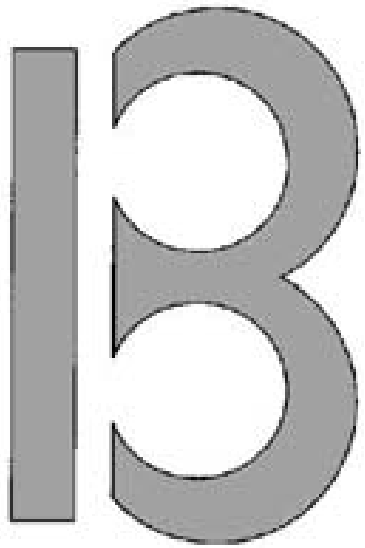
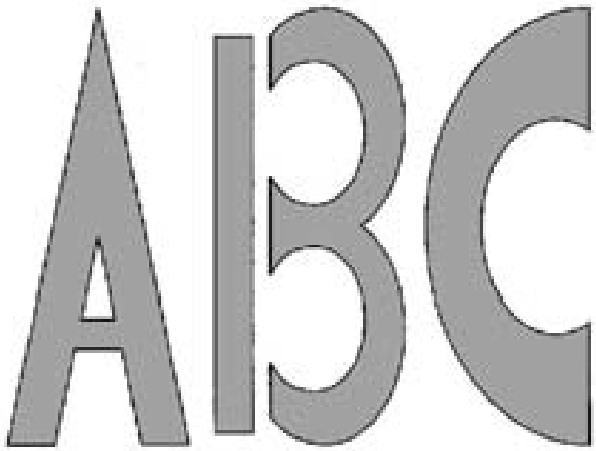
Designing for Humans (Part II)

Human limits and capabilities



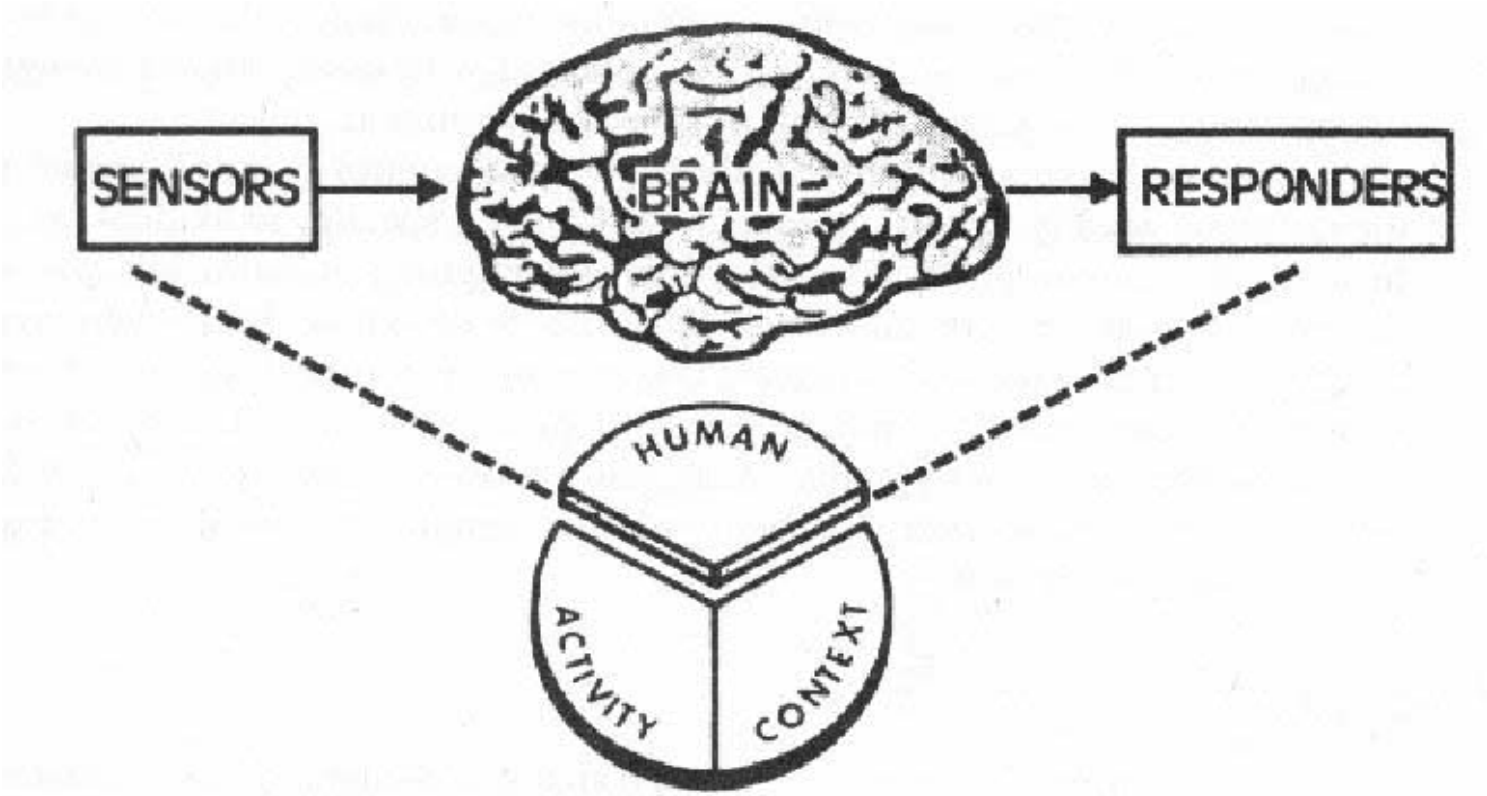


Human Performance Model

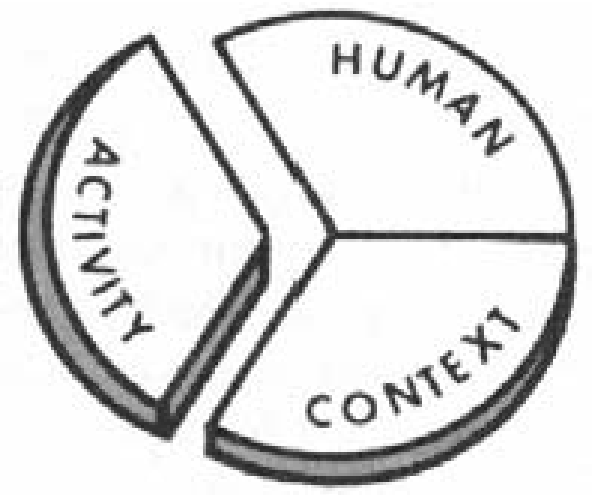
- People performing in systems have in common that they are each somebody, doing something, someplace" (Bailey, 1996)

The Human:

The most complex of the three elements



The Activity



Example: use a pointing device to
- select an icon
- write your name

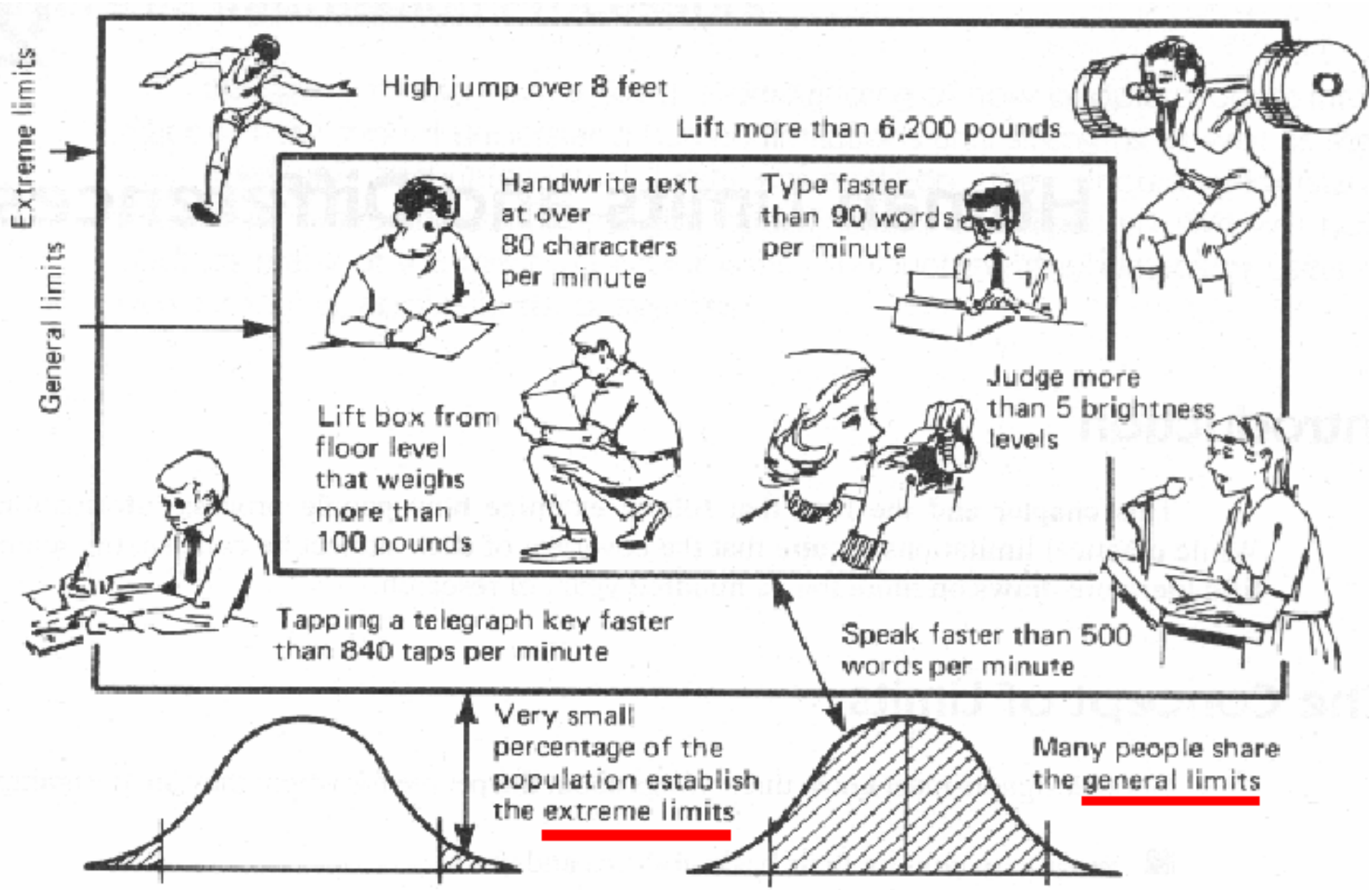
The Context

Examples:

- physical context, such as noise
- social context, such as crowds or isolation

Human Performance

- Limits and differences (next slide)


Extreme limits
General limits
High jump over 8 feet
Lift more than 6,200 pounds
Handwrite text at over 80 characters per minute
Type faster than 90 words per minute
Lift box from floor level that weighs more than 100 pounds
Judge more than 5 brightness levels
Tapping a telegraph key faster than 840 taps per minute
Speak faster than 500 words per minute
Very small percentage of the population establish the extreme limits
Many people share the general limits

Types of Limits

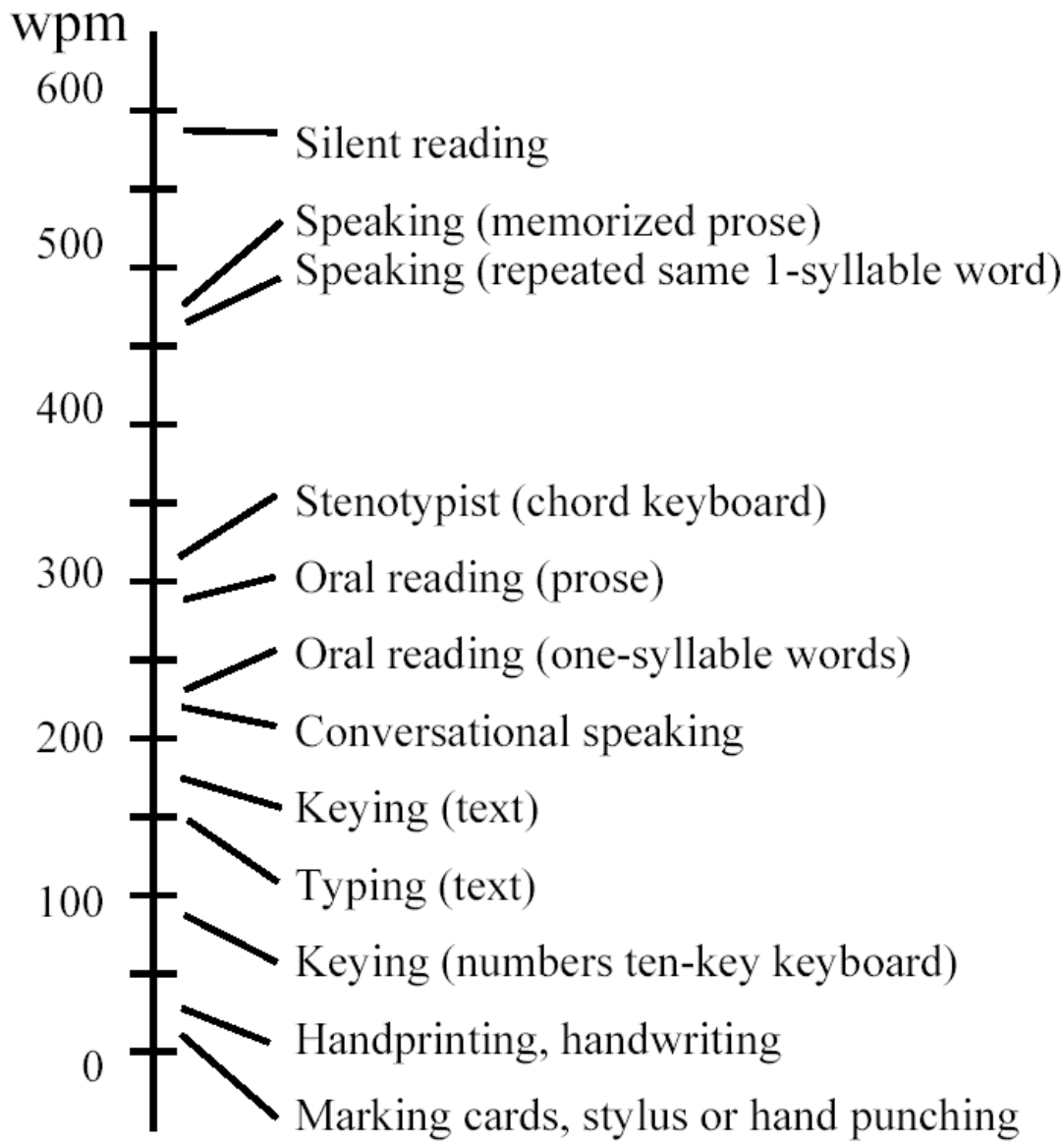
- Sensory limits
  - thresholds
  - deficiencies
- Responder limits
- Cognitive processing limits
  - reaction time (next slide)
  - speed
  - accuracy
  - estimating
  - multitasking

Reaction Time

- Includes sensory input and responding
- A “loop”

	Typical time delays (ms)
Sensory receptor	1-38
Neural transmission to brain	2-100
Cognitive-processing delays (brain)	70-300
Neural transmission to muscles	10-20
Muscle latency and activation time	30-70
Total:	113-528

Inherent Speed Limits

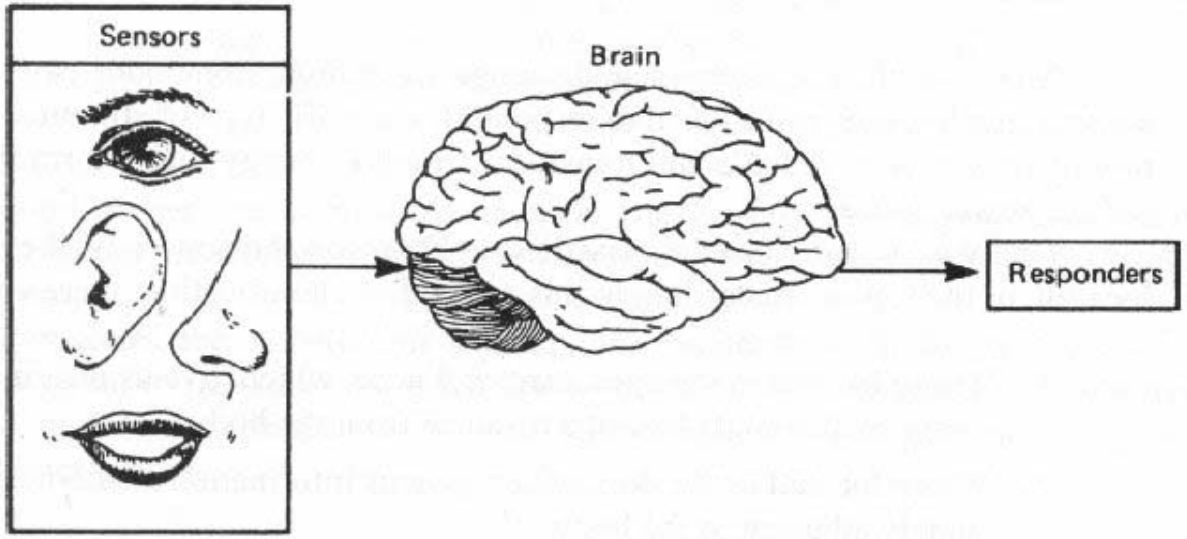


Note:
wpm = words/minute
(1 word = 5 char)

Sensory Limits

Senses:

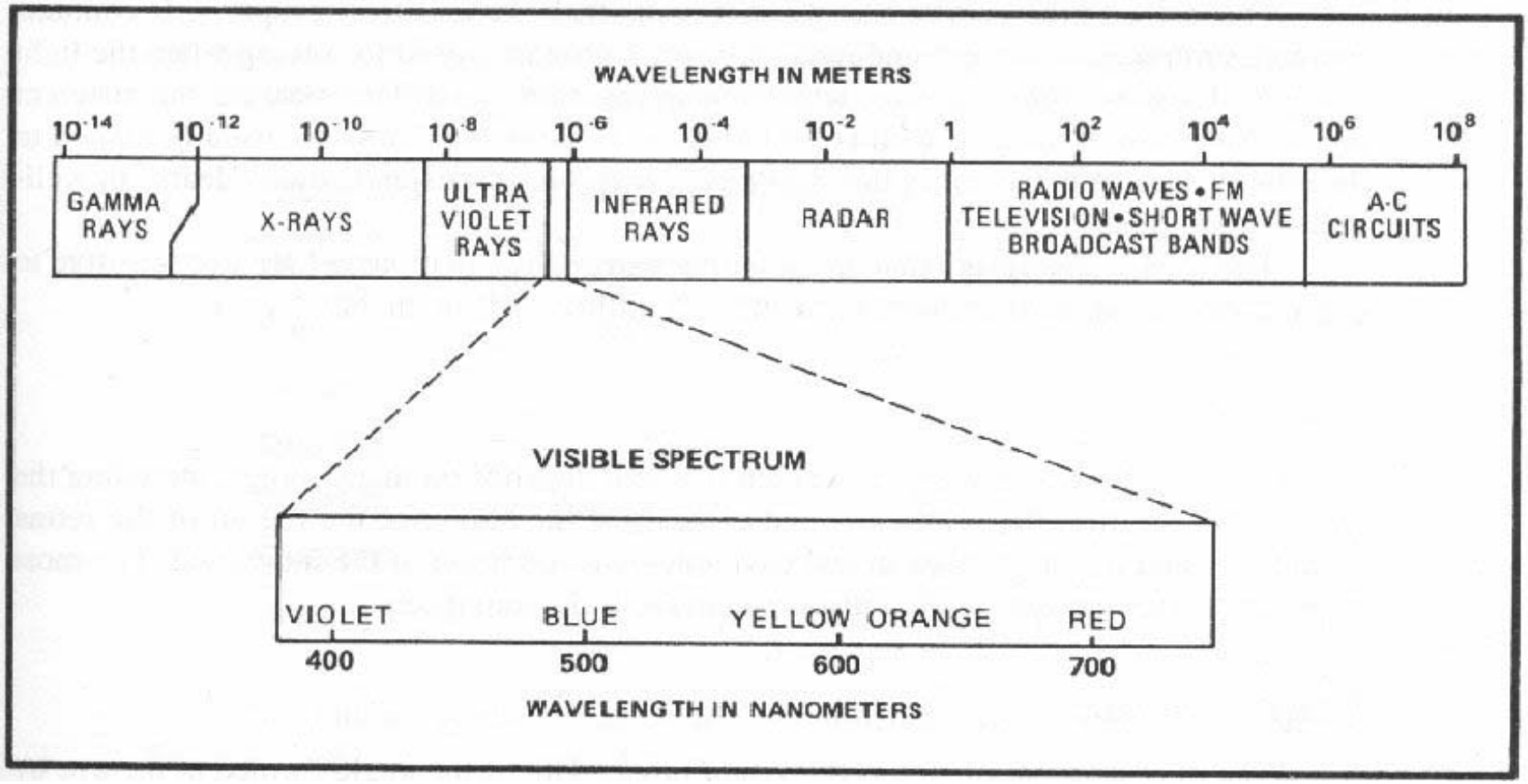
- Sight
- Hearing
- Taste
- Smell
- Touch
- Kinesthetic
- Cutaneous
- Temperature
- Vestibular



Sensory Thresholds

Sense	Detection Threshold
Sight	Candle flame seen 30 miles on a dark clear night
Hearing	Tick of a watch under quiet conditions at 20 feet
Taste	Teaspoon of sugar in 2 gallons of water
Smell	Drop of perfume diffused into a three-room apartment
Touch	Wing of a bee falling on your neck from a distance of 1 cm

Vision Frequency Limits



Visual-Cognitive Interaction
"The Stroop Effect" (Stroop, 1935)

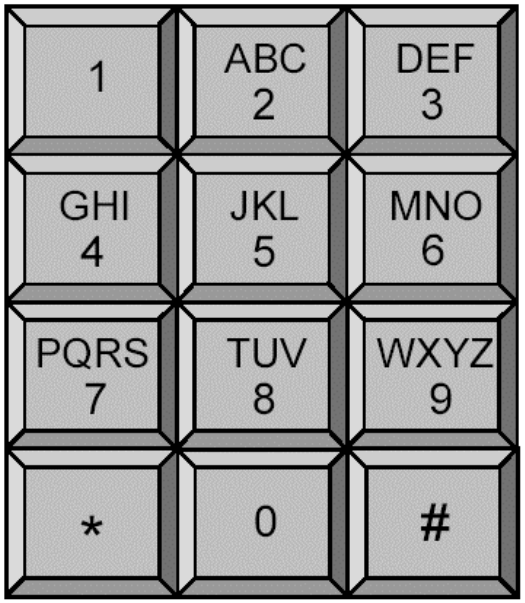
Say the words (or colours) in each list as quickly as possible

Record the speed and accuracy of responses

Are the results the same for each list?

Stroop Effect in HCI

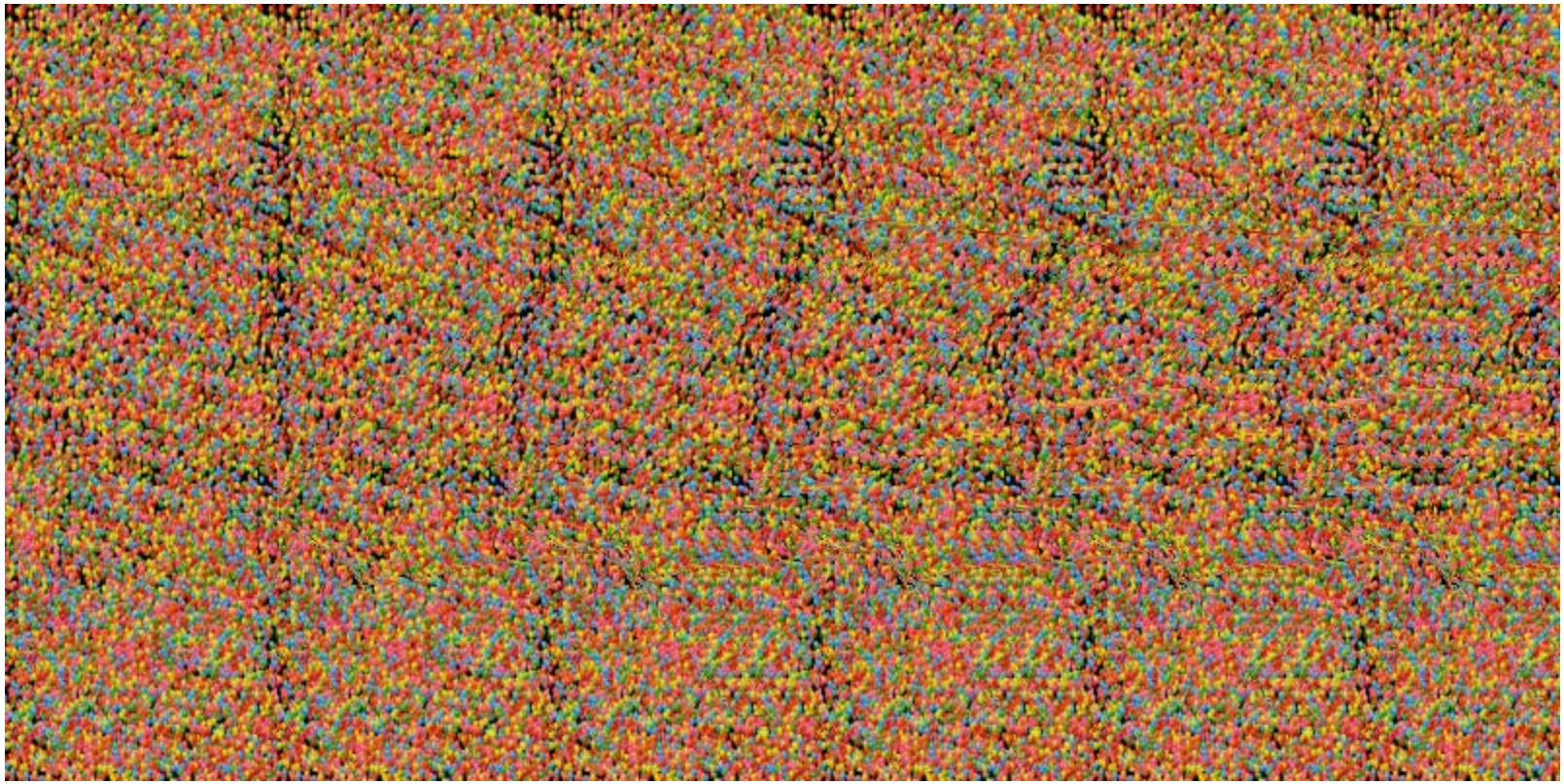
Is there Stroop interference when entering a phone number, such as 1-800-HELLO, on a telephone keypad?



Stereogram Example (Just for fun)

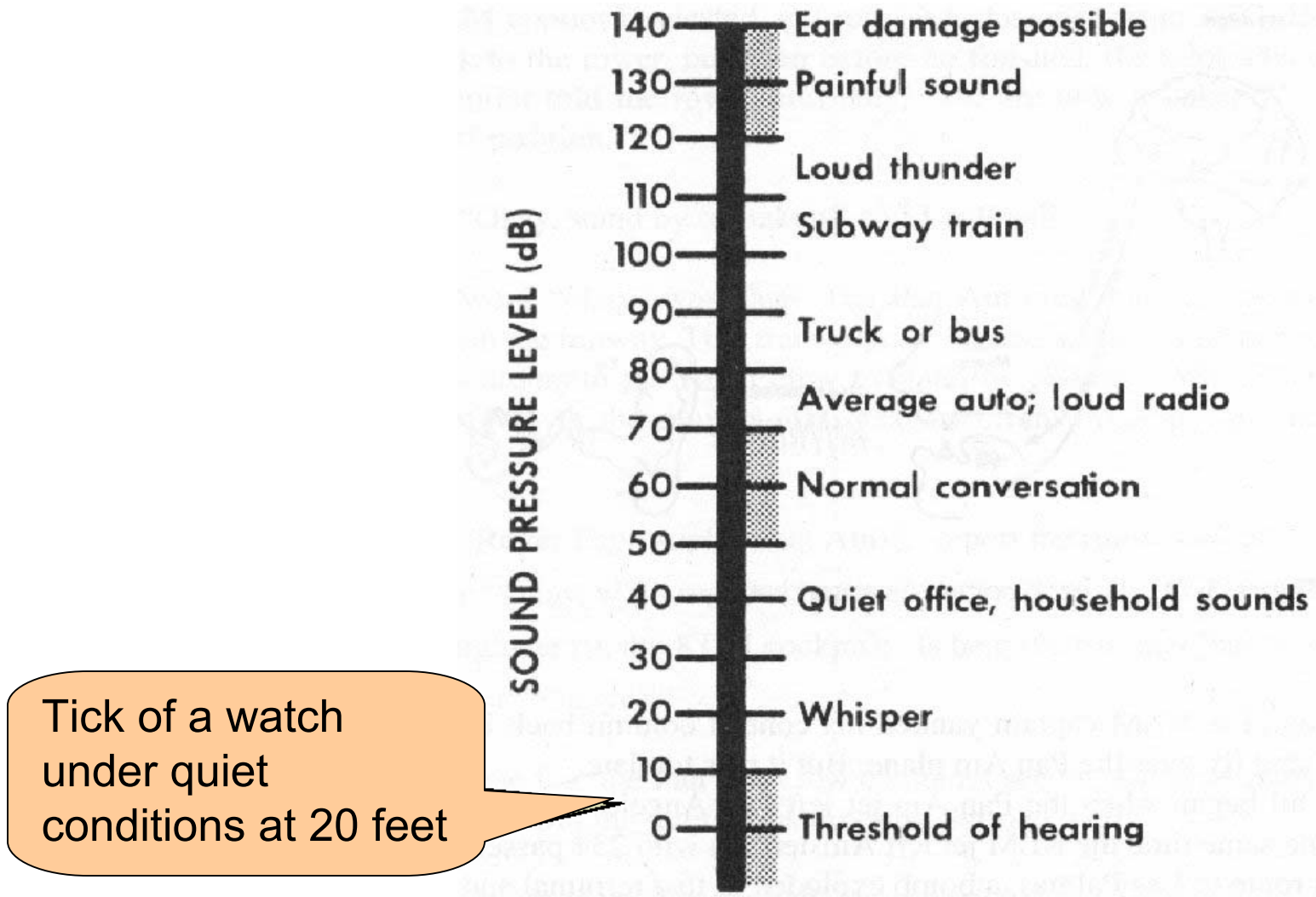
Stereogram Example "shown"

Another Example

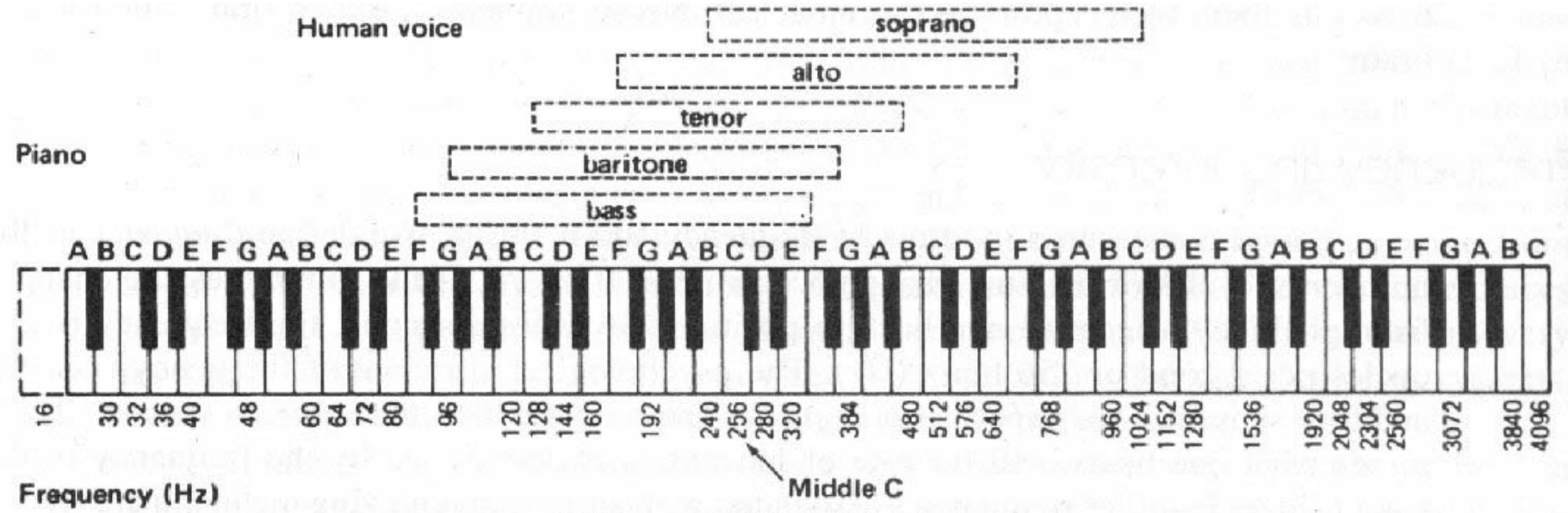


From…
http://en.wikipedia.org/wiki/Stereogram

Hearing Intensity Limits



Hearing Frequency Limits



Musical Tuning

Equal Tempered Tuning	
A	440.000
A#	466.164
B	493.883
C	523.251
C#	554.365
D	587.330
D#	622.254
E	659.255
F	698.456
F#	739.989
G	783.991
G#	830.609
A'	880.000
A#'	932.328
etc	etc
FACTOR	1.059463094

Shouldn't these notes be the same frequency?

$$2^{\frac{1}{12}}$$

Just Tuning													
A	E	B	F#	C#	G#	D#	A#	F	C	G	D	A'	Factor
440	660	990	1485	2227.5	3341.3	5011.9	7517.8	11277	16915	25373	38059	57088	
220	330	495	742.5	1113.8	1670.6	2505.9	3758.9	5638.4	8457.5	12686	19029	28544	Divide by 2
110	165	247.5	371.25	556.88	835.31	1253	1879.5	2819.2	4228.8	6343.2	9514.7	14272	Divide by 4
55	82.5	123.75	185.63	278.44	417.66	626.48	939.73	1409.6	2114.4	3171.6	4757.4	7136	Divide by 8
27.5	41.25	61.875	92.813	139.22	208.83	313.24	469.86	704.79	1057.2	1585.8	2378.7	3568	Divide by 16
13.75	20.625	30.938	46.406	69.609	104.41	156.62	234.93	352.4	528.6	792.89	1189.3	1784	Divide by 32
6.875	10.313	15.469	23.203	34.805	52.207	78.311	117.47	176.2	264.3	396.45	594.67	892.01	Divide by 64

See "musical tuning.xls"

Sheppard Scale

One of the most widely used auditory illusions is Shepard's (1964) demonstration of pitch circularity, which has come to be known as the "Sheppard Scale" demonstration. The demonstration uses a cyclic set of complex tones, each composed of 10 partials separated by octave intervals. The tones are cosinusoidally filtered to produce the sound level distributions shown in Figure 1 (next slide) and the frequencies of the partials are shifted upward in steps corresponding to a musical semitone (~6%). The result is an "ever-increasing" scale, which is a sort of auditory analog to the ever-ascending staircase visual illusion (Figure 2, next slide).

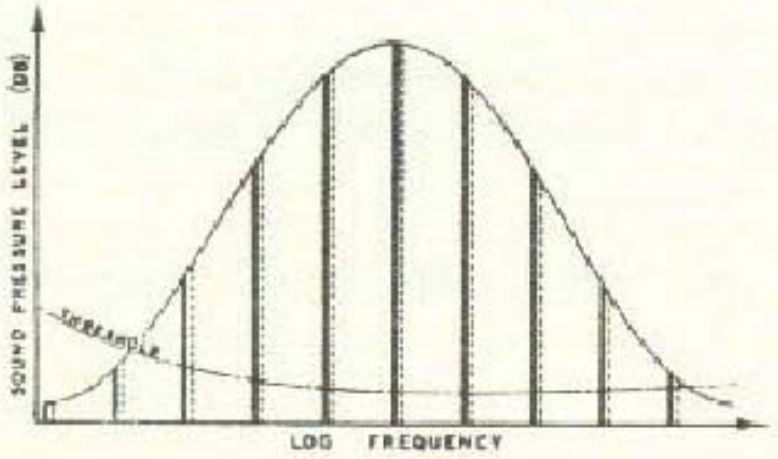


Figure 1

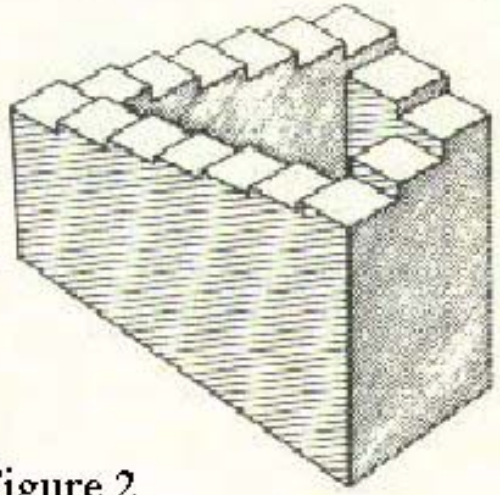
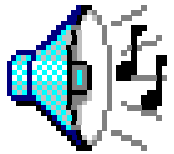


Figure 2

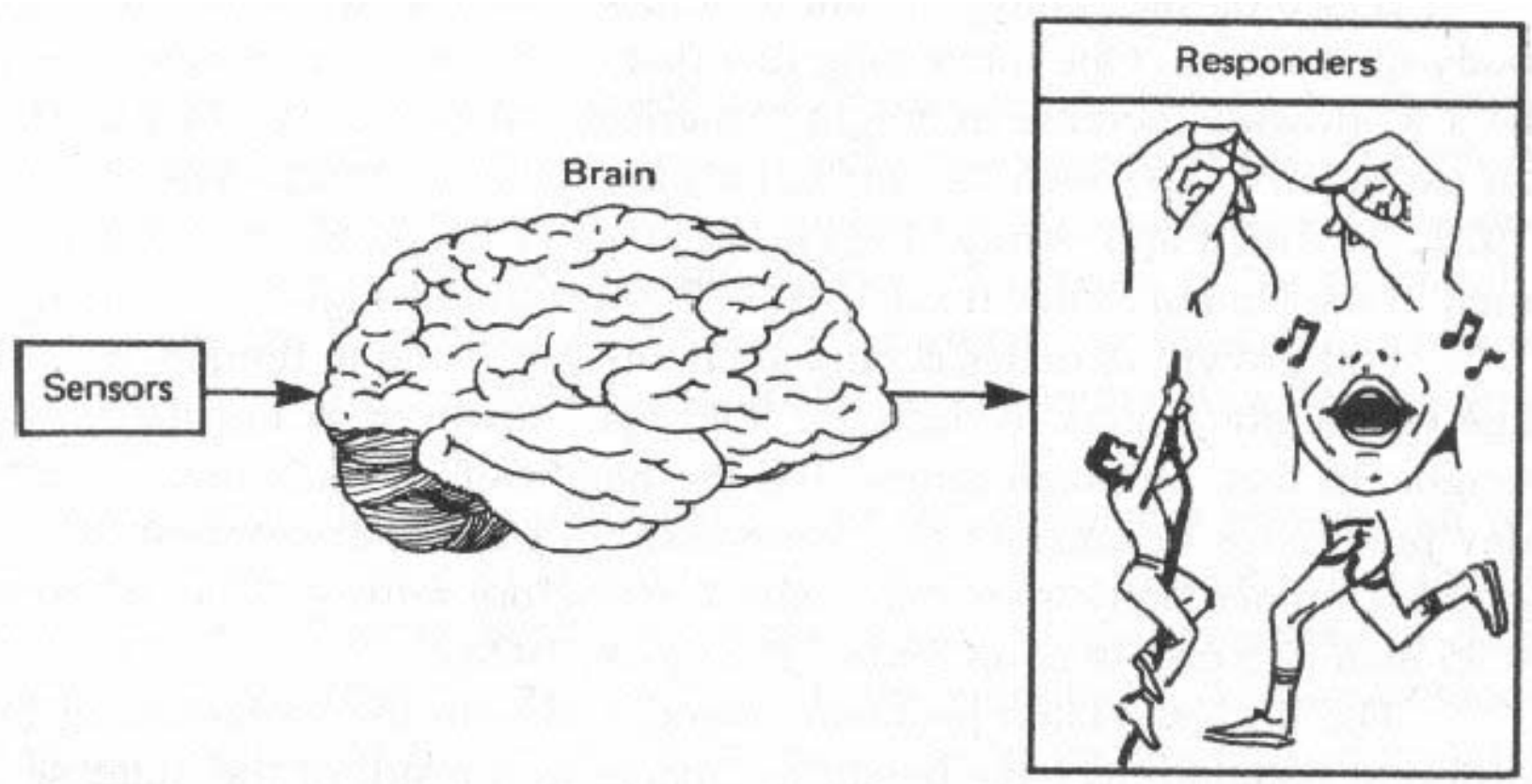
Demo



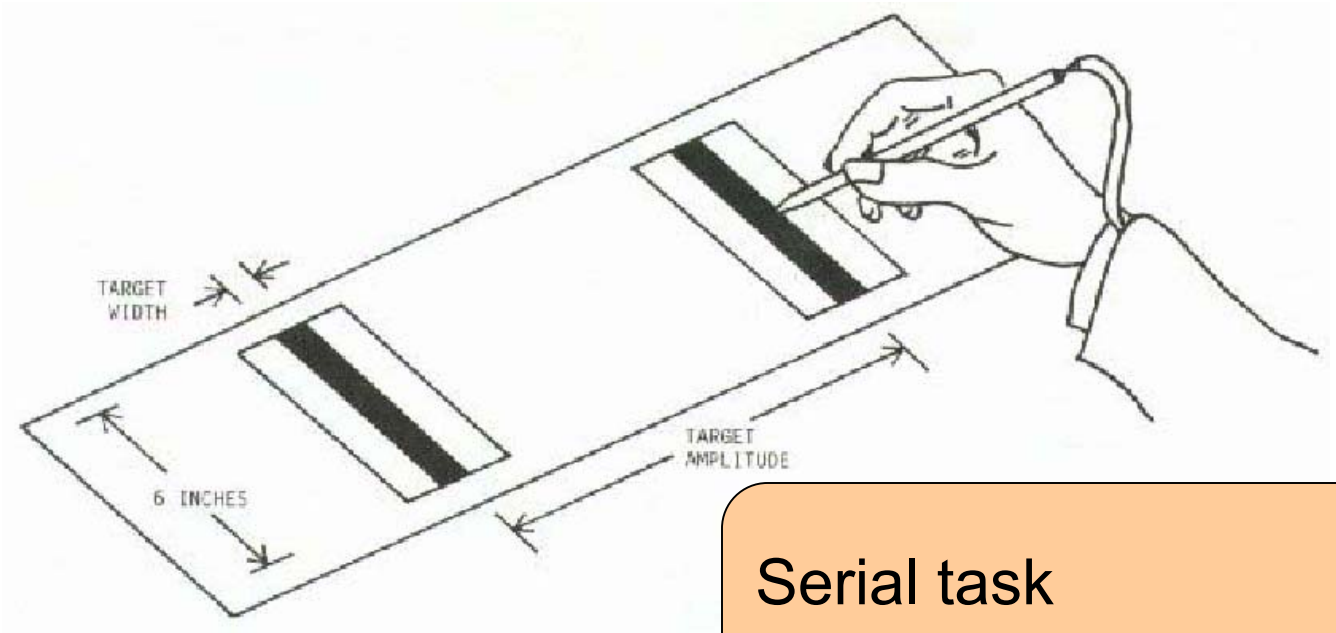
Kinesthetic

- Probably 3rd most important, next to vision and audition
- To control our actions, we need to know the position of body parts both before and after movements
- Kinethesis provides information on the position of limbs, how far they have moved, etc.

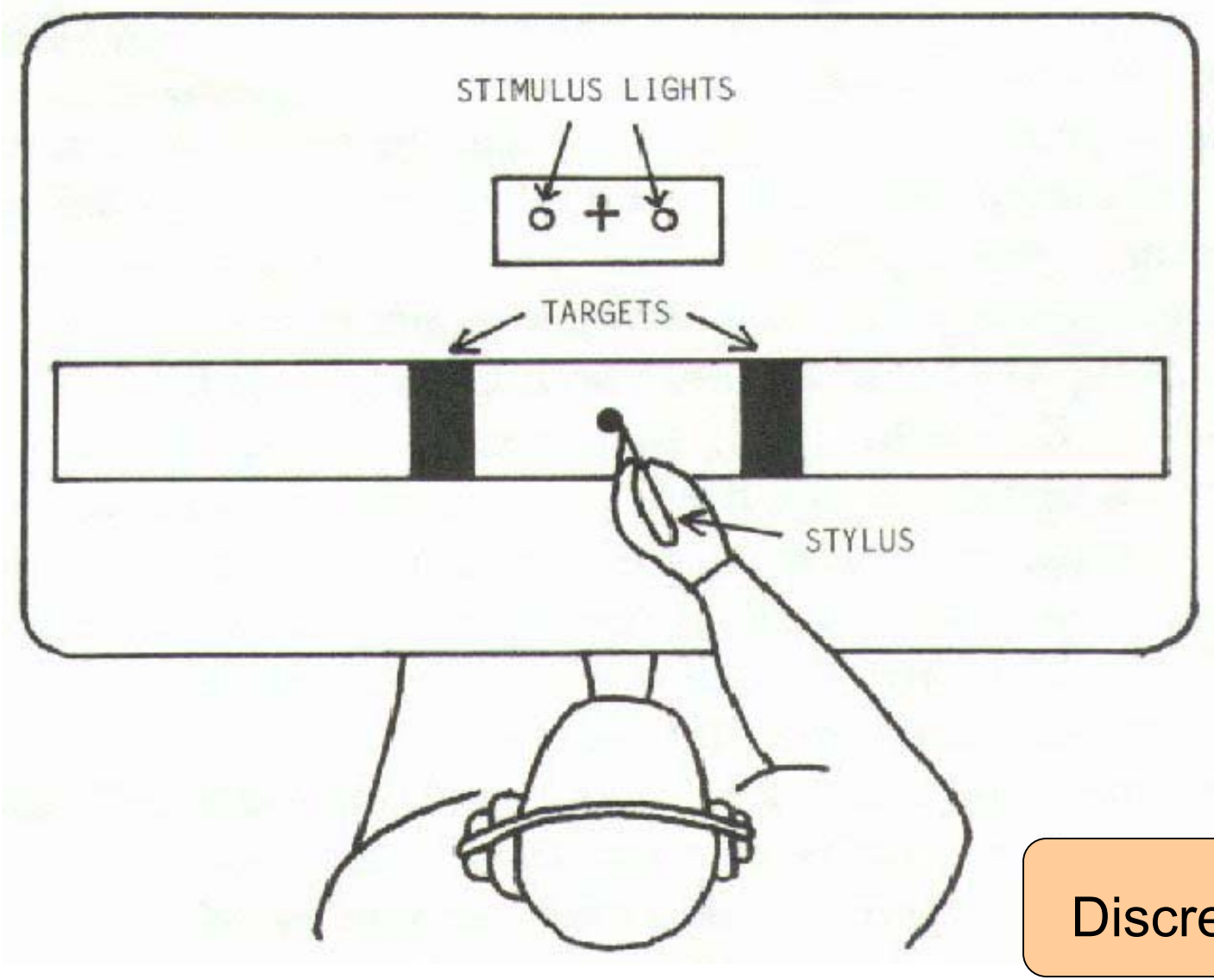
Responder Limits



Fitts' Law



Serial task
(aka reciprocal tapping task)



Discrete task

Task Difficulty

- Fitts proposed the following "Index of
- Difficulty" for target selection tasks:

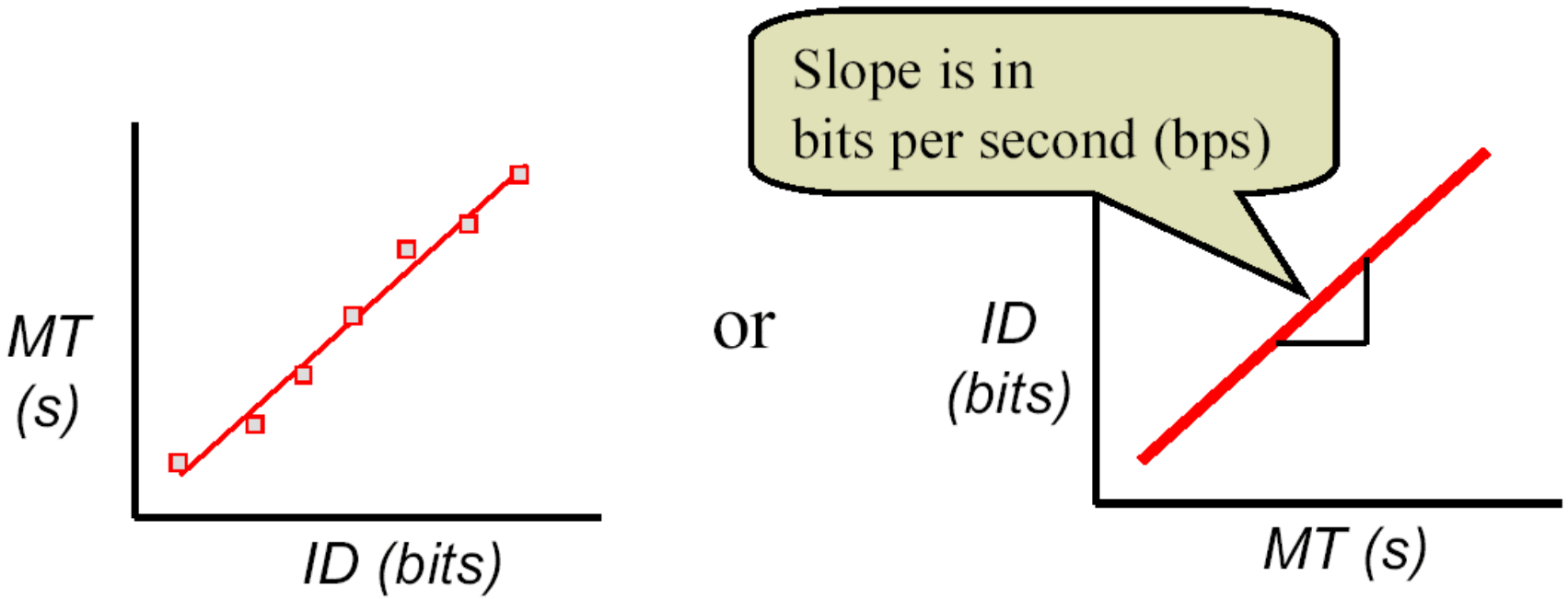
$$ID = \log_2\left(\frac{A}{W} + 1\right)$$

Unit: bits

- Where
  - *A* is the amplitude of movement
  - *W* is the width of the target

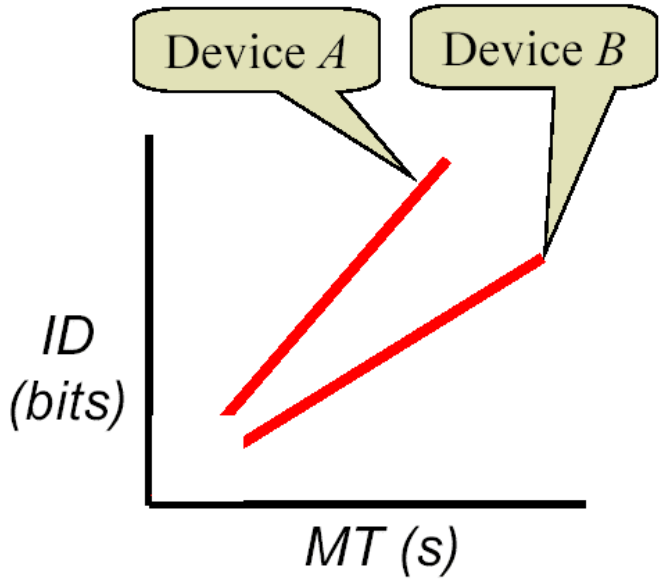
Movement Time

- proposed that the movement time (*MT*) to select a target is linearly related to *ID*:



Throughput

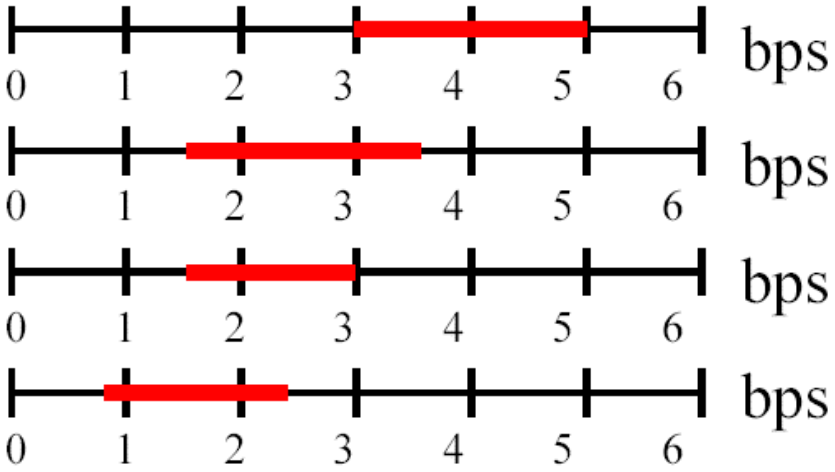
- Slope of the *ID-MT* relationship is a performance measure
- Depends on…
- Human
- Activity
- Context



E.g., mouse vs trackball vs …

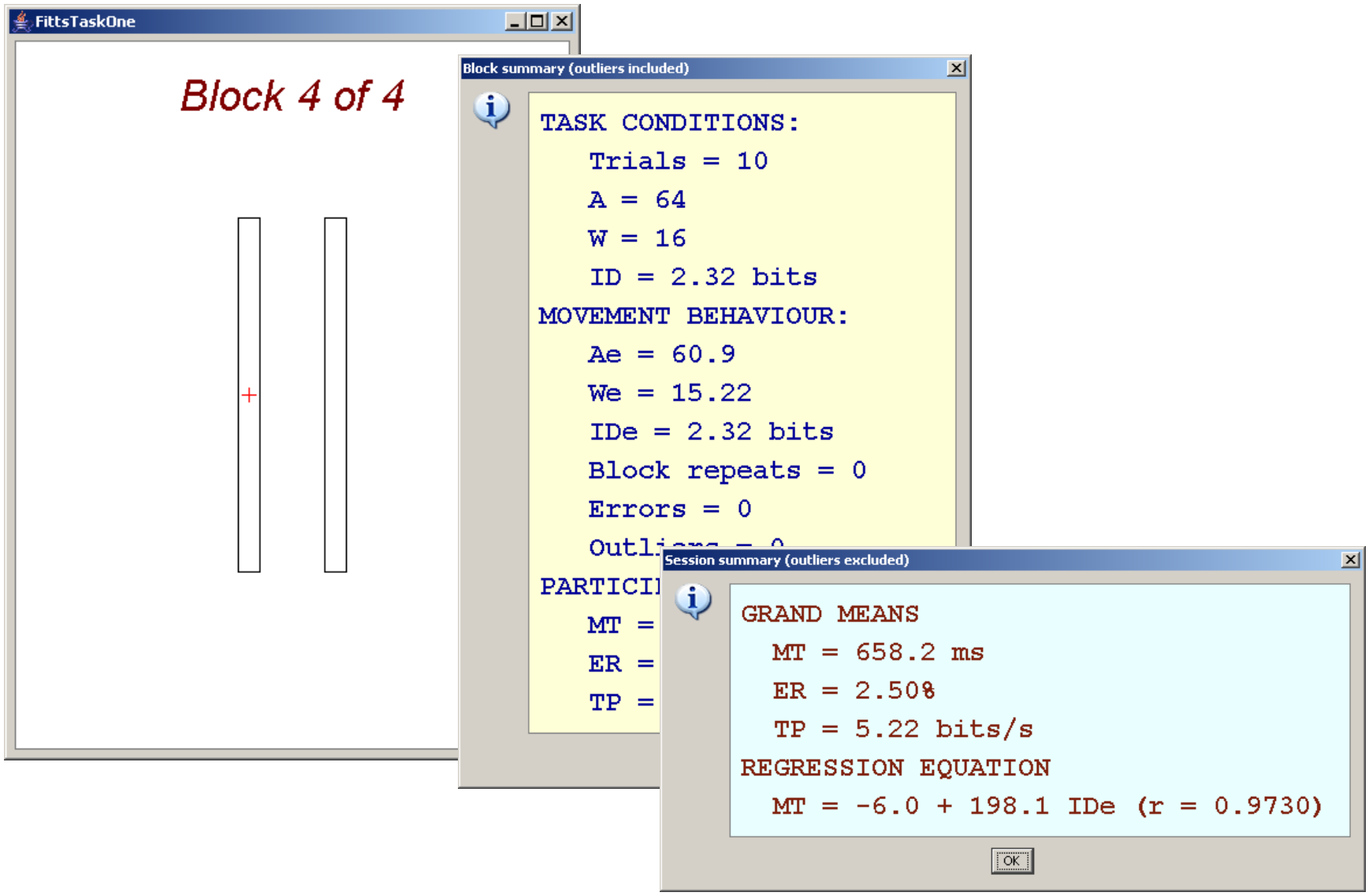
Throughput in HCI

- Mouse
- Trackball
- Joystick
- Touchpad



But…
Controlling for, or understanding, other effects is extremely difficult (e.g., learning, individual differences, apparatus, procedures)

Fitts' law Demo

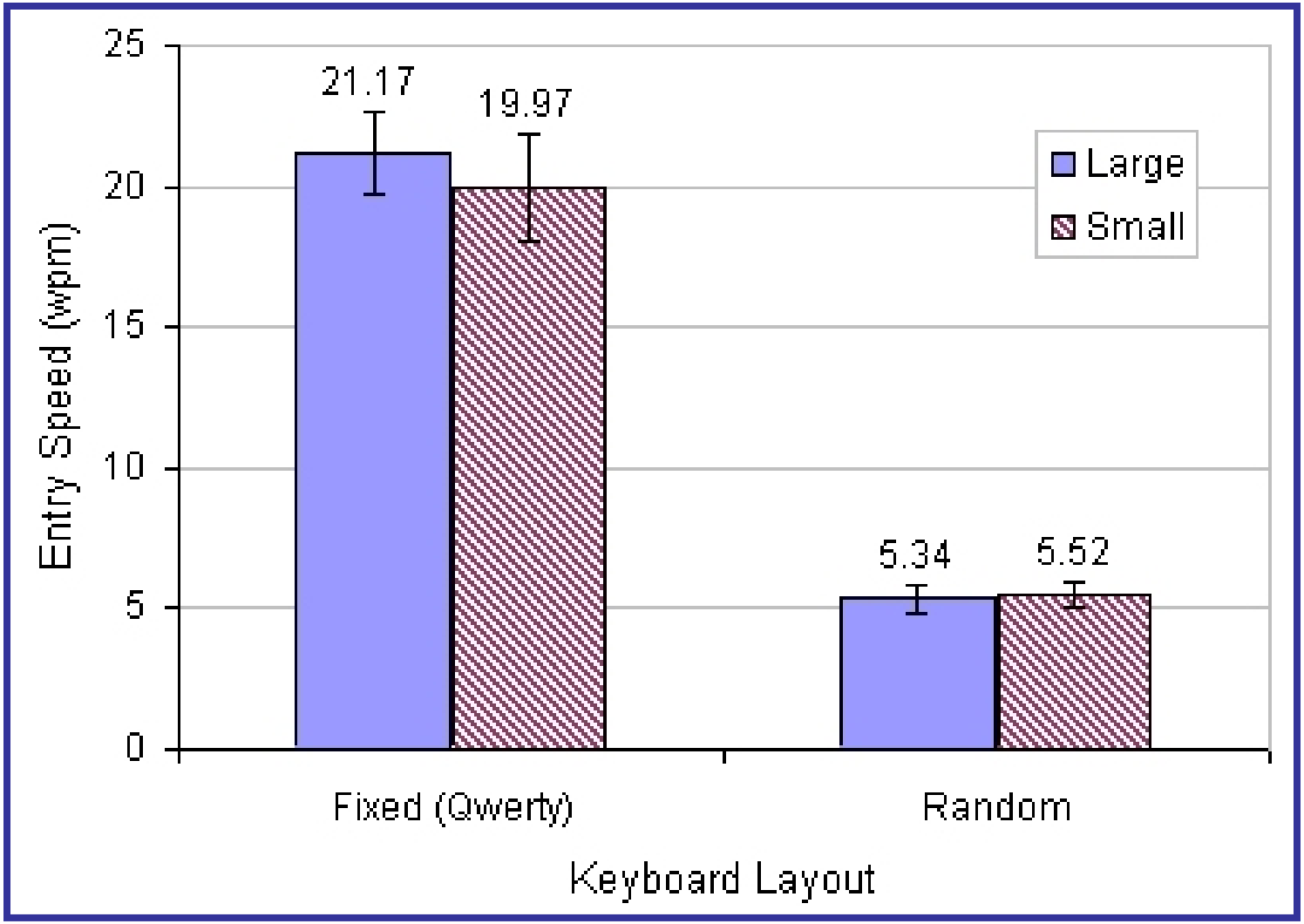


Soft Keyboard Layouts (1)

- Consider the following two layouts

- Which one is faster?

Next Slide



From…
MacKenzie, I. S., and Zhang, S. X. (2001). An empirical investigation of the novice experience with soft keyboards. *Behaviour & Information Technology, 20*, 411-418.

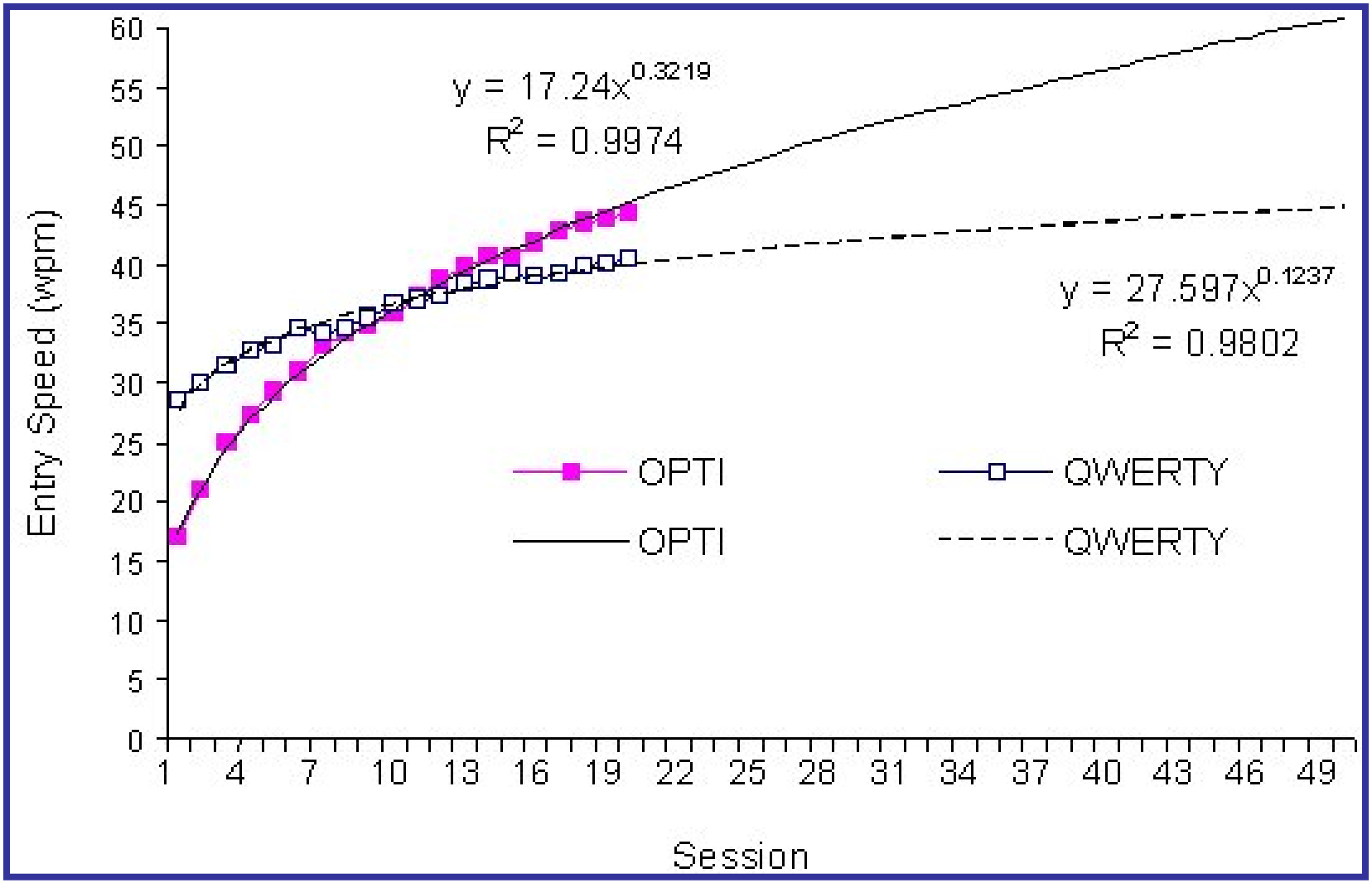
Soft Keyboard Layouts (2)

- Consider the following two layouts

"Opti"

- Which one is faster?
- How fast?

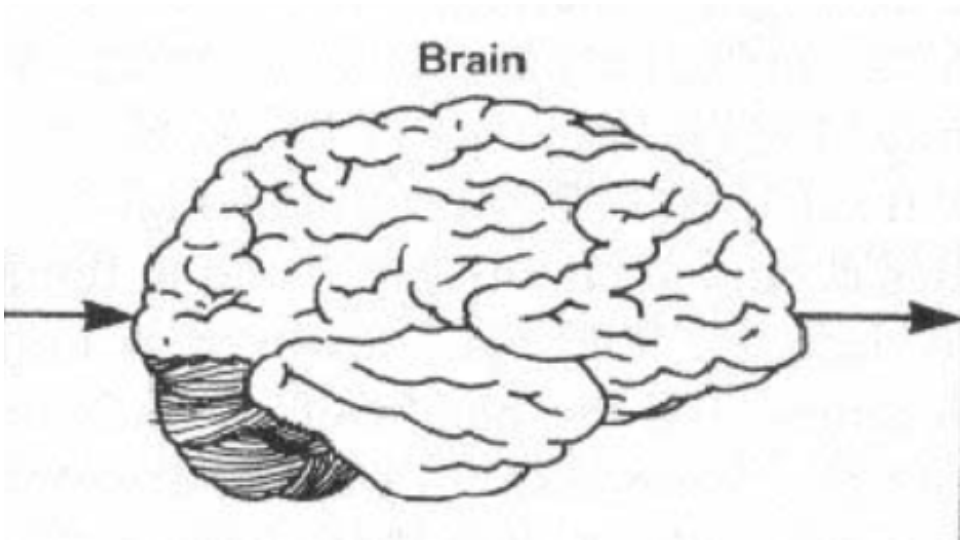
Next Slide



From…

MacKenzie, I. S., & Zhang, S. Z. (1999) The design and evaluation of a high performance soft keyboard. *Proceedings of the ACM Conference on Human Factors in Computing Systems - CHI '99*, pp. 25-31. New York: ACM.

Cognitive Limits



Memory Limit

- Remember Miller's "magic number 7 +/- 2"?
- Here's a quick experiment
  - I'll say a sequence of numbers
  - You write the sequence after I say it
  - We'll repeat this 10 times
  - Sequence will begin with 4 numbers and will increase to 13 numbers
  - Mark your neighbour's sheet (right/wrong)

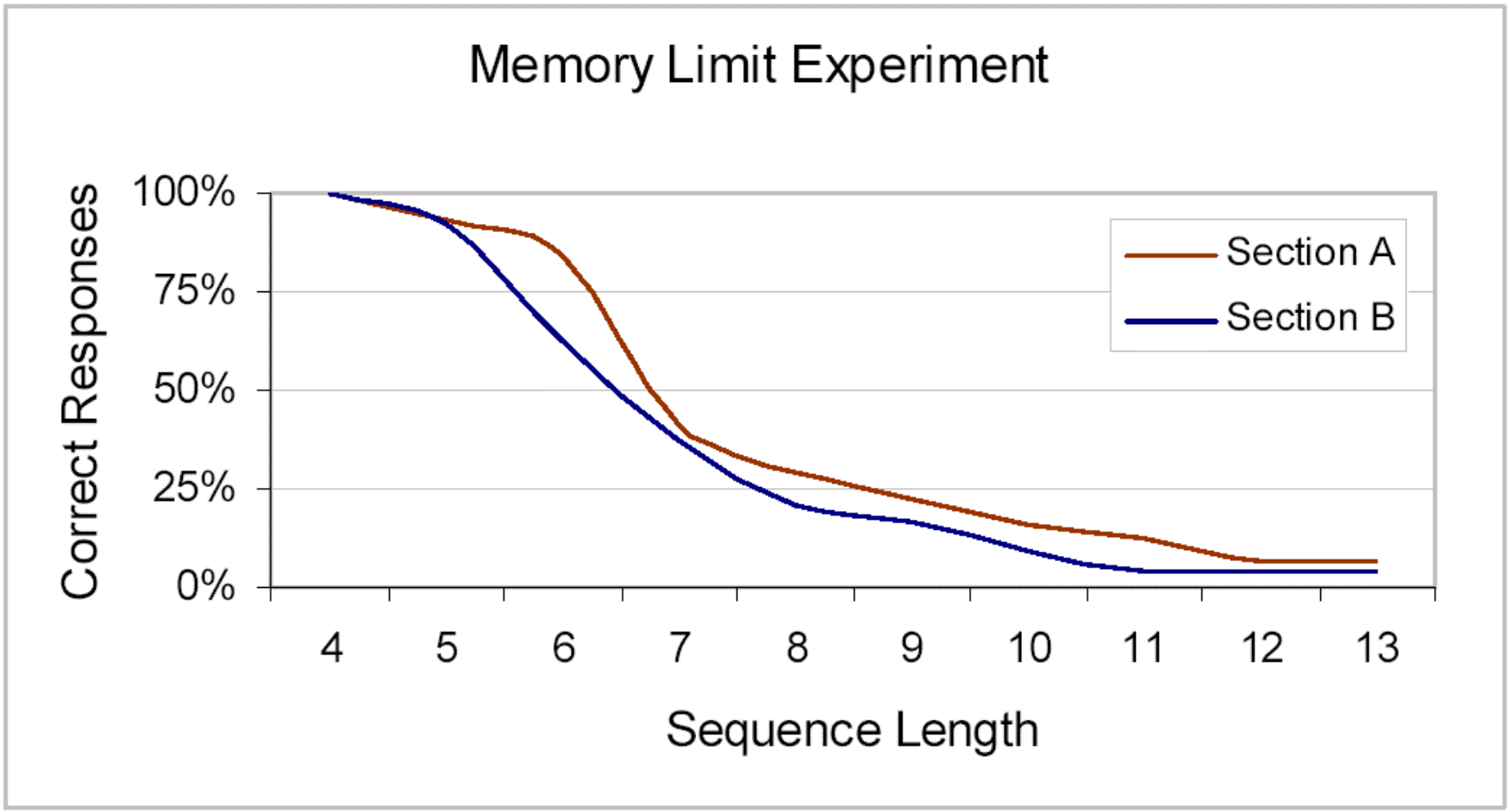
Sequences

A 7 4 9 2
B 3 0 5 8 2
C 9 3 7 1 4 6
D 3 6 5 0 7 2 4
E 2 1 9 7 8 5 4 3
F 3 7 5 6 2 5 4 5 0
G 3 5 2 7 0 8 9 3 2 5
H 0 8 7 3 9 1 2 3 5 1 6
I 3 5 2 4 9 0 6 5 8 2 0 4
J 7 5 3 9 1 8 4 5 1 3 4 3 0

Worksheet

	Enter Sequence Below										Mark 1 = correct 0 = wrong
A											
B											
C											
etc.											

Results


Memory Limit Experiment
Correct Responses
100%
75%
50%
25%
0%
4
5
6
7
8
9
10
11
12
13
Sequence Length
Section A
Section B

Other References

Bailey, R. W. (1996). *Human performance engineering: Designing high quality, professional user interfaces for computer products, applications, and systems*. (3rd ed.):
Upper Saddle River, NJ: Prentice Hall.

Shepard, R. N. (1964). Circularity in judgments of relative pitch. *Journal of the Acoustical Society of America*, *36*, 2346-2353.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.

Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology, 47*, 381-391.

Thank you