Perception / Action Colors Ergonomic criteria

Eric Lecolinet - Télécom ParisTech www.telecom-paris.fr/~elc

# Pointing





### **Ubiquitous in GUIs**

- Significant impact on time and error performance
- How can we:
  - Estimate pointing time?
  - Facilitate pointing?
  - **Avoid** pointing?

## Fitts' law





$$TM = a + b \log_2(D/W + 1)$$

ID

### **Experimental law predicting pointing time**

- Speed accuracy tradeoff
- <u>exemple</u> (@ 0.33)









$$TM = a + b \log_2(D/W + 1)$$

- **a**, **b** = **empirical constants** that depend on:
  - the device
  - the member
  - the type of population (age, etc.)



- **ID** = **index of difficulty**: depends only on **D/W ratio** 
  - similarity with Shannon's entropy

# Facilitating pointing



### **Approaches**

- 1) Reduce distance (D)
- 2) Increase size (W) of target
- 3) Modulate mouse gain
- 4) **Semantic** techniques
- 5) Avoid pointing

## 1. Reduce distance



#### Spatial organization of buttons

Popup menus reduce distance between target and command

• Most used items at the **top** (or at the very bottom: helps visual search)

## 2. Increase size

#### **Button size**

- Most used => larger
- Small buttons for **unfrequent** or **dangerous** actions



#### MacOS menu bar

- Larger distance
- But infinite size!

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$$TM = a + b \log_2(D/W + 1)$$

## 2. Increase size







#### Marking menus

- Novice mode: circular menu
- **Expert mode**: gestural interaction with infinite size



## 2. Increase size

Marking Menus	Linear Menus	Constant and a second and		Constantional an Annual     Constantion     Constantion
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#### **Expert mode**: gestural interaction

• Infinite size (only angle matters)

#### Learning by repetition

• same gestures in expert and novice modes

### Marking menus

# 3. Mouse gain

### **MOUSE ACCELERATION**



### **Mouse gain** (pointer acceleration)

- = cursor speed / mouse speed
   (visual space / motor space)
- Depends on mouse speed

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https://prosettings.net/

# 3. Mouse gain



- Slow speed => small gain : cursor move slowly (accurate pointing)
- Fast speed => high gain : cursor moves quickly
- So "natural" that people don't even realize!

# 4. Semantic pointing



- Gain depends on objects' semantics
- Motor space != visual space
  - Empty space => high gain : cursor moves quickly
  - Common actions => low gain : easier to reach
  - **Dangerous** actions => high gain : avoids clicking by **mistake**

# 4. Magnetic grids

#### "Magnetic" grids

• common in drawing software

#### "Attracting" objects

 relies on object semantics



# 5. Avoid pointing

### **Hotkeys**

#### Drawbacks

- Not the same **modality** as pointing
- Require explicit learning

#### **Usability?**

• How many of them do you use?

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# 5. Gestures

- Finger gestures
- Marking menus
- Tapping gestures, etc.

Click Press down anywhere on the Multi-Touch surface to click. Or, with Tap to Click enabled in System Preferences, simply tap the surface.

Rotate With your thumb and index finger positioned on the Multi-Touch surface, turn clockwise or counterclockwise to rotate an image.

Four-Finger Swipe for Exposé Using four fingers, brush down along the Multi-Touch surface to tile all open windows. Brush up to push all windows aside for quick access to your desktop. Three-Finger Swipe to Navigate Using three fingers, brush left and right along the Multi-Touch surface to move forward and back.

#### Mac OS gestures



JerkTilts: Using Accelerometers for Eight-Choice Selection on Mobile Devices





## 5. Gestures on a large display

# **CoReach:** Cooperative Gestures for Data Manipulation on Wall-sized Displays

### CHI 2017

Can Liu Olivier Chapuis Michel Beaudouin-Lafon Eric Lecolinet

Univ. Paris-Sud, CNRS, Inria, Telecom ParisTech, Université Paris-Saclay (France) music credit http://brokeforfree.com/ University College London (UK) c.liu@ucl.ac.uk

# Complements

### **On Fitts' law**

 Yves Guiard « Méthodes et Modèles de la Psychologie Expérimentale » <u>http://www.telecom-paristech.fr/~elc/ihm</u>

### **GOMS and Keystroke**

- **GOMS**: Behavior description model
- Keystroke: Relies on GOMS to predict execution time
  - See James Eagan's course

# Hick law

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### Time for chosing an item in a set

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

- a, b = empirical constants
- n = number of elements

# Magical number seven (G. A. Miller)

Channel capacity

How many values can be **distinguished** in an **absolute** way for a given modality?

- About 7 (+/- 2) (2 to 3 bits)
  - **sound**: ~ 6 frequencies, ~5 intensities
  - light : ~8 shades, ~5 intensities
  - salty taste : ~4 intensities
  - **pointing** in an interval: ~10 (short time) to ~15 (long time), etc.
- Related to chunking
  - immediate memory: less than 7 chunks (about 5)
  - little depends on the level of abstraction



# Colors & GUIs

# Perception of color

### Retina

- Rods (bâtonnets): grayscale, broad spectrum
- Cones: red, green, blue sensitive







## Perception of color

### **Indirect measurement**

- The visual system does not detect colors, but mixtures of them
- An infinite number of combinations are perceived identically!





# Perception of color

## **Metameric colors**

- Different color distributions •
- That are perceived identically ۲

A single wavelength, corresponding to yellow (590 nm)







nm light

nm liaht

650 700 Wavelength



https://theneurosphere.com/2015/12/07/why-are-all-the-colours-we-experience-composed-of-three-primaries/

450

500

550

600

400

# RGB color model

## **Additive model**

- Light emission (screens)
- Each pixel has 3 R, G, B subpixels
- Screens display colors as we see them (not as they are!)





# CMY(K) Model

## **Subtractive model**

- Light reflection (paper prints)
- Complementary colors: Cyan, Magenta, Yellow
- Printers: CMYK : CMY + blacK
- High-end printing (art books): more colors because of imperfect pigments





additive

substractive

# HSV Model

- Equivalent to **RGB**
- More appropriate for describing colors
  - Hue (teinte): primary color (wavelength)
  - Saturation (chroma): proportion of secondary colors
  - Value (brightness)
- Variant: HSL Model different calculation of S and L (light)



wikipedia



# CIE Lab

## CIE L\*a\*b\*

- Device-independent color space
- Takes human perception into account
- Distance respects **perceived** color difference
- L\* = black to white
- $a^*$  = value on a green  $\rightarrow$  red axis
- $b^*$  = value on a blue  $\rightarrow$  yellow axis

## Also

- CIE L\*u\*v\* for screens
- CIE xy, etc.





wikipedia

# Retinal sensitivity

## Retina

- 75 to 150 million **rods** (grayscale)
- 7 million cones (R, G, B colors)



## The eye is 10 times more sensitive to variations in V (brightness) than in H (hue)!

At night all cats are gray !



# Retinal sensitivity & GUIs

## Similar brightness makes it hard to read

texte vert brillant sur fond rouge brillant	same H & S	texte vert brillant sur fond rouge foncé
Bright green on bright red :		Bright green on dark red :
<ul> <li>same Value</li> </ul>		<ul> <li>different Value</li> </ul>
<ul> <li>difficult / unpleasant</li> </ul>		<ul> <li>easier to read</li> </ul>

## **Golden Rule**

- Contrast Value rather than Hue
- Use at least a **brightness ratio of 1/3** (1/10 if possible) between the background and the foreground

# Color vision deficiency

## **Quite common**

- 8% of men
- Green-red confusion is most common

## **One more reason to contrast V!**

• rather than Hue





Vision deutéranope en bas (Wikipedia)



test d'Ishihara (Wikipedia)

# Tetrachromacy & more

- **Tetrachromacy** (4 rods)
  - Birds and... some women(?)
- 14 rods: Silver spinyfin (Dirette Argentée)!





RGB vs. tetrachromacy

https://theneurosphere.com/2015/12/17/the-mystery-of-tetrachromacy-if-12-of-women-have-four-cone-types-in-their-eyeswhy-do-so-few-of-them-actually-see-more-colours/

## Wavelength dependency

## Human vision more efficient

• In the **center** of the spectrum (yellow, green)

#### Example

• **blue** text on **dark red** background hard to read







## Wavelength dependency

### **Chromatic aberration**

• Different focus for R, G and B

la plupart des gens voient le rouge

plus proche que le bleu

mais certaines personnes voient l'effet opposé

## Spatial dependency

### **Much greater sensitivity**

- On the **fovea**, in the center of the retina
- Area used for reading

### **Focus of attention**

 Vision accurate on a small angle (eye saccades)



## Spatial dependency

### **Focus of attention**

• Vision accurate on a small angle

## **Alerts & critical systems**

- Bad perception in **peripheral** vision
- Try to reduce eye
   back and forth movements
- Example: air traffic control



# Color encoding

- Often 24 bits per pixel : 8 bits for each R/G/B component
- 3 x 8bits = (2^8)^3 = 16 million colors







different pixel configurations (above: iPhone X)



# Color encoding

### Why 16 million colors?

- We can distinguish about **120/150 different hues**
- But high adaptability to luminance (pupil)
  - Black leaf in full sun: 1000 candela/m2
  - White sheet on desk: **50** candela/m2
- =>16 million colors is enough, but in an office environment!

### **Other common formats**

- **HDR** (High Dynamic range): 3x10 / 3x12
- **32 bits**: 24 for color + 8 for **transparency** (alpha layer)

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## Contrast

- High adaptability to luminance
- By also strong **Contrast** effects:
  - How a video projector can produce
     black text on a white screen?
  - Which of A or B is the darker?



## Contrast



# Gamma correction

### **Luminance and Brightness**

- Luminance: *measurable* quantity of light
- Brightness: *perceived* quantity of light not proportional to luminance!

### **Empirical estimation**

• **Brightness = Luminance** <sup>n</sup> (*n* depends on experimental conditions)

### **Gamma correction**

- Luminance = Voltage <sup>gamma</sup>
  - $\blacksquare$  Brightness = L<sup>n</sup> = (V gamma) <sup>n</sup> = V
  - ➡ Linear relationship if **gamma** well chosen

# Gamma correction

### In practice: ambient light

- L = V gamma + A (ambient light)
- Typically :
  - 2,5 in the dark
  - 1,5 in an office
- Generally **Gamma** = 2,2





# Color profiles

## **ICC** profile

- Describes how a **device** renders **colors**
- Goal: harmonize rendering
- Example: ColorSync tool

## sRGB

- Color space created by Microsoft & HP
- Often used as a standard profile
- Used in CSS
- Some limitations: modern devices may have a larger **gamut**





# Let's play



- http://www.xrite.com/online-color-test-challenge
- http://kolor.moro.es
- https://www.arealme.com/colors/en/
- https://www.colorlitelens.com/color-matching.html





What is the color of this dress?



Girl or boy?



## Selective attention

## **Selective Attention Test**

### from Simons & Chabris (1999)

## The Monkey Business Illusion

**Daniel J. Simons** 

## The "Door" Study

### from Simons & Levin (1998)

Ergonomic Criteria

## Ergonomic Criteria (Bastien et Scapin)

- 1. Guiding
- 2. Workload
- **3. Explicit Control**
- 4. Adaptability
- **5. Error Management**
- 6. Homogeneity / Consistency
- 7. Significance of Codes and Denominations
- 8. Compatibility
- Rapport INRIA No 156, juin 1993
- <u>http://www.ergoweb.ca/criteres.html</u>
- <u>http://www.ergolab.net/articles/criteres-ergonomiques-1.php</u>

## **1.1 Incentives**

- Identify state of context
  - to lead the user to take appropriate actions:
  - "where am I, what can I do, how do I get out..."
- Examples
  - formats, units, current status, online help





## **1.2 Grouping / distinction between items**

- Visual organization (location, format, color)
  - according to relationships between items, categories, etc.
- Examples
  - hierarchical lists, menus, groups, boxes

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Couleurs et images d'arrière-plan en mode Page	Balises des contacts
Caractères non imprimables	
Tabulations	Traits d'union conditionnels
Espaces	Texte masqué
Marques de paragraphe	Tous
Fenêtre	
✓ Barre d'état	Sarre de défilement horizontale
🗹 Statistiques en cours de frappe	Barre de défilement verticale
🗹 Règle verticale	🥑 Ajuster à la fenêtre
Largeur de la zone de style : 0 cm 🗘	
Description de l'option	
Affichage Spécifie le mode d'affichage de votre document et les t	ypes d'objets qui apparaissent à l'écran.
	Annuler OK

## **1.3 Immediate feedback**

- **Provide an answer** as quickly as possible
- Example
  - long operation → visual feedback (clock, gray ...)



Où ? 🗆 Recherche à proximité de	
place de	
Place De La Republique Paris Place De La Madeleine Paris	
Place De Clichy Paris Place De La Nation Paris	
Place De La Porte Maillot Paris	

## **1.4 Readability**

#### Presentation

color, contrast, size, text spacing





# 2. Workload

## 2.1 Brevity

- Limit reading and intermediate steps
  - short entries, short items, minimal actions
- Examples
  - abbreviations, shortcuts
  - avoid sub-sub menus



# 2.Workload

## **2.2 Information Density**

- Avoid forcing the user to memorize long/complex procedures
- Examples
  - display only what is needed
  - avoid having to remember previous data
  - precalculate what that can be







# 3. Explicit Control

## **3.1 Explicit actions**

- The system should execute only the requested operations,
- Examples
  - explicit confirmation (Enter key, OK button)
  - avoid implicit actions

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"Print" should not perform "Save"

# 3. Explicit Control

## **3.2 User control**

- The user must be "in control"
- Examples
  - Stop, Undo/Redo
  - Avoid moving the cursor programmatically

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sourceforge	Find Open Source Software	Browse Blog		

# 4. Adaptability

## 4.1 Flexibility

- Ability of the user interface to adapt to users
  - customization
  - offer several ways to achieve a goal
- Example: preference setting

	Vue Audition   Clavier   Souris et trackpad	
VoiceOver :	Activer ou désactiver VoiceOver : %fn F5	
🔾 Oui 💿 Non	Ouvrir l'utilitaire V	oiceOver
Zoom :	Activer ou désactiver le zoom : ℃%8	
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	Réduire/Agrandir dans la fenêtre	Options
Afficher :	Passer en blanc sur noir : ^\#8	
💿 Noir sur blanc	Utiliser des niveaux de gris	
OBlanc sur noir		
Renforcer le contrast	te :	
	Normal Maximum	
	Diminuer le contraste : ^\%.	
	Augmenter le contraste : ^て第.	



# 4. Adaptability

## 4.2 Take experience into account

- Novice users:
  - guided interaction, cascaded menus
- Expert users:
  - keyboard shortcuts, contextual menus
  - inhibit auto-guidance, more concise messages

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# 5. Error Management

## **5.1 Protection**

- Detect errors during input, before validating
- Examples
  - confirmation of end of session
  - consider possible accidental actions



# 5. Error Management

## **5.2 Quality of messages**

- Relevance, readability, accuracy
- Examples
  - invalid key  $\rightarrow$  no action or appropriate message
  - short messages, specific terms, avoid humour!







# 5. Error Management

### **5.3 Correction**

- Make it possible for the user to **correct**:
  - during input
  - only the wrong part (so that she does not have to retype everything)

00	Evaluation de stage			
Groupe des ecoles des telecommunications [FR] https://eole.telecom-paristech.fr/stages/Stage_ev				
Appréciation du directeur de stage	<ul> <li>Commentaire :</li> <li>Connaissance technique :</li> <li>Comportement :</li> <li>Points à améliorer :</li> </ul>			
Appréciation du correspondant				
>> Attention, les commentaires sont à destination de l'élève.				
Qualité du travail : Tr	avail absolument remarquable			
A	A+ ‡			
Rapport de stage : (Contenu scientifique, rédaction, forme)	n modèle du genre -			
A	A+ ÷			
Soutenance (si elle a lieu) : (Mise en valeur du travail effectué, maîtrise du sujet, clarté de l'exposé, quaîté des supports, respect du temps imparti)	n mondioxision sur TED !			
A	<b>↓</b> + ↓			
Constitution du jury : A. S. D.	Einstein Jobs Ritchie			
Note synthétique du jury :	<b>↓</b> +			

example: don't loose data on a timeout

# 6. Homogeneity / Consistency

### **Homogeneity of design choices**

- Similar screen formats
- Uniformity of:
  - menus
  - formats
  - headings
  - procedures



# 7. Codes and Denominations

## Adequacy of displayed objects and referents

- Informative and distinguishable titles
  - **Explicit** abbreviation rules
  - Significant codes and names
- Example: M and F rather than 1 and 2

# 8. Compatibility

## 8.1 Coherency between

- System dialogue and users' habits or what they imagine of the system
- Examples
  - follow standards and paper conventions
  - standard terminology, international conventions
  - beware of **dates**, **numbers**, **units**!

![](_page_66_Picture_7.jpeg)

# 8. Compatibility

## 8.2 Degree of similarity (transfer)

- Between environments or applications :
- → style guides (Mac, Windows, Java...)

![](_page_67_Picture_4.jpeg)