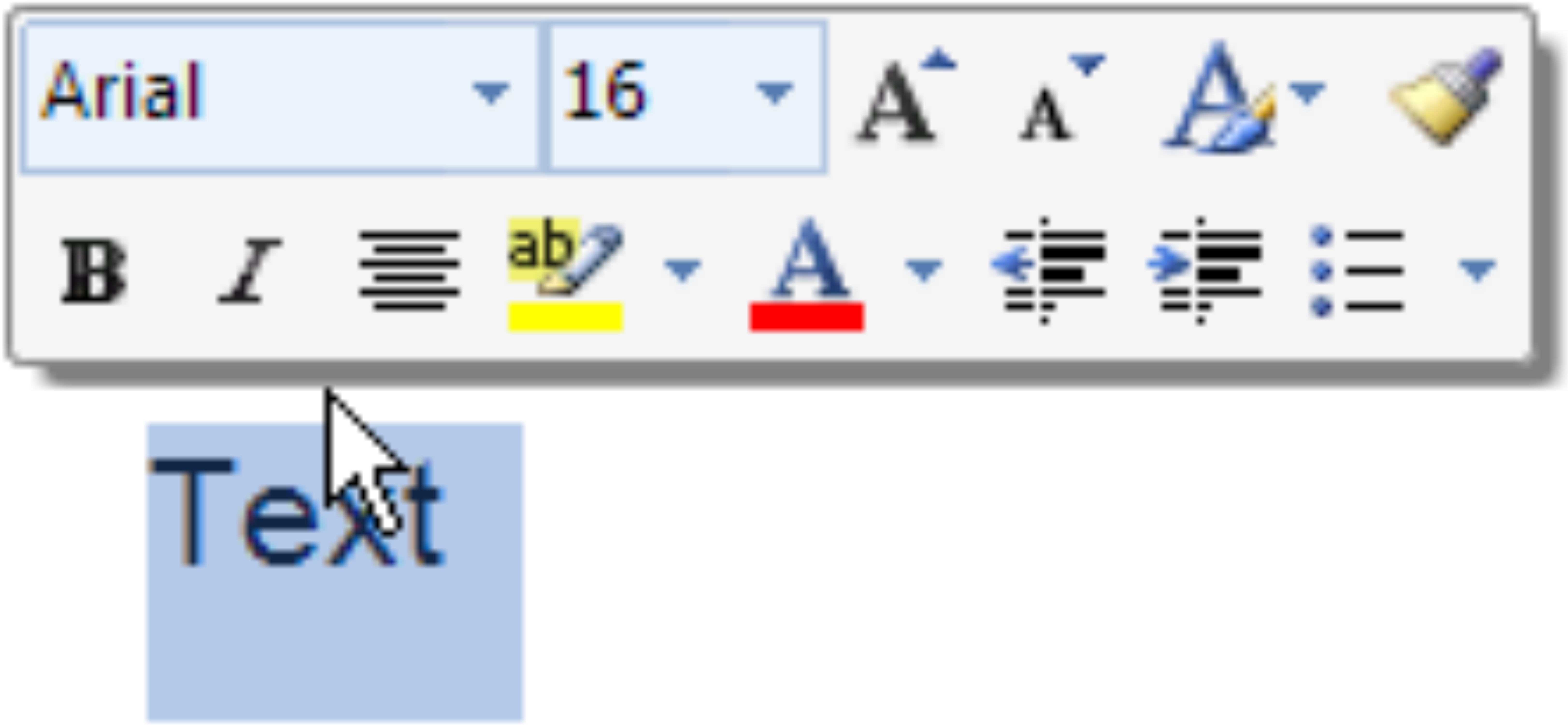
Bring items closer to the cursor

Make them larger

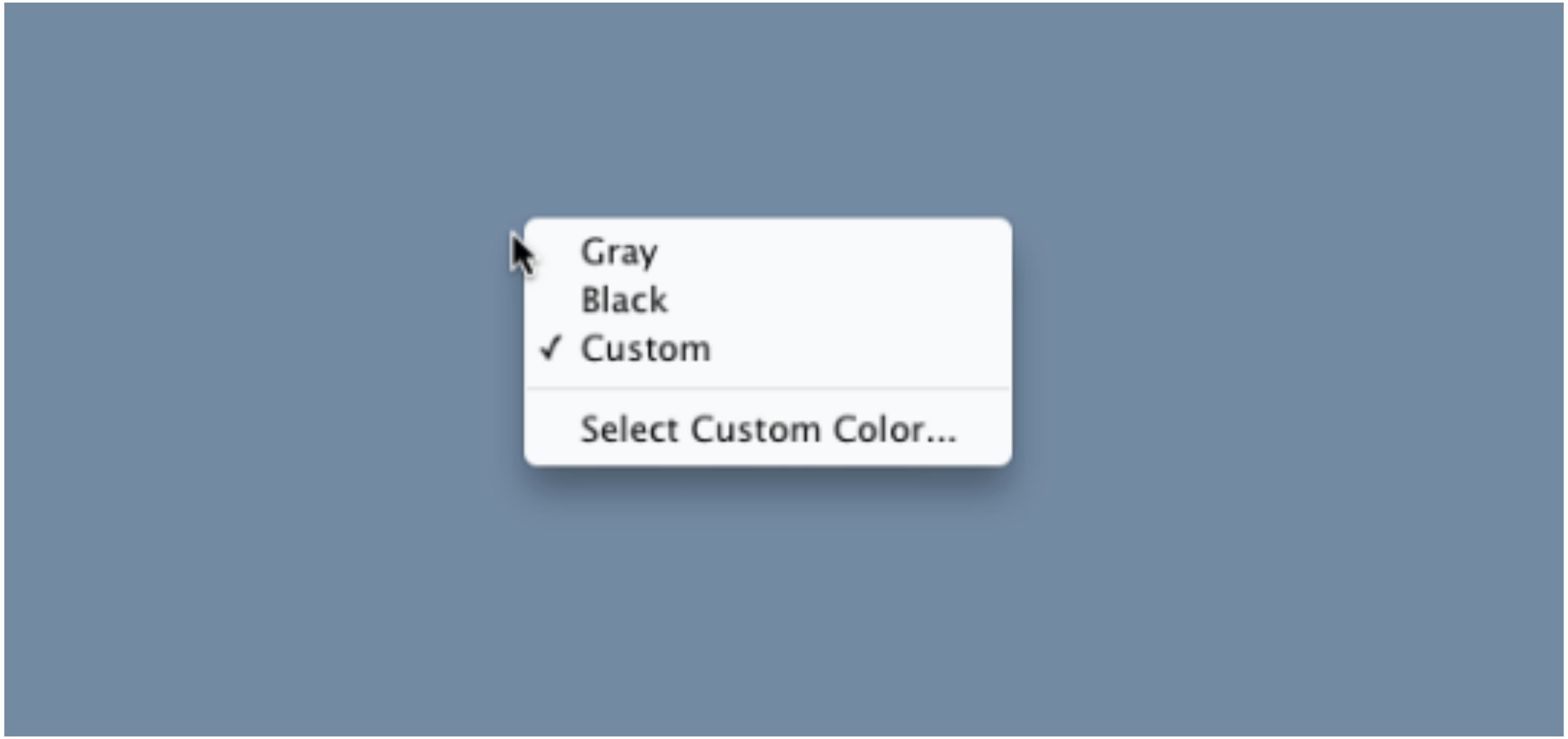
Exploit the edges



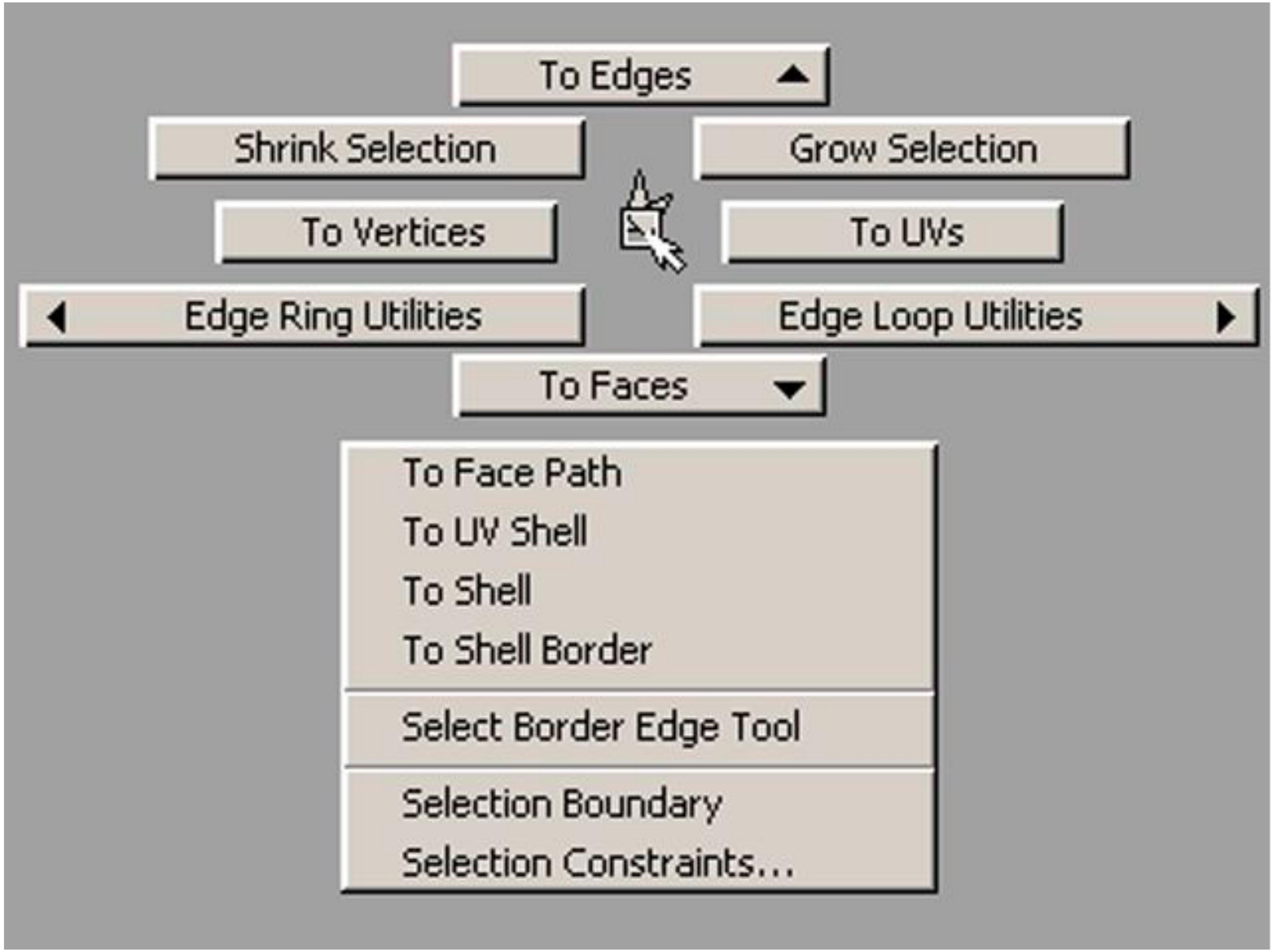
BRING ITEMS CLOSER TO THE CURSOR



BRING ITEMS CLOSER TO THE CURSOR



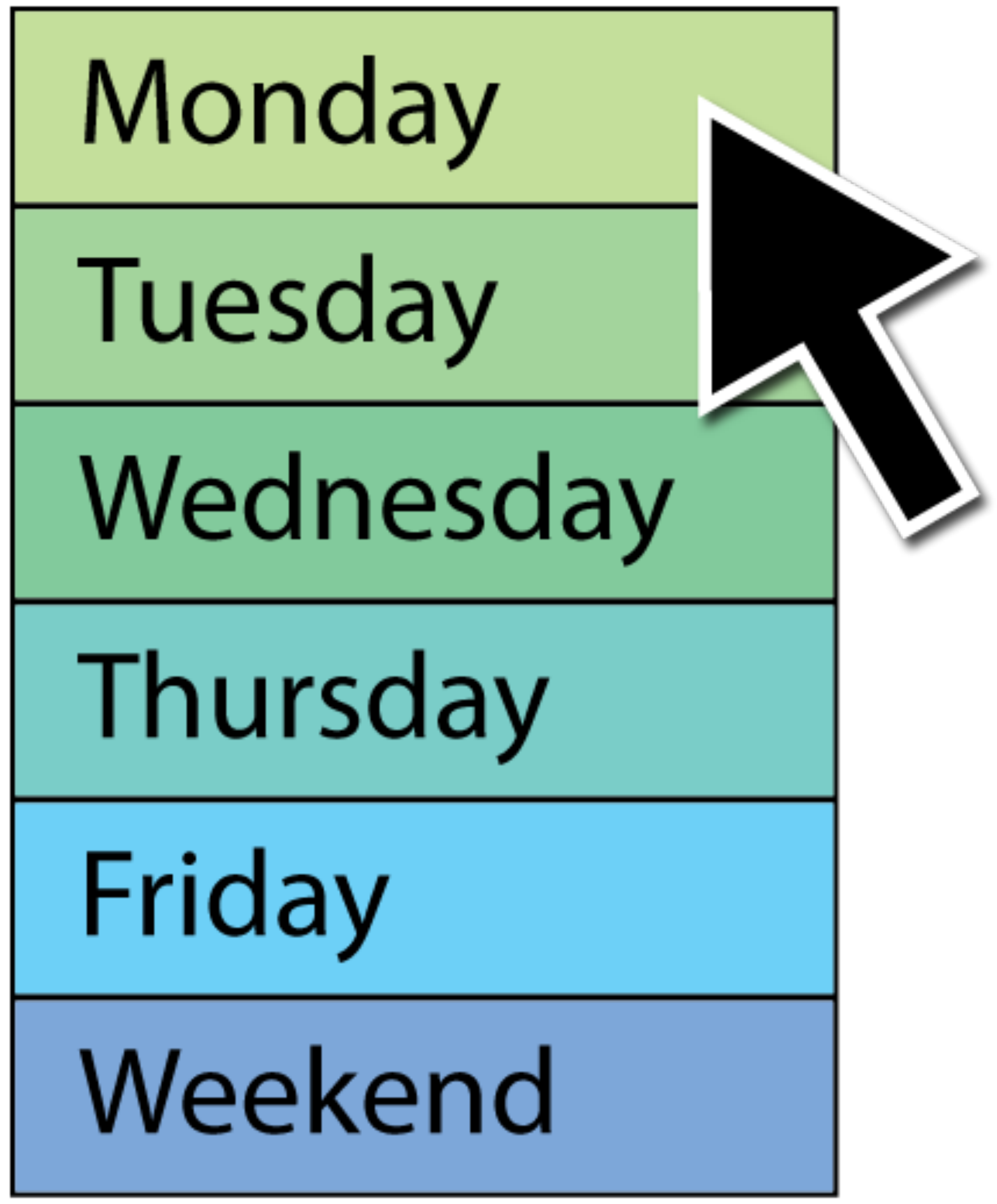
FITTS’ LAW EXAMPLE

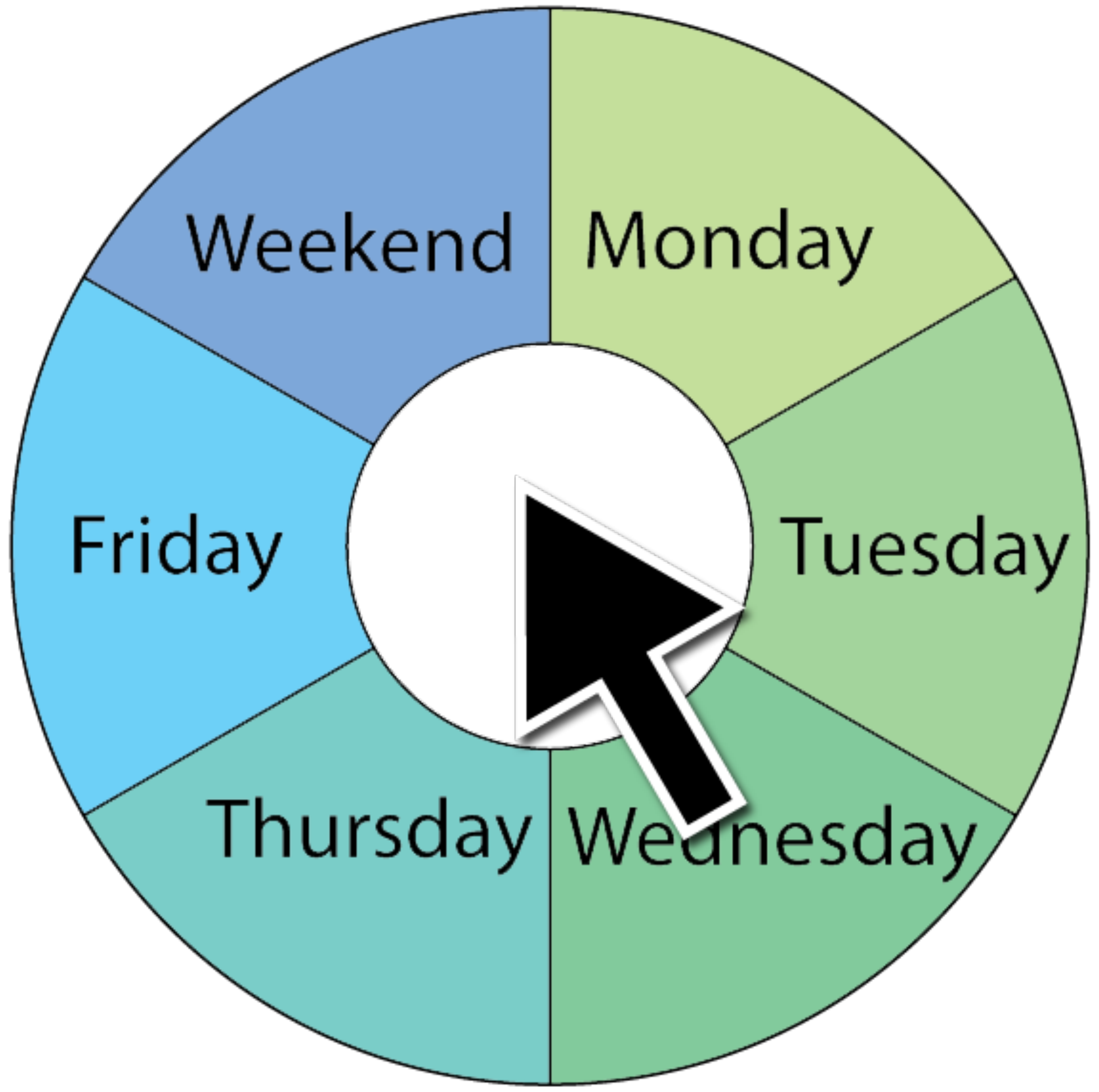


FITTS' LAW EXAMPLE

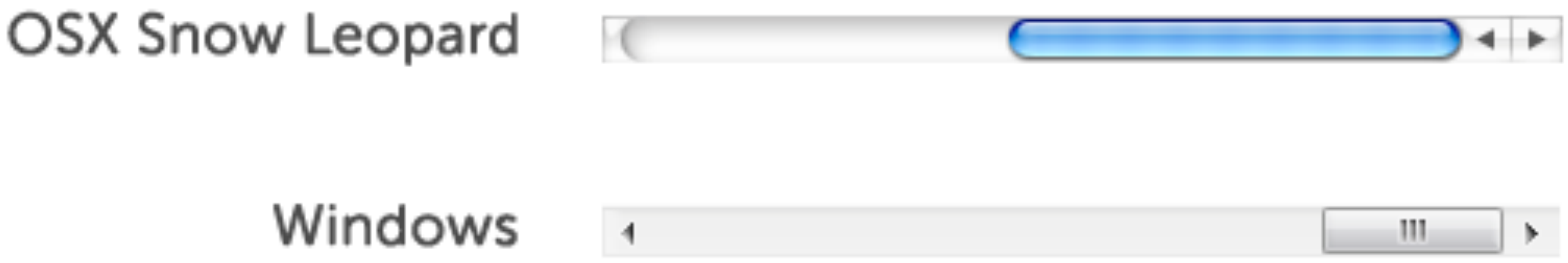
Which will be faster on average?

pie menu (bigger targets & less distance)

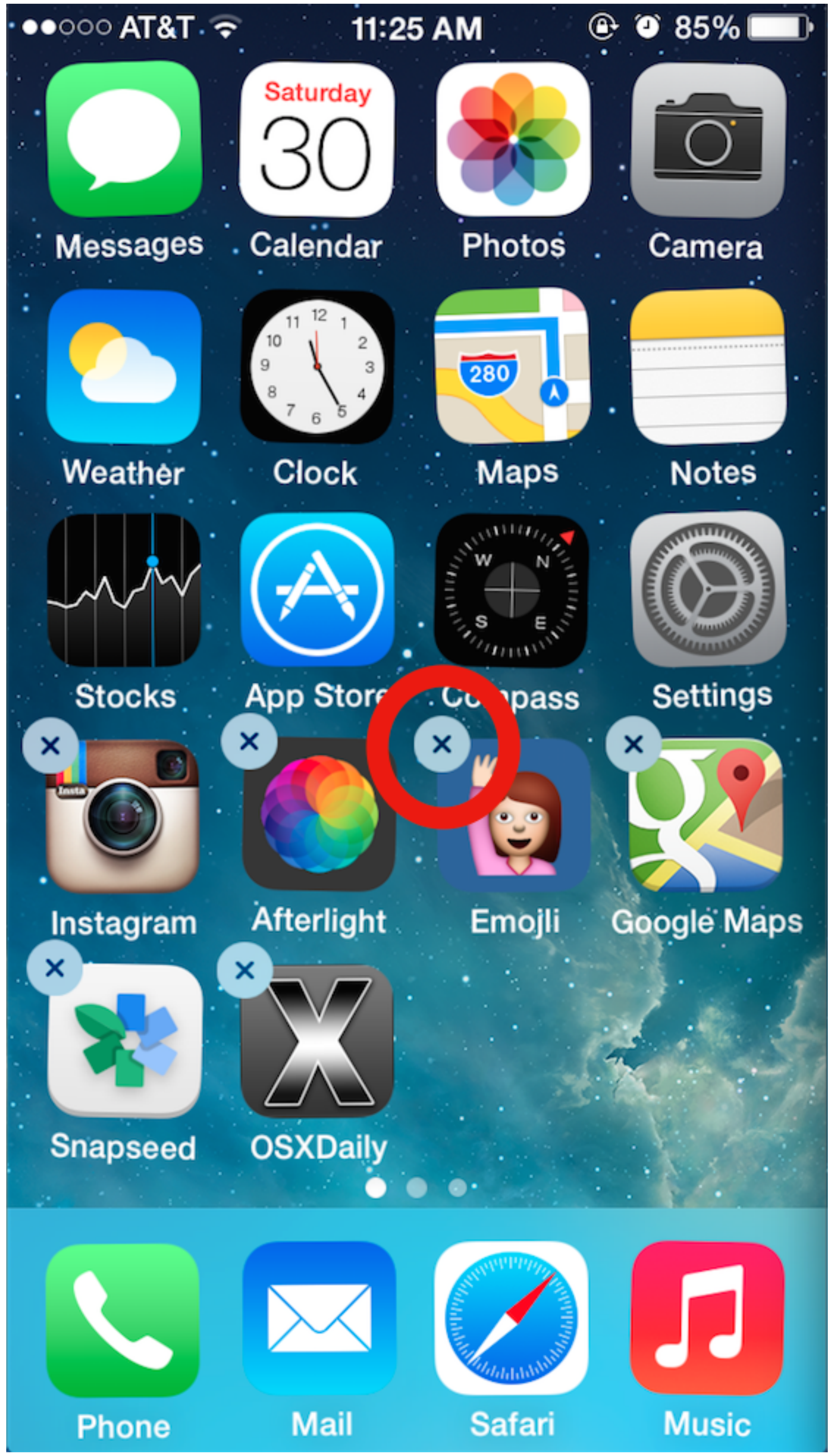




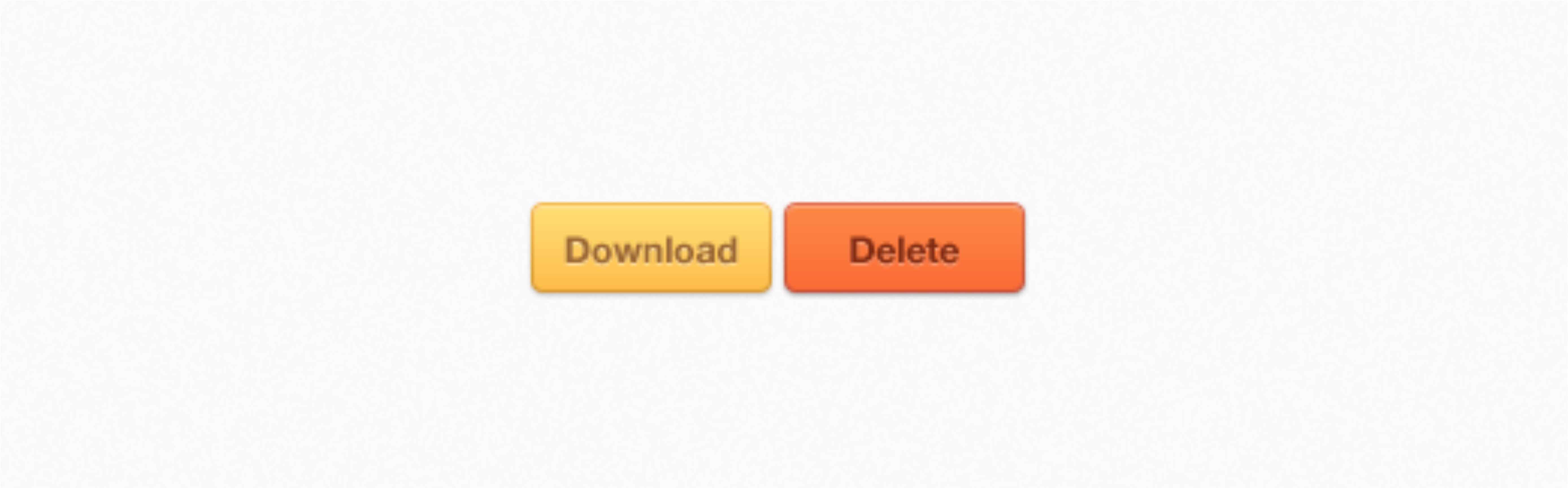
FITTS' LAW EXAMPLE



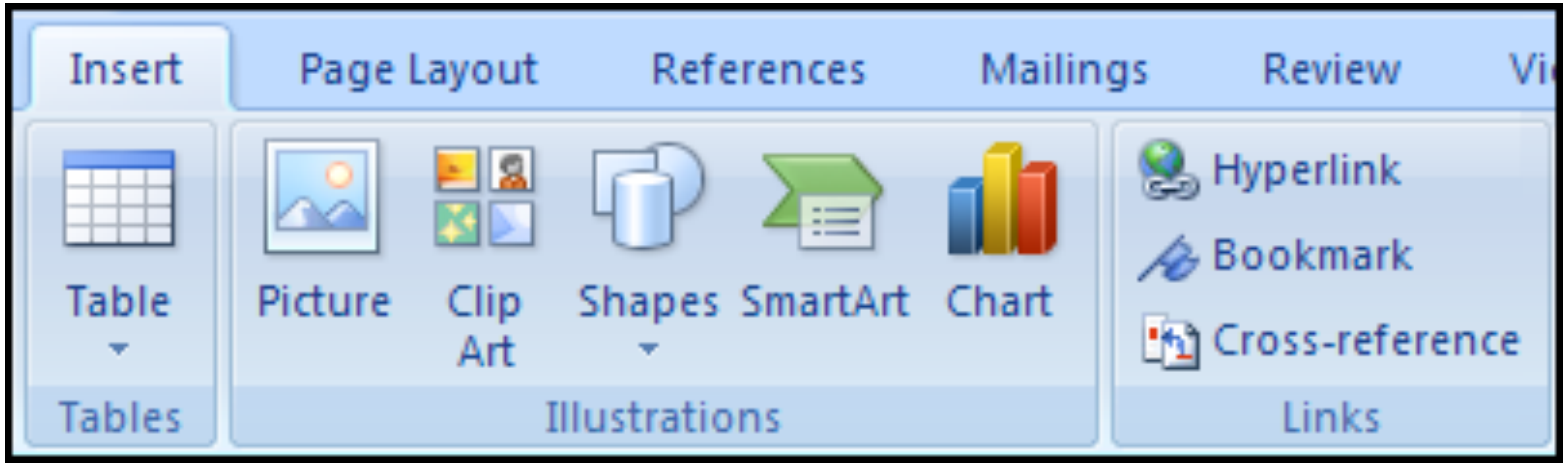
FITTS' LAW EXAMPLE



FITTS' LAW EXAMPLE



INCREASE TARGET SIZE

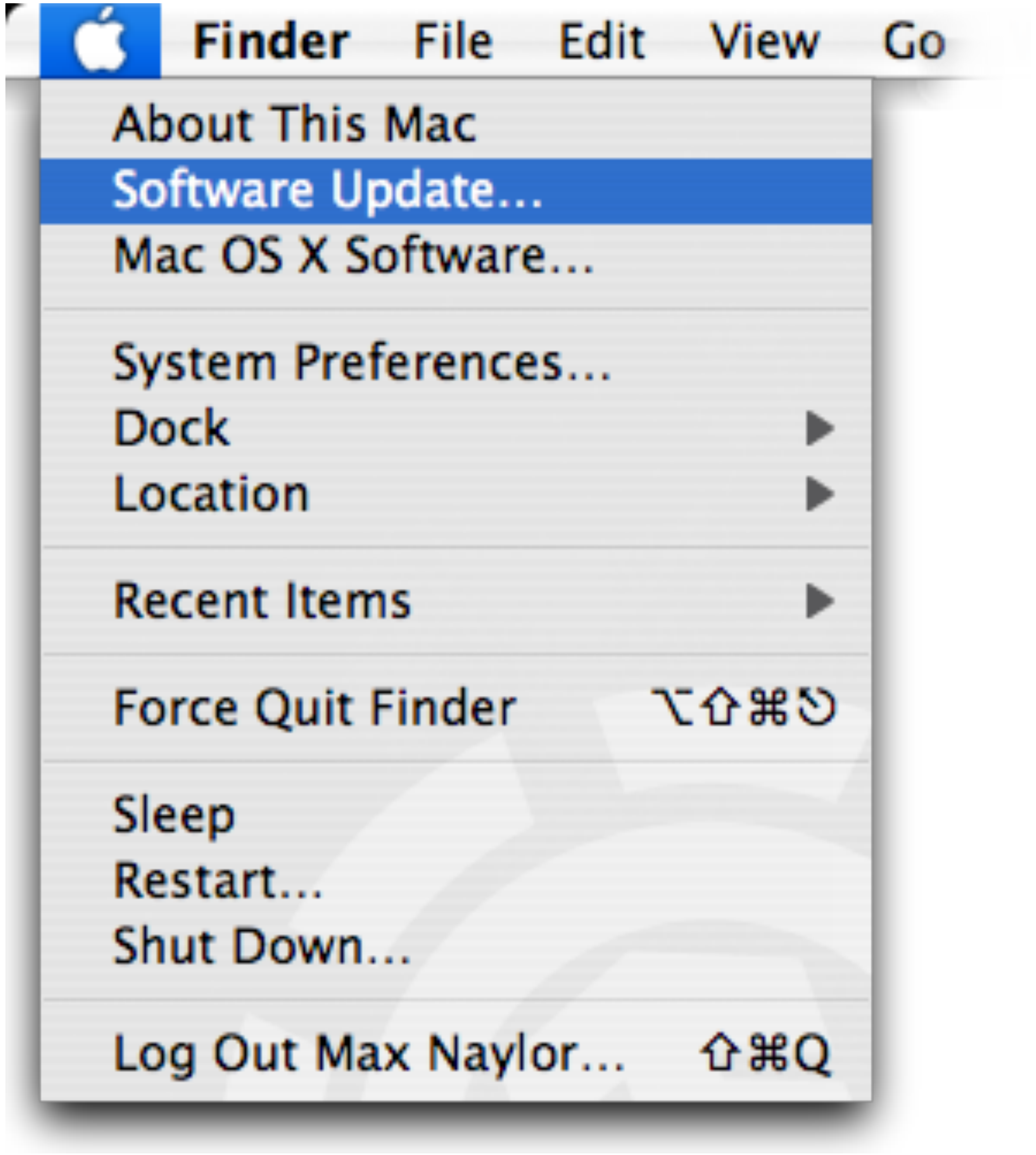


Larger, labeled controls can be clicked more quickly

EXPLOIT THE EDGES

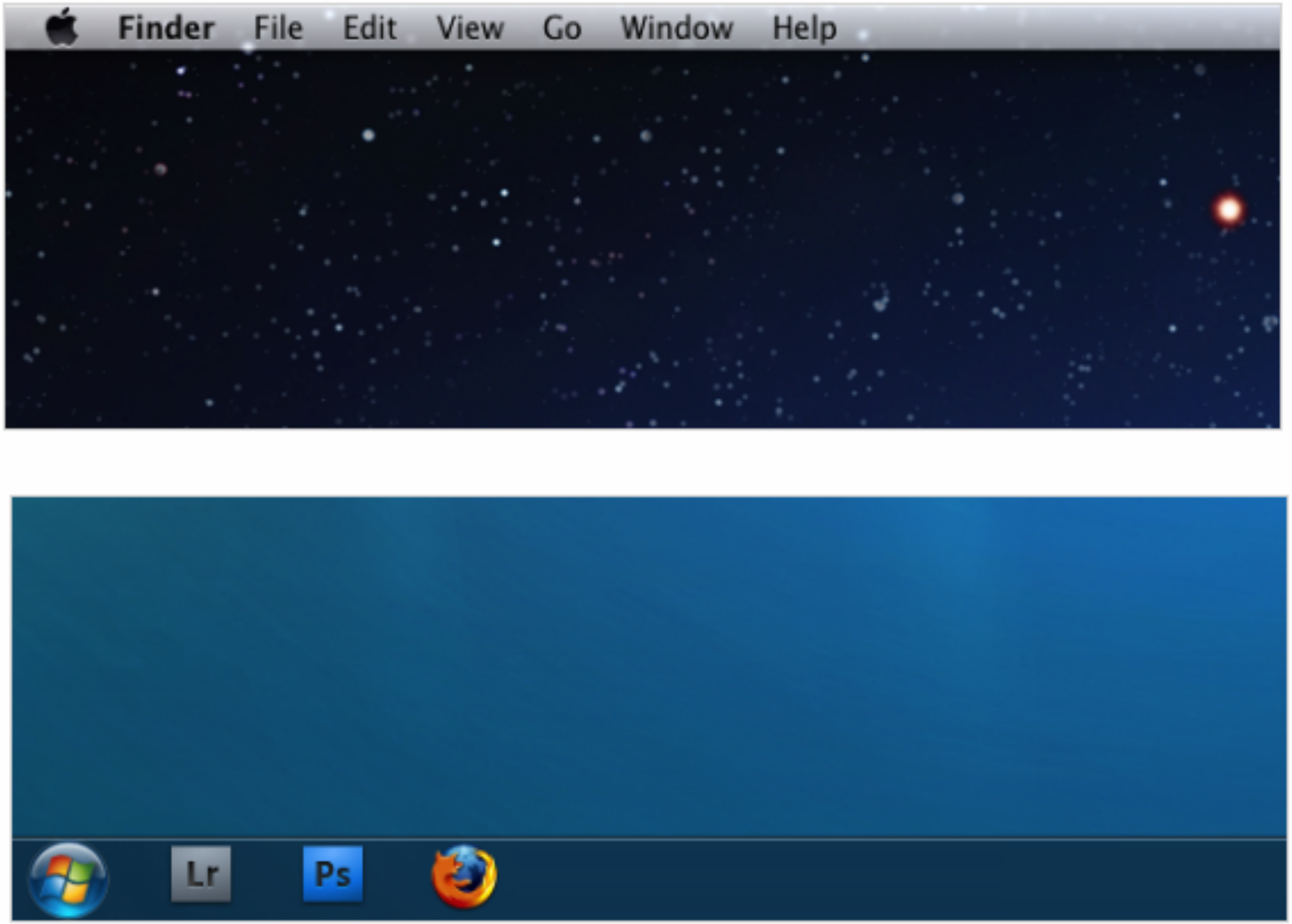
Windows 95: Missed by a pixel

Windows XP: Good to the last drop



Apple menu in Mac OS

EXPLOIT THE EDGES



DOES FITTS' LAW ONLY APPLY TO MOUSE POINTING?

Journal of
Experimental Psychology

VOL. 47, NO. 6 JUNE, 1954

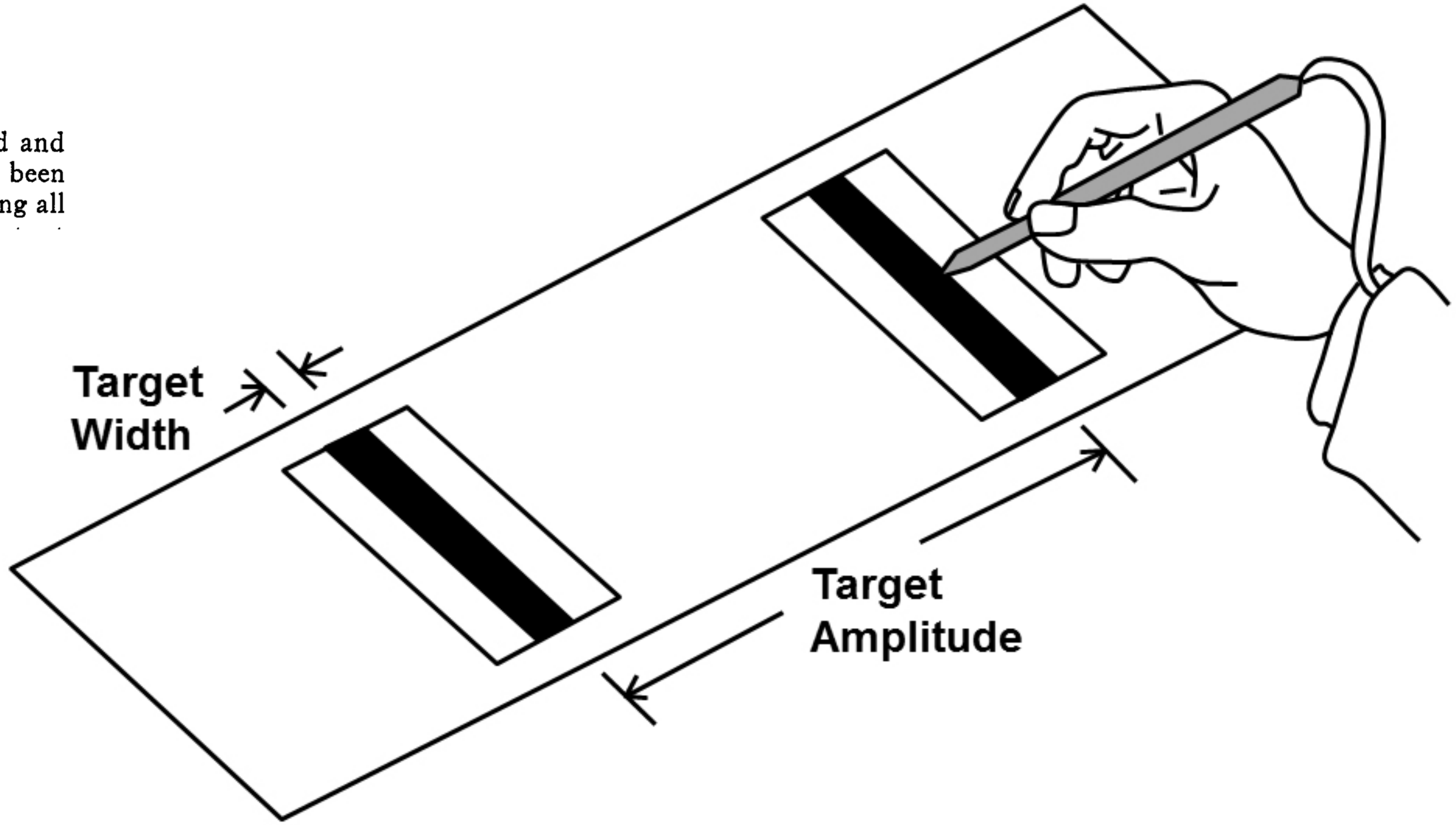
THE INFORMATION CAPACITY OF THE HUMAN MOTOR SYSTEM IN CONTROLLING THE AMPLITUDE OF MOVEMENT[1]

PAUL M. FITTS[2]

The Ohio State University

Information theory has recently been employed to specify more precisely than has hitherto been possible

ever, by asking *S* to make rapid and uniform responses that have been highly overlearned, and by holding all



DOES FITTS' LAW APPLY TO MOBILE DEVICES?

Yes! Original experiment by Fitts was on human arm movement, not mouse pointing!

Extension to target acquisition with mouse was a big result of Card et al. and not obvious.

Tablet setting is closer to original experimental setting.

No more benefit on device edges

How device is held

MOBILE