INTERACTION DESIGN. SESSION 1

Dept. Computer Science – UPC

MOTIVATION

- **Usability & Design Principles**
- **Perception Laws**
- **Interaction ??**

DIRECT MANIPULATION INTERFACES (Pointing, choice selection)

- Interaction Design and Evaluation allows to:
  - Design User Interfaces
  - Measure/Predict performance
  - Design interaction

OUTLINE

Session 1:

- Understanding the fundamentals of basic interaction in UI
  - Background (Information Theory)
  - Hick-Hyman Law: *Measuring Choice-Reaction Time*
  - Fitts' Law: *Measuring Pointing Time*
  - Crossing and Steering Laws: *Continuous Gestures*
- Fitts' Law in UI Design
  - Applications in UI Design
  - Accelerating Target Acquisition
- Exercises

Session 2:

- Typing & Keyboards
- Pointing Devices
- Mobile Interaction Design
- Exercises

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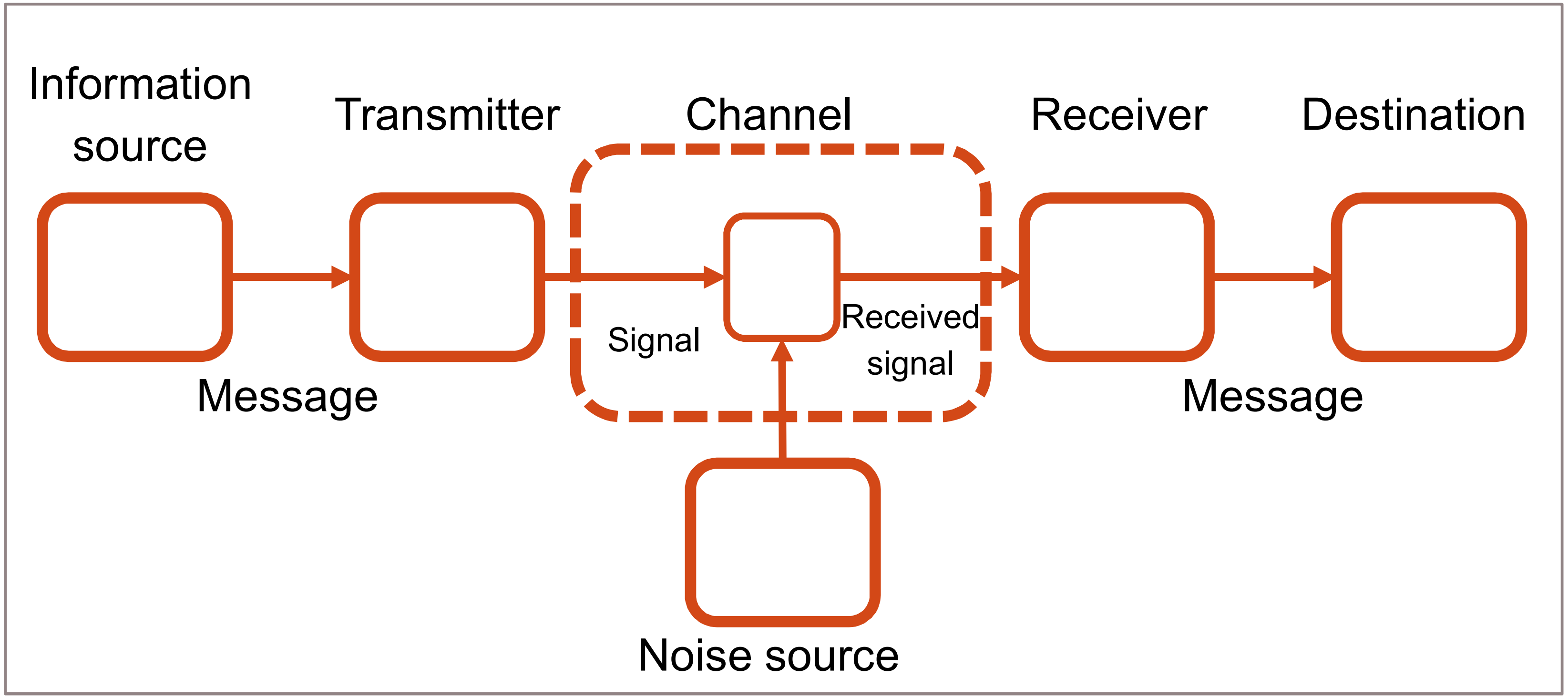
BACKGROUND. BASICS

- **Information Theory**:
  - Due to Claude E. Shannon
    - *A Mathematical Theory of Communication* (1948)
  - Based on previous works by Nyquist and Hartley
  - Analysis of transmission of electrical signals for telegraphic communication
  - Shannon Entropy measures:

    The amount of information to be transmitted by a message

BACKGROUND. BASICS

- Information Theory. Elements (telegraph):



BACKGROUND. BASICS

- Information Theory. Elements (telegraph):
  - **Information source:** The element that produces a message or sequences of message.
  - **Transmitter:** Operates on the message to make it transmissible through a medium.
  - **Channel:** The medium that transmits the message.
  - **Receiver:** The element that reconstruct the message to the destination.

BACKGROUND. INFORMATION MEASURES

- Let *d* be a device that produces symbols A, B, C and D with the same probability
  - M = 4 is the total number of symbols
  - Each time a symbol is produced we are uncertain on which symbol is going to be generated
    - This uncertainty is not so big, since there are only four possibilities
  - The probability of a symbol to appear is 1/M : 1/4

- The **uncertainty** is measured by $\mathbf{log_2(M)}$ → here $log_2(4)$=2bits
- Logarithms are commonly taken in base 2, and the units are bits.

BACKGROUND. INFORMATION MEASURES

- **Example 1**: Let *d* be a device that produces one single symbol: C
  - **M = 1** is the total number of symbols
  - We have **no uncertainty** and **$\log_2(1) = 0$**
  - The probability of getting the symbol C is 1
  - We previously know which symbol will appear!

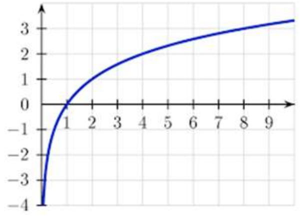
- **Example 2:** Let *d* and *e* be two devices, one with outputs A, B, C, and the second with outputs 1, 2.
  - We combine *words* by concatenating one symbol of device *d* and one with device *e.*
  - We will have 6 different words: A1, A2, B1, B2, C1, C2
  - 6 symbols → uncertainty of $\log_2(6) \rightarrow \log_2(2) + \log_2(3) = \log_2(6)$.

- The uncertainty of combined the signals of a set of devices is the sum of their uncertainties.

BACKGROUND. INFORMATION MEASURES

- For M symbols with equal probability ➔ each symbol has probability P=1/M
  - Rewriting the uncertainty

$$\log_2(M) = \log_2\left(\left(\frac{1}{M}\right)^{-1}\right) = \log_2\left(P^{-1}\right) = -\log_2(P)$$



  - ***$-\log_2(P)$*** is called the **surprise** or *surprisal* of finding a certain symbol
  - We will use p_i from now on for the probability of a symbol i
- For M symbols that have different probabilities, we may have a different p_i for each, provided that

$$\sum_{i=1}^{M} p_i = 1$$

BACKGROUND. INFORMATION MEASURES

- **Information is the reduction of uncertainty or average surprise of a set of symbols**
  - Measuring the surprise for an *infinite* set of N symbols (produced by a device) ➔ the frequency of each symbol transforms to the probability.
  - Shannon Entropy measures the amount of information:

$$H = \sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right) = -\sum_{i=1}^{N} p_i \log_2 p_i$$

    - *N* is the number of alternatives
    - p_i is the probability of the *i*th alternative.
    - H is the entropy of the message that is to be transmitted,

      ➔ the amount of information expected to be received (no noise).

BACKGROUND. INFORMATION MEASURES

- **Example 1: Source with two equiprobable symbols: A and B**
- **$p(A)=0.5$, $p(B)=0.5$**
- **$H= -0.5 \log_2 (0.5) - 0.5 \log_2(0.5) =- \log_2(0.5)=- \log_2(2^{-1})=1$**
- The source requires an average of 1 bit per symbol.

- **Example 2: Source with two symbols: A and B**
- **$p(A)=0.1$, $p(B)=0.9$**
- **$H= -0.1 \log_2 (0.1) - 0.9 \log_2(0.9) = 0{,}332 + 0{,}137=0{,}47$**
- The source requires an average of 0,47 bit per symbol.

BACKGROUND. INFORMATION MEASURES

p(A)=0.1, p(B)=0.9

H=0,47 bits → Is it possible? We can achieve it using a smart codification of the information. For instance:

Symbols	Codification	Probability	Bits	Weighted bits
AA = 00	000	0,1*0,1=0,01	3	0,03
AB = 01	001	0,1*0,9=0,09	3	0,27
BA = 10	01	0,1*0,9=0,09	2	0,18
BB = 11	1	0,9*0,9=0,81	1	0,81
		1		1,29bits in average to send 2 symbols
				0,645 bits per symbol

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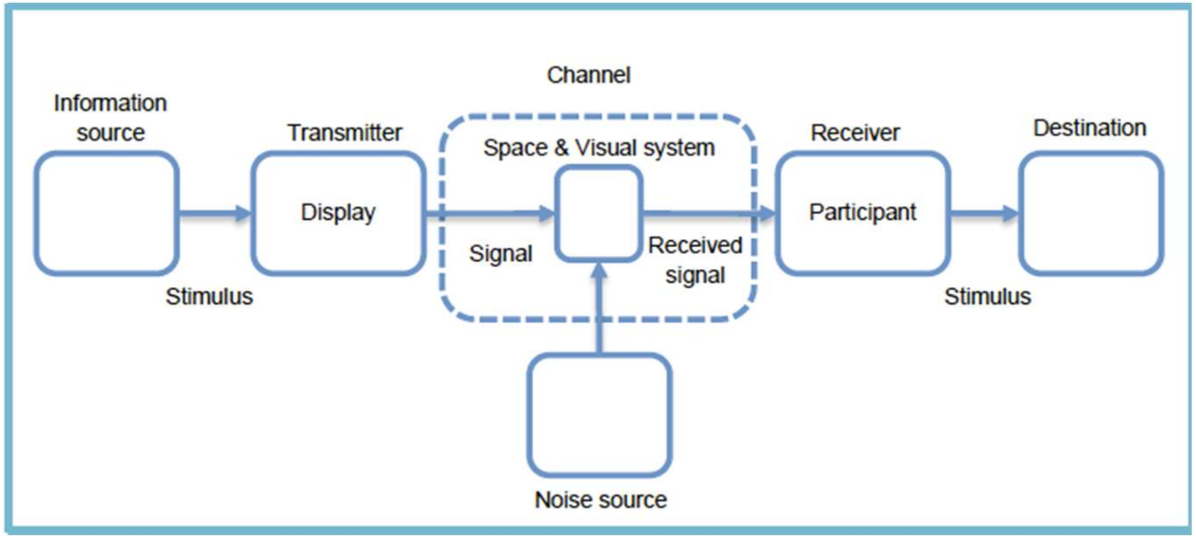
HICK-HYMAN LAW

- Hick-Hyman Law:
  - Initially stated by William E. Hick (1951)
  - Describes <u>human decision time</u> as a function of the information content conveyed by a visual stimulus
  - It takes longer to respond to a stimulus when it belongs to a large set as opposed to a smaller set of stimuli
  - Extended by Ray Hyman (1952)



HICK-HYMAN LAW

- Time to make a decision (Reaction Time):

$$RT = a + bH_T$$

  - a, b constants
  - H_T transmitted information

HICK-HYMAN LAW

- Hick-Hyman Law:
  - H_T: Transmitted information:

$$H_T = \log_2(n+1)$$

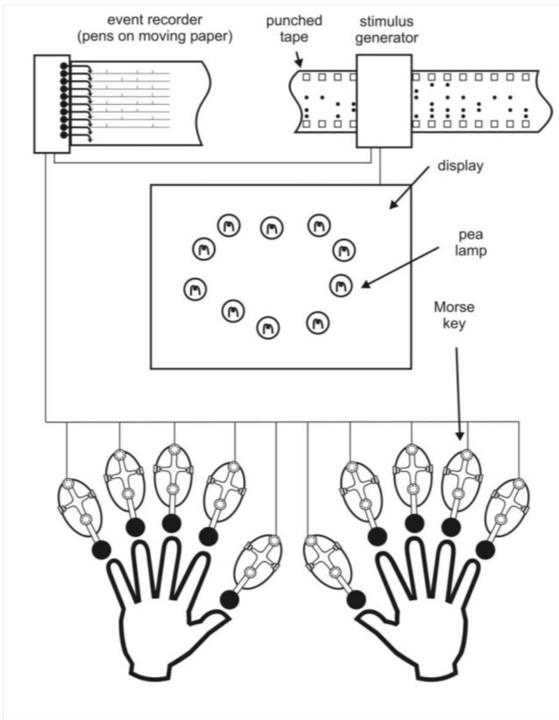
    - n are the equiprobable alternatives
    - original formulation did not have the "+1", it attends for the uncertainty whether to respond or not

  - Time to answer is the Reaction Time:

$$RT = \mathrm{a} + \mathrm{b}\log_2(n+1)$$

HICK-HYMAN LAW. EXPERIMENTAL ASSESSMENT

- Hick's initial experiment:
  - 10 pea lamps are arranged in an irregular circle
  - One random lamp is lit every 5 seconds
  - User has to press the correct key corresponding to the lamp that is lit
  - Stimulus and response encoded in a moving paper in binary code



HICK-HYMAN LAW. EXPERIMENTAL ASSESSMENT

- Time to answer. Reaction Time is a linear function of stimulus information

$$RT = \mathrm{a} + \mathrm{b}\log_2(n+1)$$

- Hyman [Hyman53] found that it

  also holds for not equiprobable alternatives

- Experiment:
  - 8 lights (whose names were *Bun, Boo, Bee, Bore, By, Bix, Bev,* and *Bate*)
    - The users had to name the one lit
    - A microphone attached to the throat detected the voice and stopped the timer
    - First with equal probabilities
    - Then, with varying probabilities

HICK-HYMAN LAW. EVIDENCES

- **Evidences of Hick-Hyman Law**

  - Performance *in hierarchical full-screen menu selections* is well described by Hick-Hyman [Landauer85]

  - Selection times decay logarithmically with menu length for frequently selected items, but linearly with infrequent ones [Sears94].

    - Learnt locations (most frequent) fit Hick-Hyman decision times
    - Non-learnt locations fit a linear search

  - Novice users search linearly while experts decide upon item location and fit a Hick-Hyman curve [Cockburn2008]

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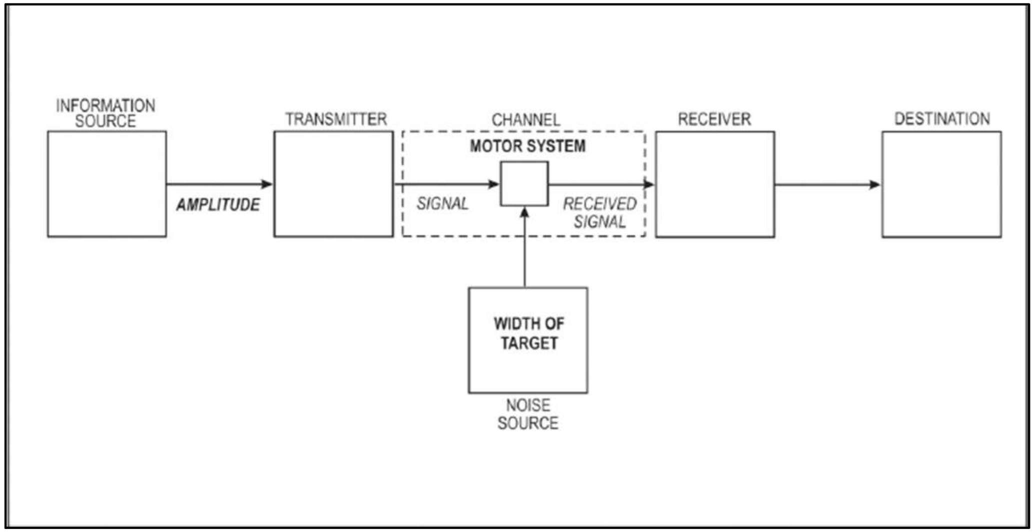
FITTS' LAW. ORIGINAL FORMULATION

- States a **linear relationship between the movement time (MT) and task difficulty**

$$MT = a + bID$$

- Formulation is also based on Information Theory
  - Amplitude of movement is the *signal*
  - Human motor system is the communication *channel*
  - Target width is the *noise*



FITTS' LAW. ORIGINAL FORMULATION

- **Task difficulty:**

$$ID = \log_2\left(\frac{2A}{W}\right)$$

  - *ID:* Index of difficulty
  - *A*: Amplitude of movement
  - *W*: Target width

➢ The larger the amplitude the higher the difficulty

➢ The larger the target the lower the difficulty

FITTS' LAW. ORIGINAL FORMULATION

- **Movement Time:** Time to point a certain objective (target)

$$MT = a + bID$$

  - a start/stop times in seconds
  - b inherent speed of the device

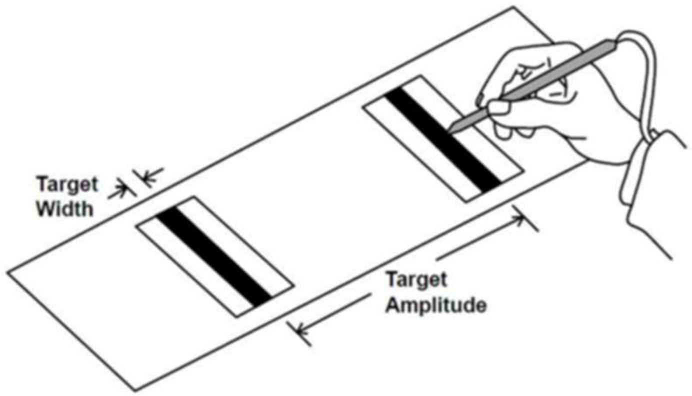
$$ID = \log_2\left(\frac{2A}{W}\right)$$

  - A: Amplitude of movement
  - W: Target width

FITTS' LAW. EXPERIMENTAL EVIDENCES

Fitts' Law. Original experiments:

- Experiment 1: Reciprocal tapping:
  - Participants used a metal-tipped stylus:
    - Two experiments with two different stylus: ~ 28.35 and 453.6 gr
  - Tap two strips of metallic targets of width from ~ 0.635 to 5.08 cm
  - At distance 5.08 to 40.64 cm
  - Participants instructed to be accurate!



FITTS' LAW. EXPERIMENTAL EVIDENCES

Fitts' Law. Original experiments:

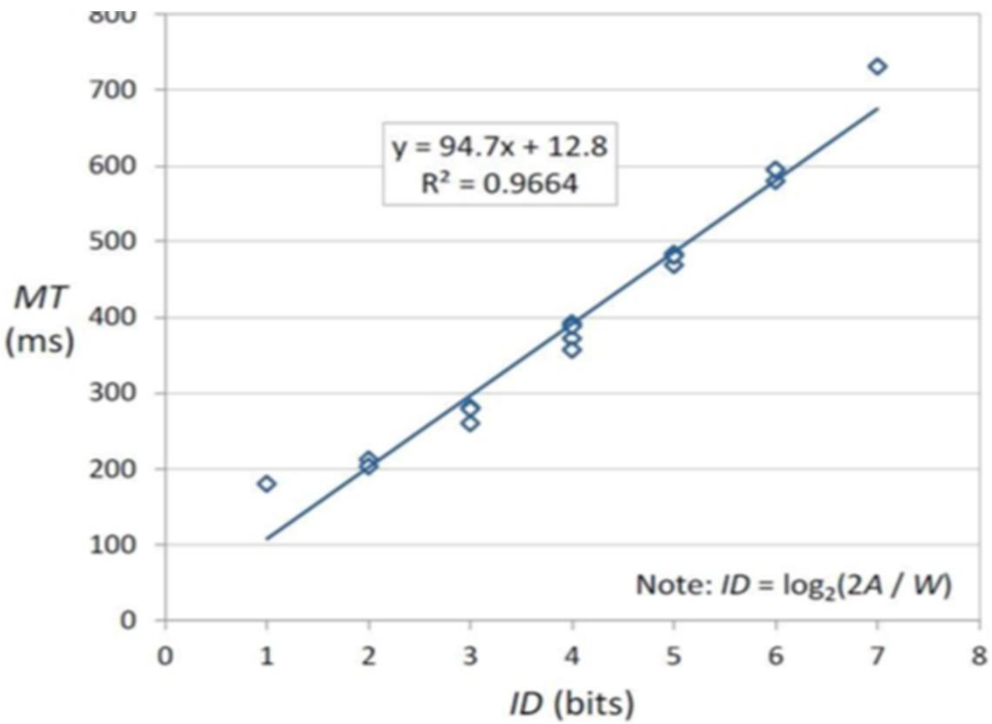
- Experiment 2: Disk transfer
  - Participants had to transfer stack round plastic disks (with holes drilled trough the middle) from one pin to another
  - Holes of different sizes and pins of different diameters used
- Experiment 3: Pin transfer
  - Participants had to transfer pins of different diameters from a set of holes to another set of holes

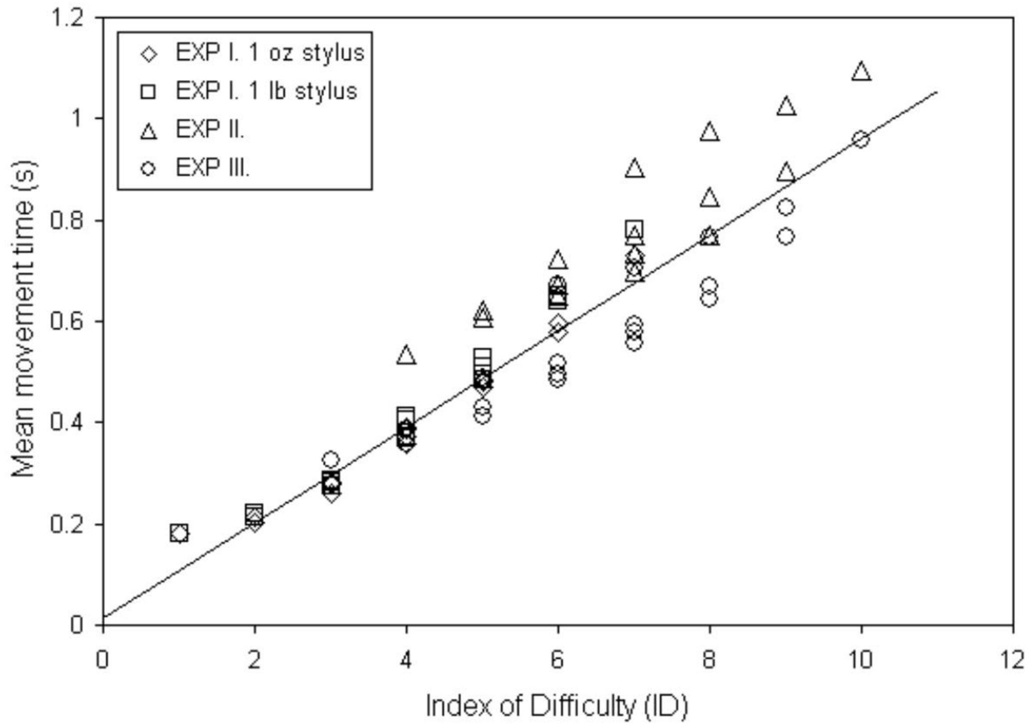
FITTS' LAW. EXPERIMENTAL EVIDENCES

$$ID = \log_2\left(\frac{2A}{W}\right)$$

- Fitts' Law. Results.

MT = 12.8 + 94.7 ID





- ➢ Results show that there is a linear relationship between MT and ID
- ➢ ***Most difficult condition: Smaller W and largest A***
- ➢ Only valid for the experiments carried out
  - ➢ One curve per experiment fits better (different a and b values)

FITTS' LAW. VARIANTS

- Original formulation fits well to the original experiments
  - But it might fit better
- Other researchers have found different formulations that better model the experimental data
  - Including the experimental data by Fitts

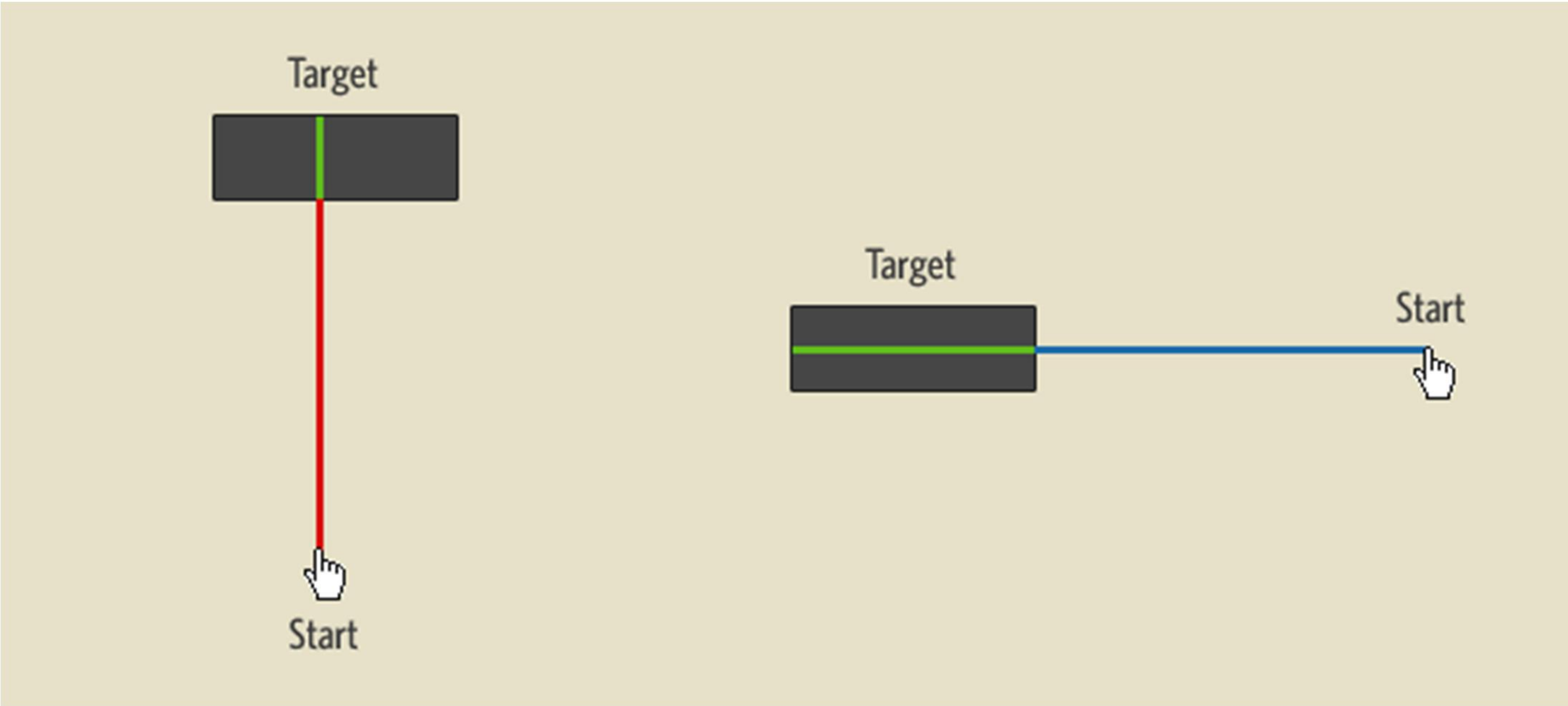
- **MacKenzie's** approach [MacKenzie92] is one of the most accepted:

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

- D is the distance of movement
- W is the width of the target

FITTS' LAW. VARIANTS

- Vertical and horizontal movements can be treated equally

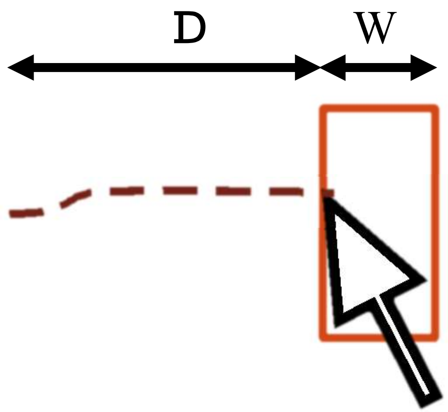


FITTS' LAW. EXTENSIONS

- Main application of Fitts in HCI is evaluation/design of UI and interaction
- Today's interfaces are much more complex
  - Variety of sizes
  - 2D movements
  - Use of fingers

FITTS' LAW. EXTENSIONS

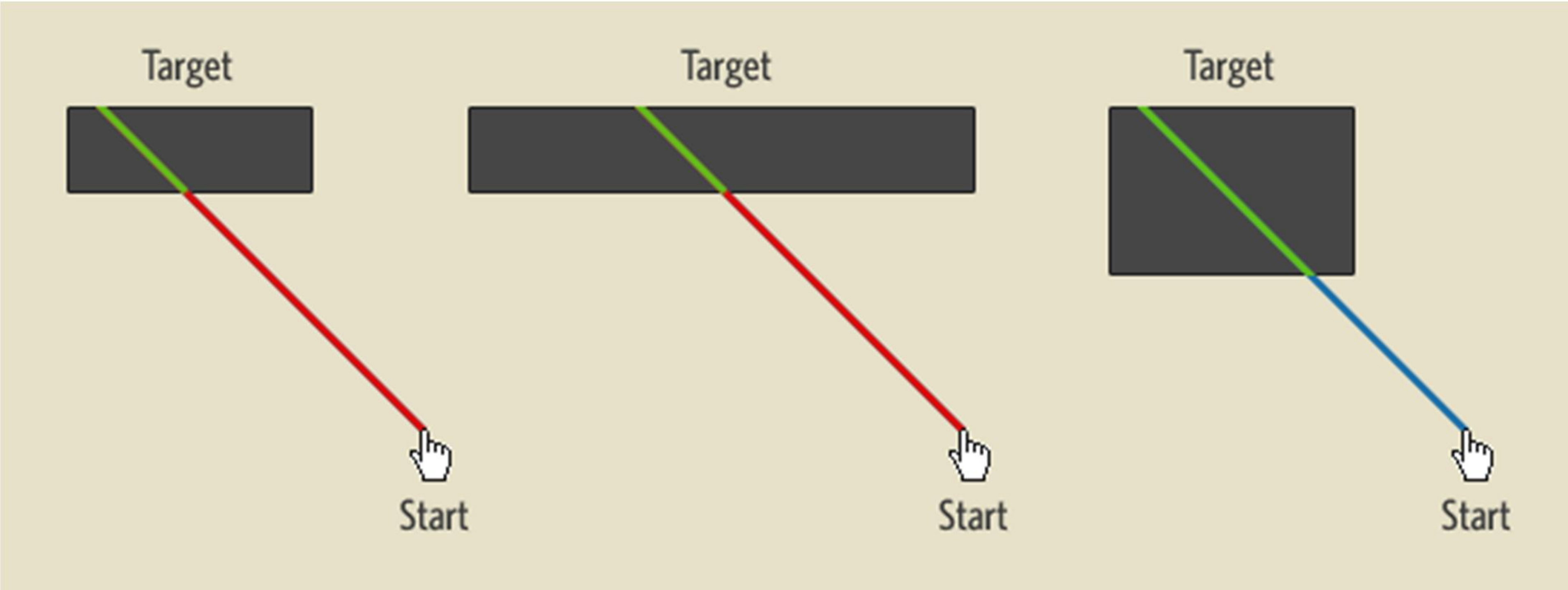
- Use in UI design or evaluation:



  - D is the distance the pointer (mouse) covers to reach the target (button)
  - W is the width of the target (button)

FITTS' LAW. EXTENSIONS 2D

- Fitts' Law is designed for 1D movements
  BUT…most movements in a UI are 2D
- Vertical and horizontal movements can be treated equally… or not?



FITTS' LAW. EXTENSIONS 2D

- Several extensions deal with 2D movements
  - Mimicking Fitts' Law, but changing some of the parameters
  - [Crossman83]:

$$MT = a + b\log_2\left(\frac{2D}{W}\right) + c\log_2\left(\frac{2D}{H}\right)$$

  - [Accot97]:

$$MT = a + b\log_2\left(\sqrt{\left(\frac{D}{W}\right)^2 + \eta\left(\frac{D}{H}\right)^2} + 1\right)$$

FITTS' LAW. EXTENSIONS: PRECISION POINTING

- Fitts Law does not model properly very small targets:
  - Extra time devoted to fine adjustment
  - Increase of errors
  - …
- Very small targets yield a lower fit of the regression curve of the MT function
- Touchscreens also modifies the timing we require to point targets, the finger movement is in 3D space.

FITTS' LAW. EXTENSIONS: PRECISION POINTING

Extension of Fitts' Law by analyzing the behavior both in tactile screens and small targets ([Sears91]):

- Named FFitts (**Finger Fitts**), also PPMT (Precision Pointing Movement Time) by some other authors :

$$FFits = a + bID + dID_2$$

$$FFitts = a + b\left[\log_2\left(\frac{cD}{W}\right)\right] + d\left[\log_2\left(\frac{e}{W}\right)\right]$$

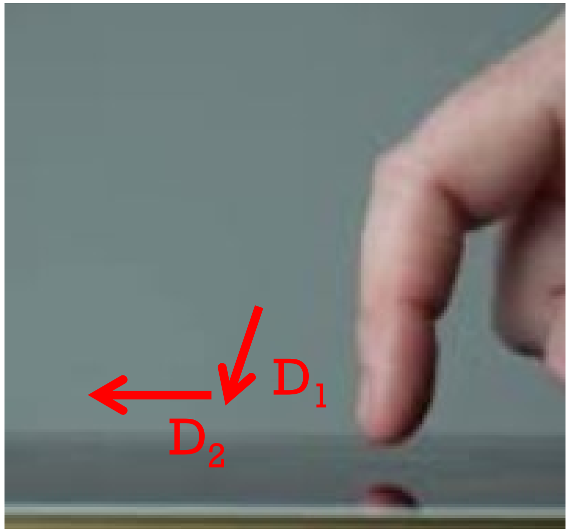
- The higher number of freedom degrees, the easier to fit in a regression curve

FITTS' LAW. EXTENSIONS: PRECISION POINTING

- **FFitts:**

$$FFitts = a + b\left[\log_2\left(\frac{cD}{W}\right)\right] + d\left[\log_2\left(\frac{e}{W}\right)\right]$$

  - the first logarithmic factor measures *the time to place the finger on the screen initially*
  - the second factor measures *the time to position the cursor*
  - *D* is the distance, measured in three dimensions, from the original hand location to the location of first contact
  - If the task consists of iteratively clicking targets: *D* is the distance from one target to the next one
  - W is some measurement of target size
  - *a*, *b*, *c*, *d*, and *e* must be determined for each specific case



FITTS' LAW. ASSESSED RESULTS

- Validation of Fitts' Law may not extrapolate to outside the experiments carried out
  - ➢ ***Validity Fitts → Experimentation***
- Fitts' Law have been formulated in a number of ways, however its prediction is consistent:
  - ''the ID to acquire a target is functions of the distance to and the size of the target''

FITTS' LAW. ASSESSED RESULTS

- Fitts' Law has shown its validity in multiple setups and devices:
  - Mouse, joystick, finger, stylus…
  - Different screen types of varying sizes…
  - **But the results cannot be extrapolate to data outside the experiment.** ***Validity Fitts → Experimentation***
- Fitts' law is a really good predictive model of human movement.
- Precued targets lead to more efficient and precise pointing movements than for non-precued targets [Hertzum2013].
  - Most common case: we know the buttons' positions in advance.
  - The benefit of precuing is larger for the mouse than the touchpad
    - Maybe movement preparation is more effective if the device is more demanding

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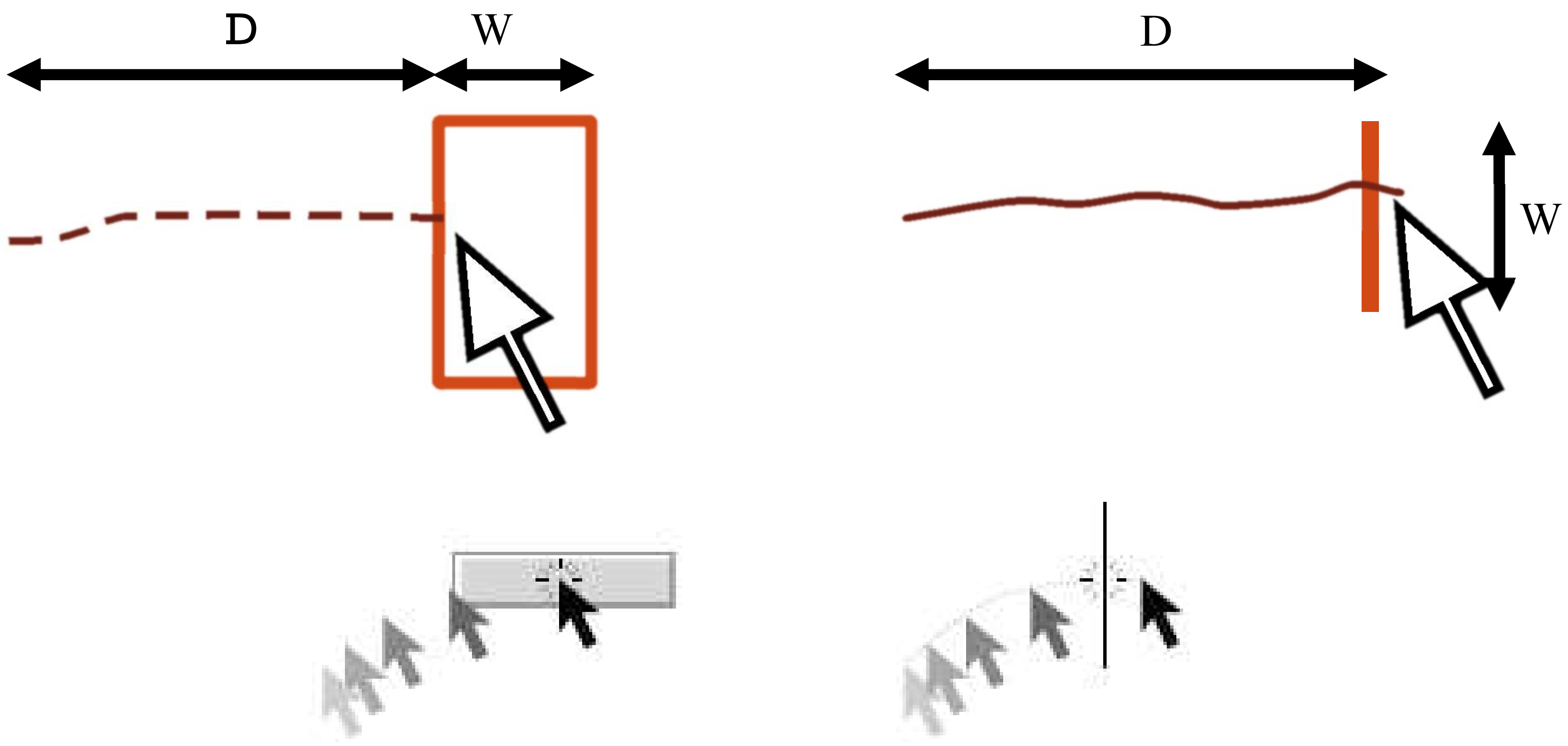
LAW OF CROSSING

- Crossing movement as compared to pointing

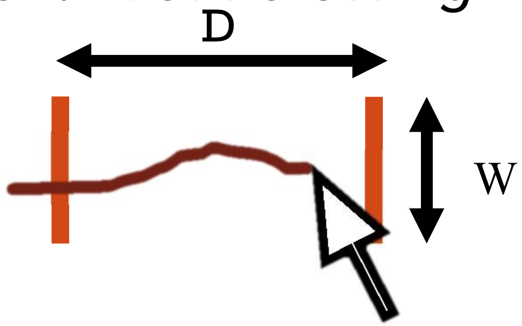


(a) Pointing a target (b) Crossing a goal

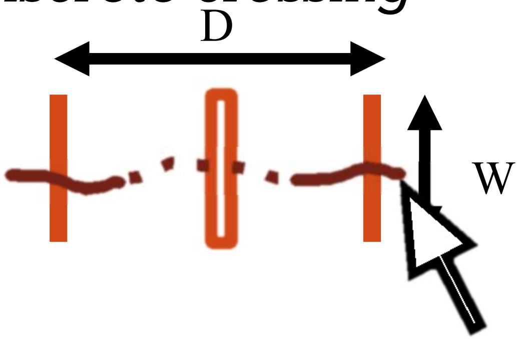
LAW OF CROSSING

- **Crossing configurations:**
  - Discreteness vs continuity of the movement:
    - ➢ Landing and lifting off the stylus

Continuous crossing

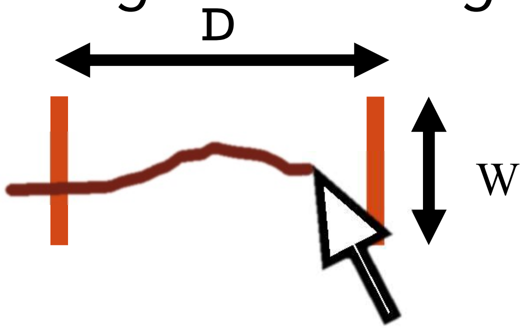


Discrete crossing

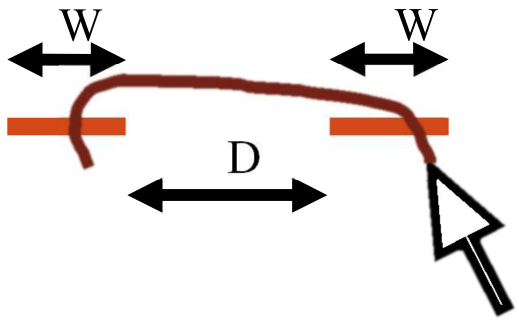


  - Direction of the targets vs direction of the movement:
    - ➢ If parallel, the trace will be larger

Orthogonal crossing

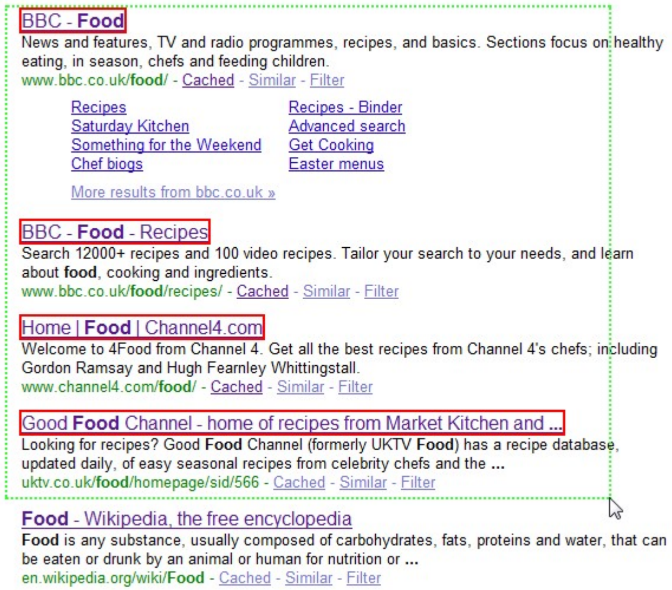


Collinear crossing



LAW OF CROSSING

- Stylus or fingers naturally lead to crossing gestures
  - Especially useful in tactile devices
  - Crossing an object is easier than double-clicking.
    - Drag & drop, multiple selections
  - Crossing can be a good alternative for users who have difficulties with clicking or double-clicking.
- Several objects can be crossed at the same time within the same gesture



Multi-links extension for Chrome (LinkClump)

LAW OF CROSSING

- Crossing performance across two goals [Accot99, Zhai2002]:
  - Follows the same characterization than the Fitts' Law:

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

    - T is the average moving time between passing the two goals.
    - *D* is the distance between the two goals
    - *W* is the width of each goal
    - *a* and *b* are constants to be determined

LAW OF CROSSING

- Results of the experiments:
  - Crossing-based interfaces achieve similar (or faster) times than pointing.
  - The error rate in crossing is smaller than in pointing.
  - Discrete crossing becomes more difficult if the distance between the targets is small.

LAW OF CROSSING

https://www.youtube.com/watch?v=C5L4vV3T2mU

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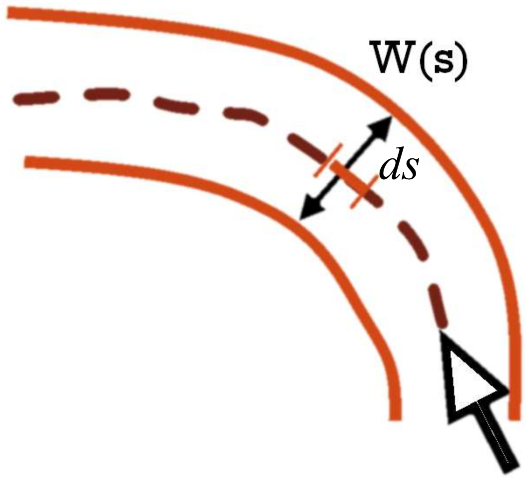
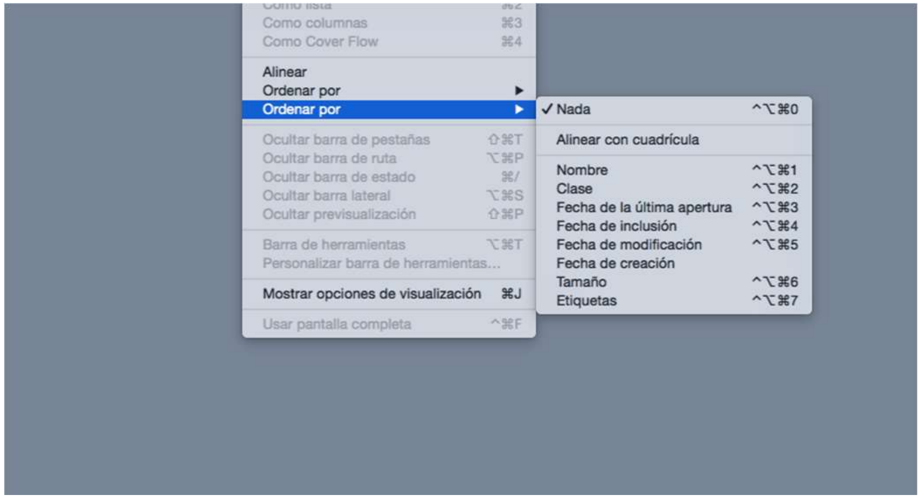
STEERING LAW

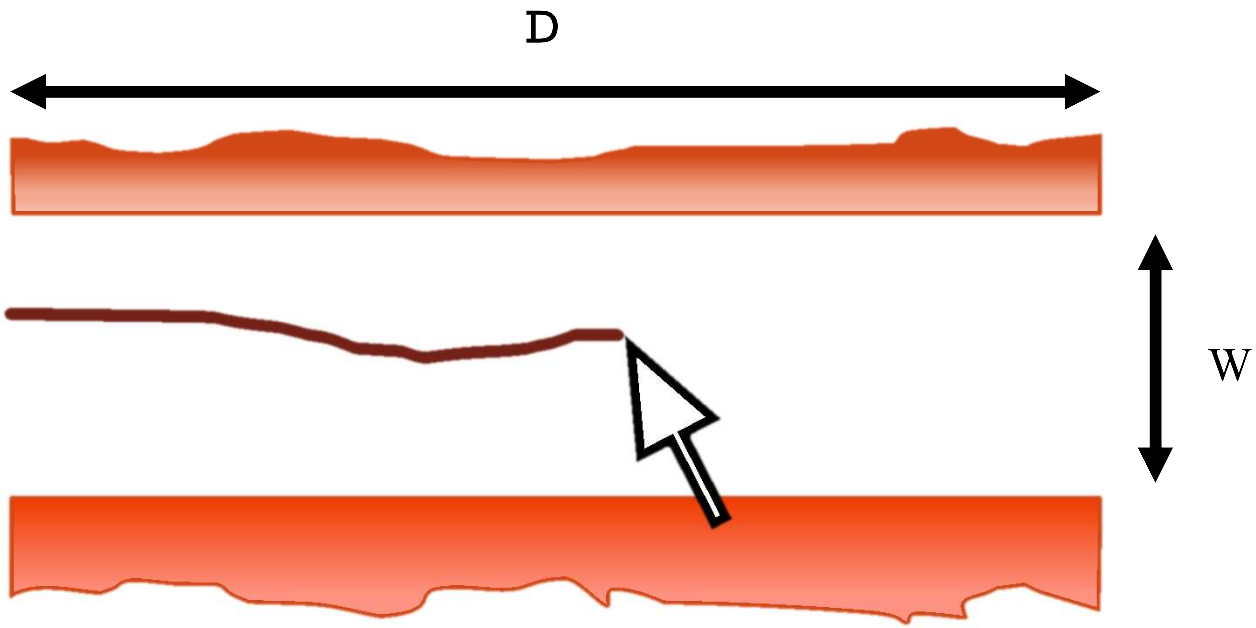
- Navigating through a constrained path is an useful operation in modern UIs
  - Navigating through nested menus
  - 3D navigation
  - Dragging elements
  - Free-hand Sketching/Drawing





STEERING LAW

- Steering through a **straight path**:

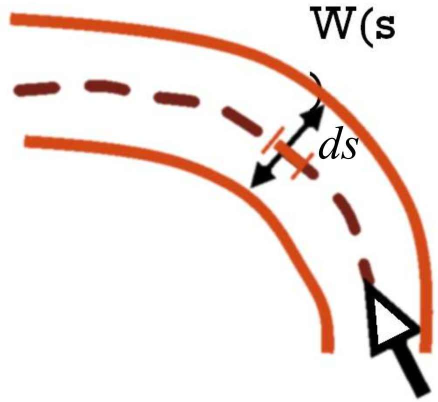


STEERING LAW

- Navigating through a **generalized path** can be expressed as infinite crossings [Accot97]
- Movement time across the path T_s:

$$T_s = a + bID_s \qquad T_s = a + b\int_C \frac{ds}{W(s)}$$

  - C is the length of the path
  - $W(s)$ is the path width at point s



STEERING LAW

- Time to navigate through a **straight path** (tunnel) T_p [Accot97]:

$$T_s = a + b\int_C \frac{ds}{W(s)} \qquad\qquad T_P = a + b\frac{D}{W}$$

  - D is the length of the path/tunnel
  - W is the width of the path/tunnel

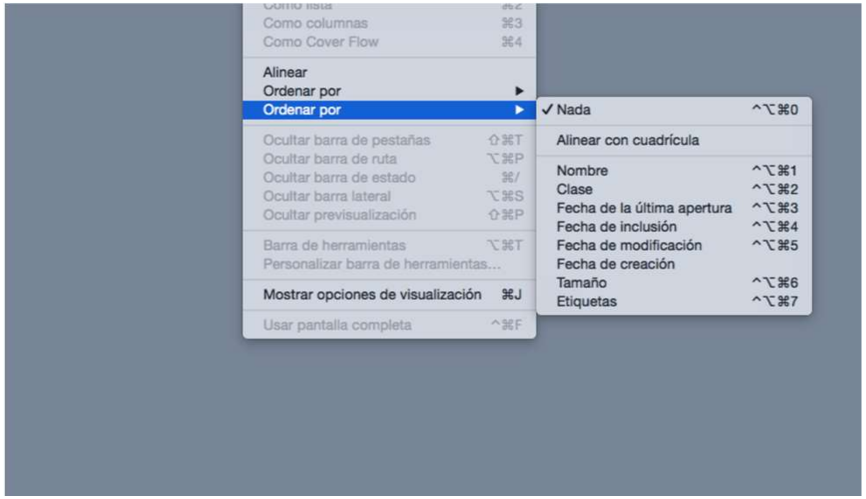
- Applying Fitts' formatting:

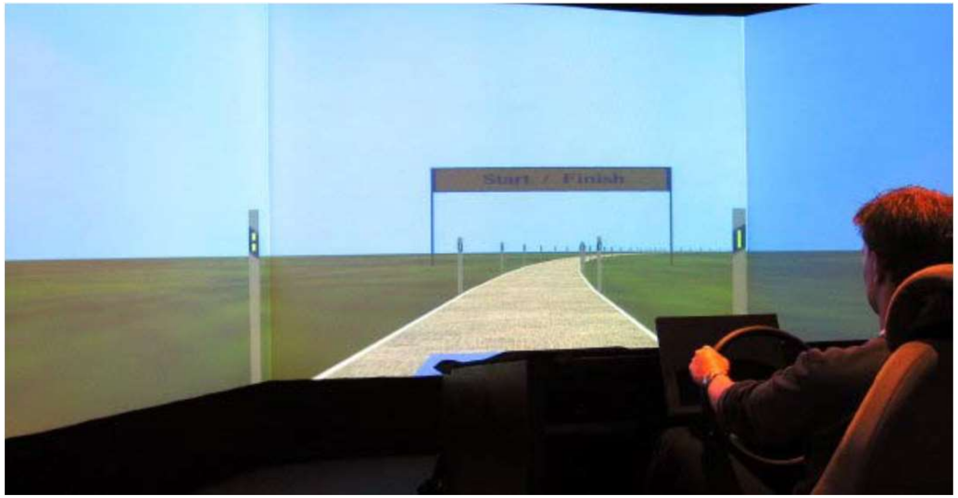
$$T_P = a + bID_P \qquad ID_P = \frac{D}{W}$$

  - Which also applies to circular paths of constant width

STEERING LAW

- Results [Accot97, Zhai2004] show that the steering law is applicable to different configurations:
  - Different path shapes: cone, spiral, straight
  - Works with different devices, works in VR…
  - Can be used to analyse navigation through nested menus, compare menu designs…





OUTLINE

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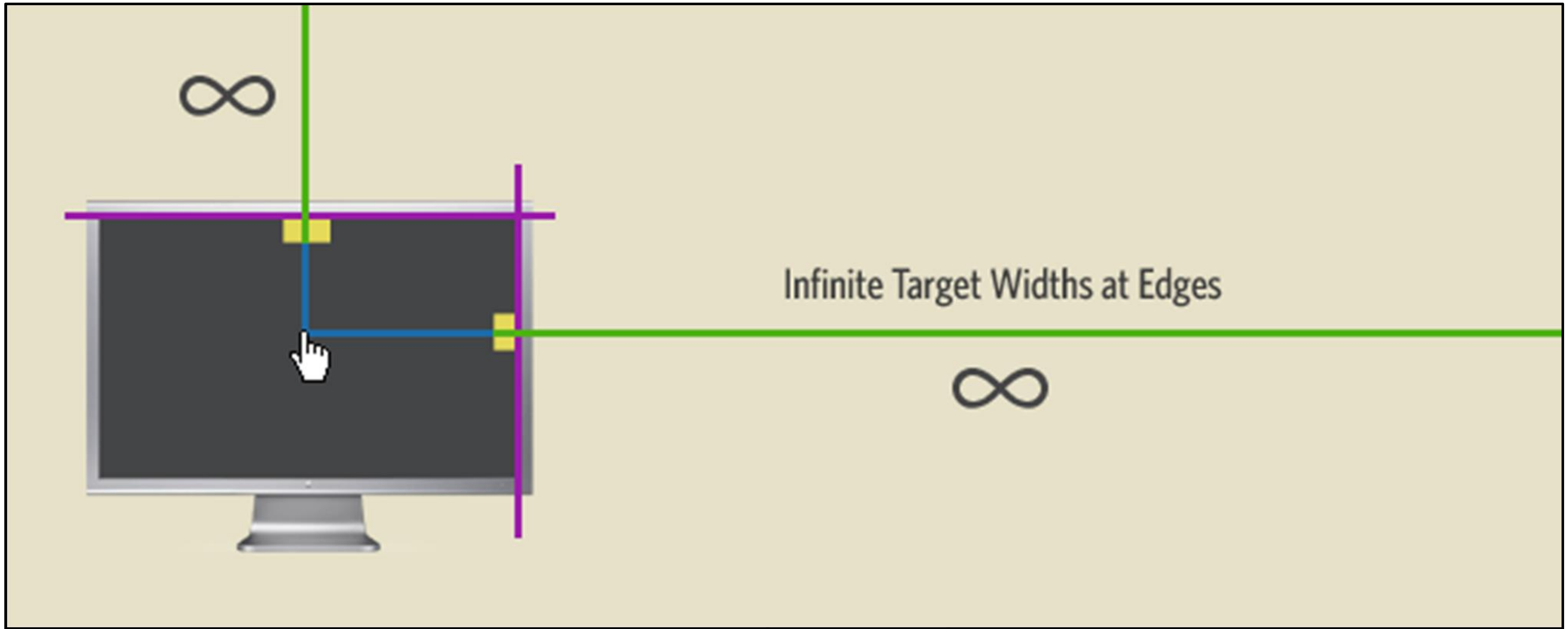
FITTS' LAW IN UI DESIGN. IMPLICATIONS

- Fitts' Law accurately predicts **pointing** movement
  - ➢ Further distance ➔ Harder to select
  - ➢ Larger target ➔ Easier to select
- If improvement required, it can help us modify our UI
  - Change target width:
    - Increase size for faster reach
  - Change de "virtual distance" or pointer movement:
    - Increase speed, pop-up menus,….
- But <u>visual stimuli must also be taking into account…</u>

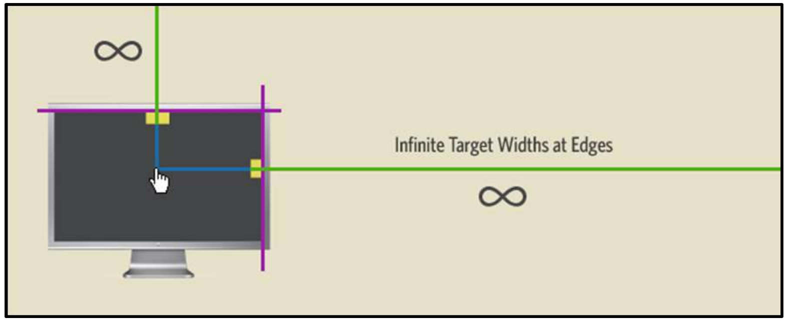
FITTS' LAW IN UI DESIGN. APPLICATIONS

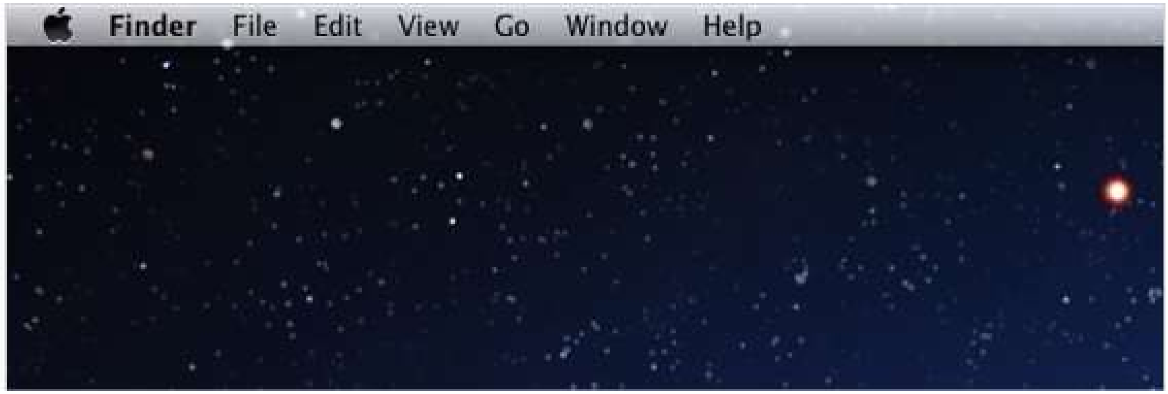
The outer edges and corners



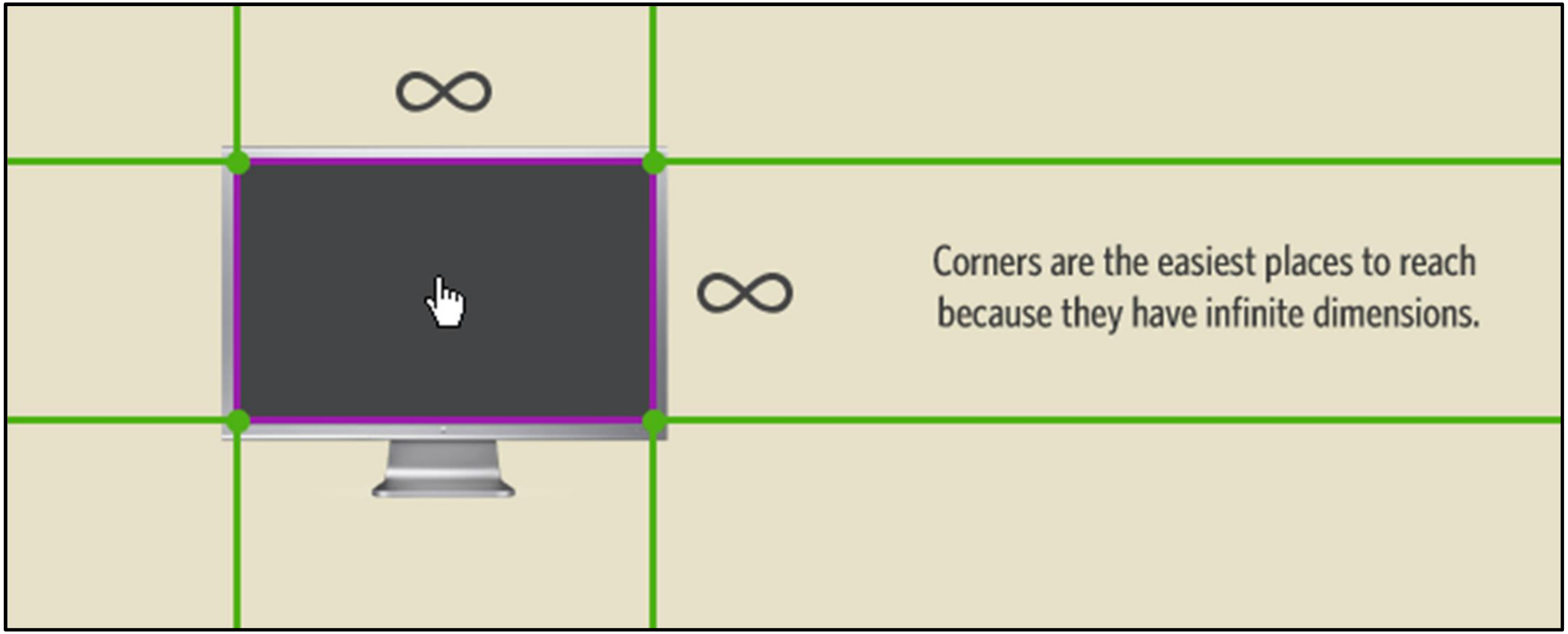
$$MT = a + b\log_2\left(\frac{D}{W} + 1\right)$$

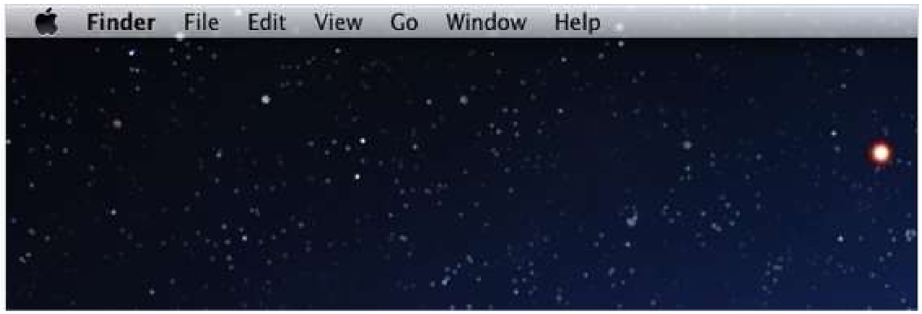
FITTS' LAW IN UI DESIGN. APPLICATIONS





FITTS' LAW IN UI DESIGN. APPLICATIONS





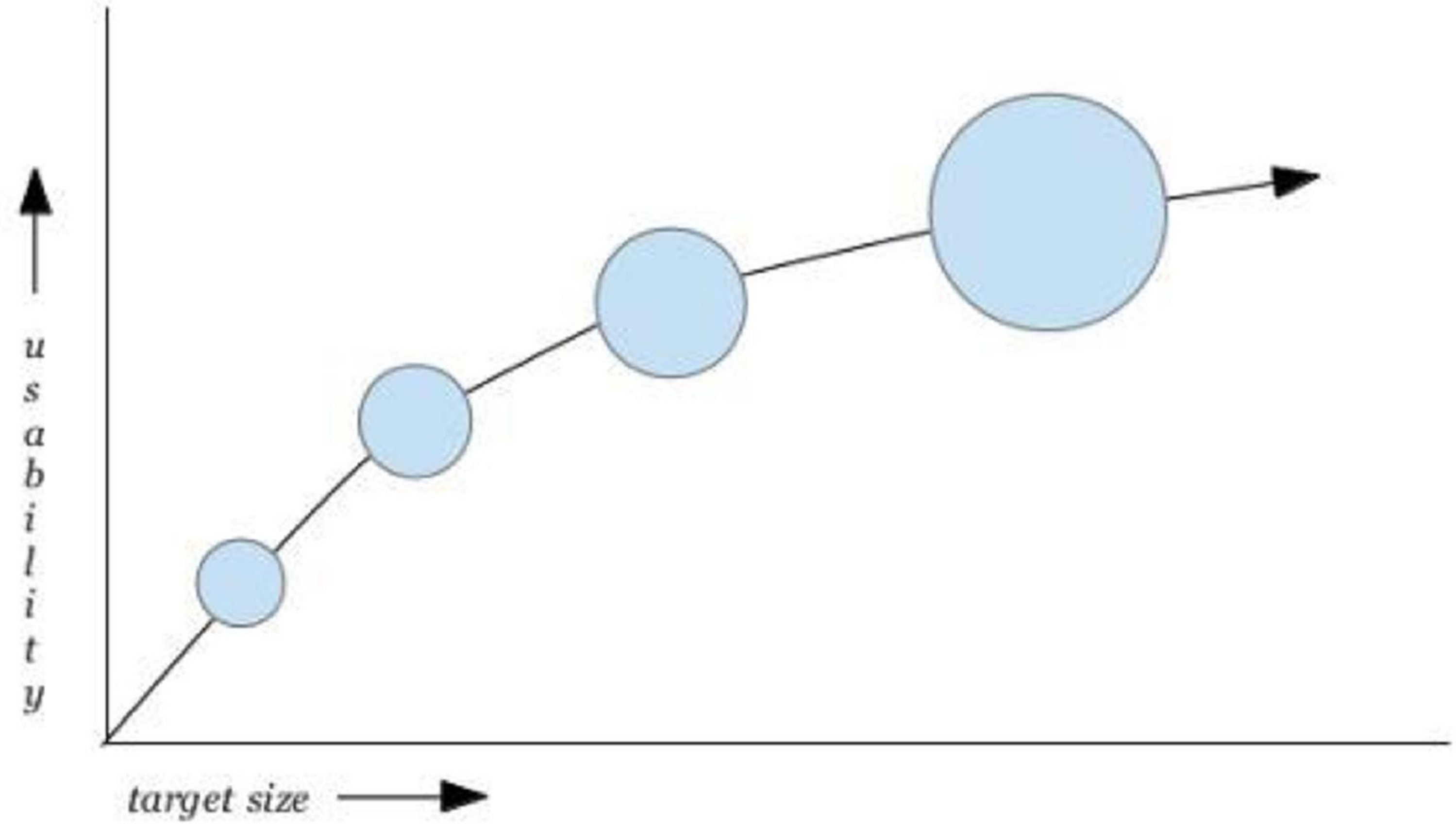
FITTS' LAW IN UI DESIGN. APPLICATIONS

Web sites do not have edges or corners of infinite width.

:(

FITTS' LAW IN UI DESIGN. APPLICATIONS

Create larger target size



FITTS' LAW IN UI DESIGN. APPLICATIONS

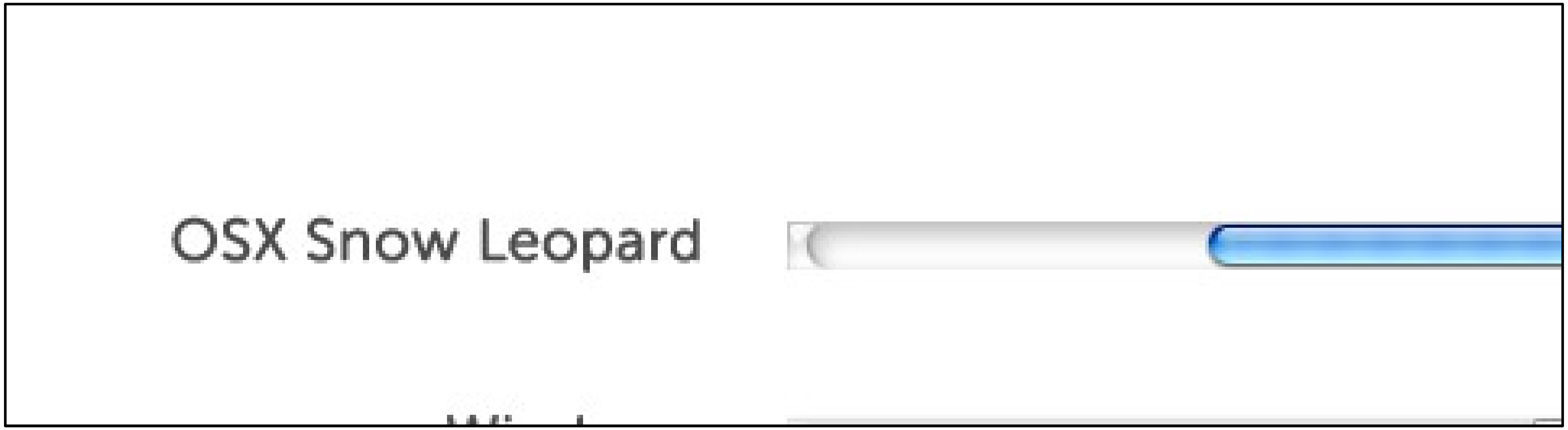
Keep related things close

- Filters should be placed close to the search field

FITTS' LAW IN UI DESIGN. APPLICATIONS

Keep related things close

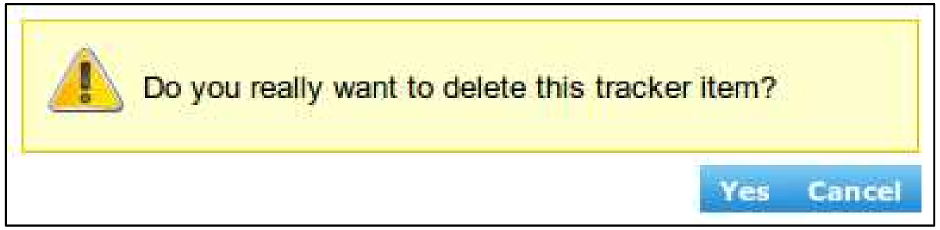
- Mac OS scrolls are faster to navigate



FITTS' LAW IN UI DESIGN. APPLICATIONS

Keep related things close and **Opposite Elements Far**

- These buttons should be placed far away from each other



But…don't forget the usability principles!!!

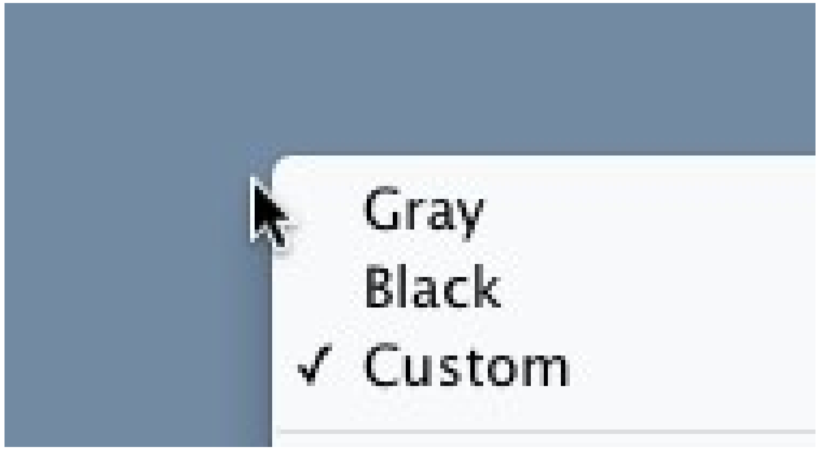
FITTS' LAW IN UI DESIGN. APPLICATIONS

Pop-up menus: Reduce travelling distance

- **Improve two aspects:**
  - Reduction of distance to travel (Fitts)
    - The option is close to the menu emerging place
  - Frequency-enabled may improve the time to pick an option:
    - Based on Hick-Hyman:

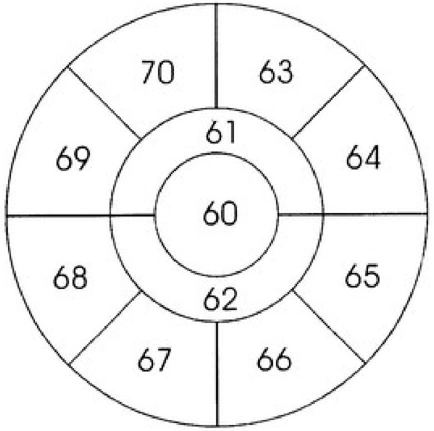
      Recall that *users are able to point faster objects that are known*

- Only used by experts!



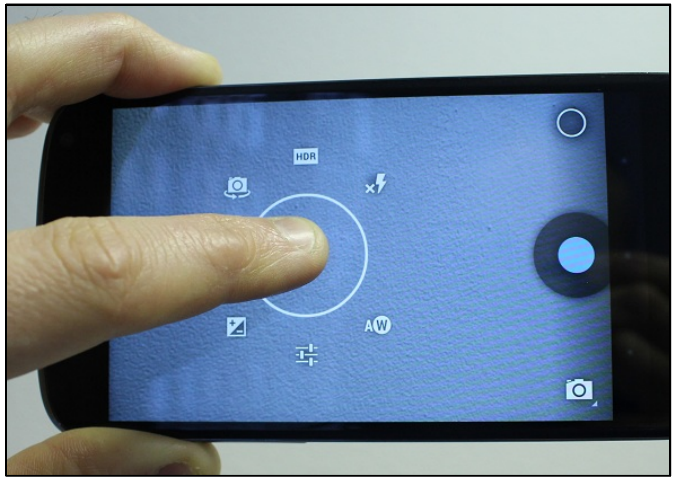
FITTS' LAW IN UI DESIGN. APPLICATIONS

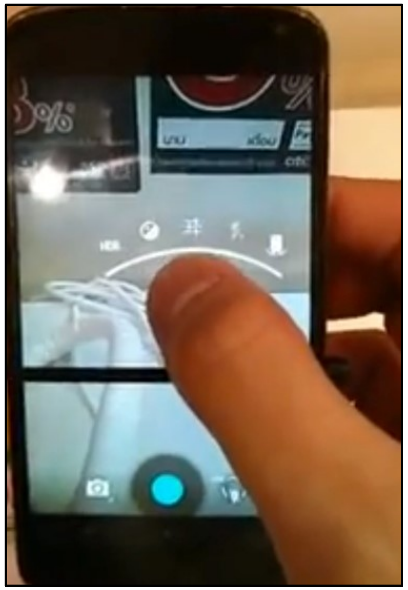
- *What about pie menus?*



FITTS' LAW IN UI DESIGN. APPLICATIONS

- *What about pie menus?*
  - <u>Sort of contextual menu</u>
    - Needs to be created on demand
    - Needs some room!
  - <u>Should not have occlusions</u>
    - On mobile half-pie menus better than fully circular





FITTS' LAW IN UI DESIGN. APPLICATIONS

Pie menus difficult to design!

- Second layer changes the size and distance
- Organizing by frequency may be a problem (learning)

FITTS' LAW IN UI DESIGN. APPLICATIONS

+ **Perception:** Grouping things may improve over distance

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  - **Accelerating Target Acquisition:**
    - Dynamic Expanding Targets
    - Target moving
- Exercises

ACCELERATING TARGET ACQUISITION: EXPANDING TARGETS

➢ **Increase the size of targets close to the pointer**

Two implementation approaches:

- Size-enlargement and position-changing icons
- Enlarged icons overlap over their neighbours

ACCELERATING TARGET ACQUISITION:
EXPANDING TARGETS

Increase the size of targets close to the pointer

Exemple1: Implemented in Mac OSX Dock:

- Mix of target size increase and moving target

ACCELERATING TARGET ACQUISITION:
EXPANDING TARGETS

Enlarged icons overlap over their neighbours

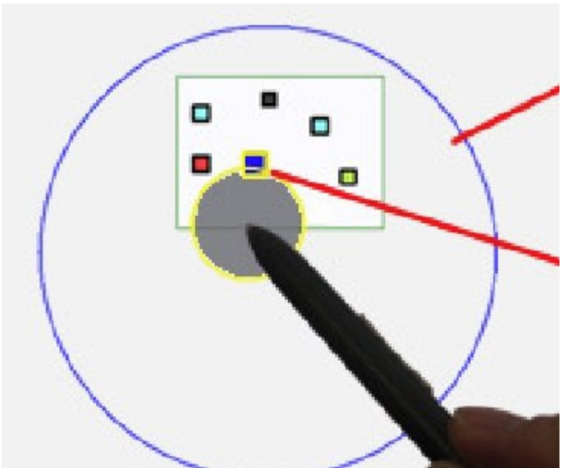
Dynamic Scaling (DS)

Objects near the selection ray are dynamically scaled

ACCELERATING TARGET ACQUISITION: EXPANDING TARG

- **Bubble targets:**
  - Increase selectable region around target
    - Only when the mouse is close
    - Improves selection times
  - Issues:
    - Bubble appearing may distract users
    - Overlapping targets:

      Close selection points may generate several bubbles



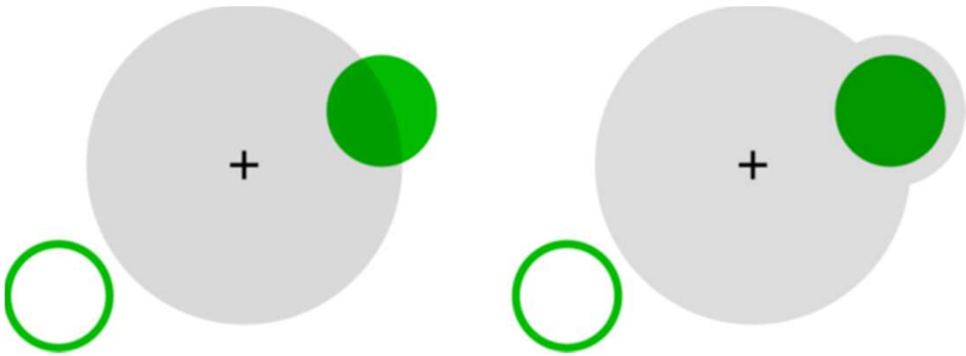
Aliakseyeu, Dzmitry, et al. "Bubble radar: efficient pen-based interaction." *Proceedings of the working conference on Advanced visual interfaces*. 2006

ACCELERATING TARGET ACQUISITION: EXPANDING TARG

➢ **Bubble cursor** [Grossman2005] ➔

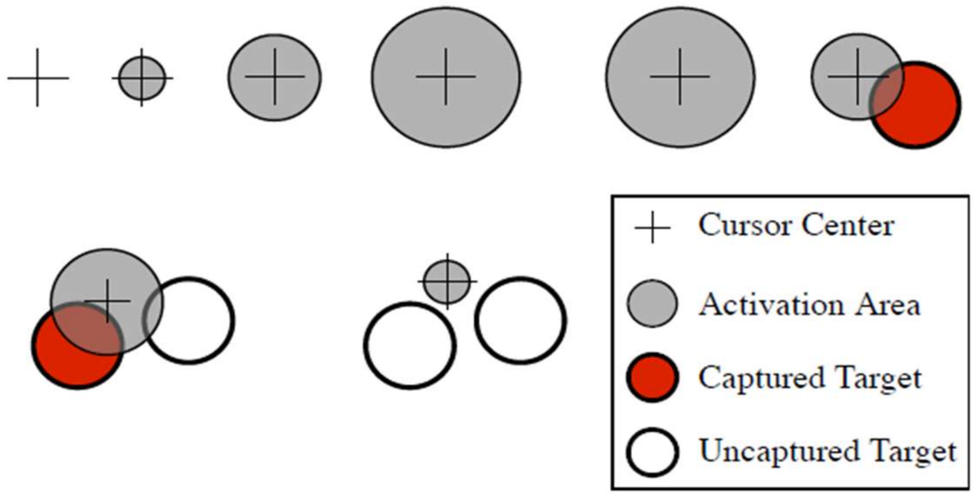
Reduction of amplitude movement

- Cursor size increases when it is close to objectives
- It may even grow to *absorb the* closer target when it is not completely inside the main cursor bubble.
  - Based on position, no speed
  - In experiments Control-Display ratio fixed to 1



ACCELERATING TARGET ACQUISITION: EXPANDING TARG

- **Dynamic Bubble cursor** [Chapuis2009]:
  - Based on the Bubble cursor idea
  - It takes into account the speed of the mouse
    - Area increases according to speed and position
    - Visual cues to indicate the captured target: the target closer to the cursor center.



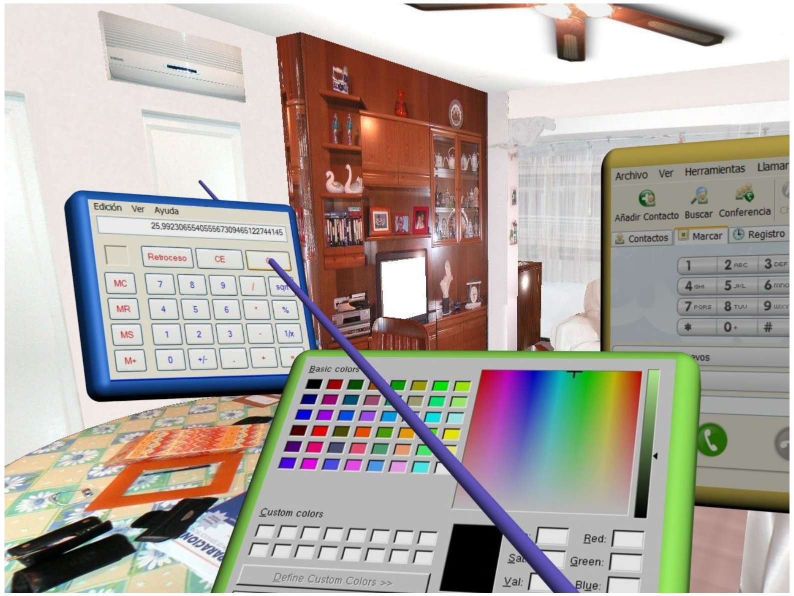
ACCELERATING TARGET ACQUISITION: TARGET MOVING

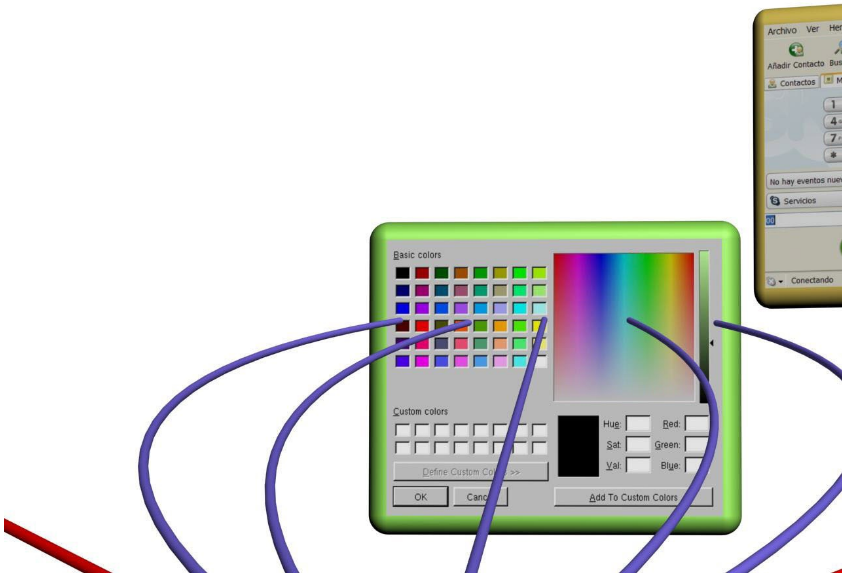
➢ **Move targets to the user:**

➢ **Generate targets next to the user: pop-up menus**

ACCELERATING TARGET ACQUISITION: TARGET MOVING

- **Sticky targets:**
  - Attract pointer
    - When the pointer is close to a selectable area
    - May reduce selection time
      - Precision not required
    - Users adapt easily





ACCELERATING TARGET ACQUISITION: CONTROL-DISPLAY RATIO

- Relation between the amplitude of movements of the user's real hand and the amplitude of movements of the virtual cursor

- Moves in real world (physical move) mapped to moves in virtual desktop (cursor move)
- Different strategies:
  - Constant
  - Dependent on mouse speed
  - Dependent on cursor position

- Interpretation according to Fitts Law:
  Dynamic C-D ratio adaptation can be interpreted as dynamic change of physical motor space

ACCELERATING TARGET ACQUISITION: CONTROL-DISPLAY RATIO

- Mac OSX and Windows both use mouse acceleration
  - When mouse moves fast, it is accelerated
    - Reducing the amplitude of movement to cover large distances
  - When mouse moves slow, it is decelerated
    - Magnifying amplitude of movement to improve precision
- No clear how the mapping affects perception and productivity
  - Some studies say it is not intuitive
  - Some studies say it improves some pointing tasks

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Donades les constants a = 400 ms, b = 200 ms/bit i un objectiu de mida 2.1 cm a una distància de 10.5 cm. Marca la resposta correcta assumint que fem els càlculs amb la versió de McKenzie de la llei de Fitts.

a. ID ≈ 3.4.
b. 2 < ID < 3.
c. ID ≈ 4.3.
d. MT està entre 1100 i 1200 ms.

La llei de Hick-Hyman:

a. Modela el temps de decisió com una funció de la informació transmesa.
b. Modela el temps de selecció d'un element com a funció de la distància a recórrer i la mida de l'element.
c. Modela el temps de decisió com una funció de la distància a recórrer i l'entropia dels elements a seleccionar.
d. Utilitza l'entropia de Shannon per a mesurar la distància del recorregut mínim.

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

- Els *expanding targets*:
  a. Es basen en la llei de Hick-Hyman.
  b. Pretenen reduir el temps d'accés als elements basant-se en el fet que, segons la llei de Fitts, el temps d'accés es redueix si s'augmenta la longitud del desplaçament.
  c. Si es combinen amb el moviment dels objectius poden causar confusió a l'usuari.
  d. Cap de les anteriors.

Ens han encarregat fer un disseny d'una interfície per a un sistema tipus desktop en la qual hi haurà botons i menús drop-down.

a. Podem predir la dificultat d'accedir als botons utilitzant la llei de Fitts i la dificultat de recórrer els menús amb la llei de crossing.

b. Podem analitzar el nombre d'elements a posar en un menú utilitzant la llei de steering i en funció dels digrams.

c. Podem analitzar el nombre d'elements a posar en un menú utilitzant la llei de Fitts.

d. Podem analitzar la dificultat de recórrer els menús utilitzant la llei de steering.

- **La llei de *steering*:**
  a. No es pot derivar a partir de la llei de *crossing*.
  b. Serveix per a modelar el temps necessari per a recórrer un camí de forma arbitrària.
  c. Diu que hi ha una relació logarítmica entre l'índex de dificultat de creuar un objectiu i el temps que requerit per a fer-ho.
  d. Diu que l'índex de dificultat de creuar un objectiu és D/W.

- Dos elements T1 i T2 a distàncies D1 = 10 cm i D2 = 8 cm en direcció horitzontal i d'amplades 5 cm i 2 cm, respectivament. Per a T1 emprem un dispositiu amb a1= 200 ms i b1 = 200 ms/bit. Per a T2 utilitzem un dispositiu amb a2 = 200 ms i b2 = 100 ms/bit. Assumint la formulació original de la llei de Fitts:
  a. ID1 > ID2.
  b. ID1 = ID2.
  c. MT1 = MT2.
  d. MT2 < MT1.

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