Principles of Effective Interface Design

COMP2044: Human-Computer Interaction (2024-2025)

Matthew Pike

Overview

Objectives for today

- Define and distinguish between discrete and continuous controls.
- Identify key design factors for effective control interfaces.
- Review case studies to illustrate design challenges and solutions.
- Introduce key design principles such as natural mapping and affordances.

Design Factors

Types of Controls

Discrete Controls

- Offer a limited number of choices.
- E.g. buttons, switches, radio buttons. 按钮,开关,单选按钮

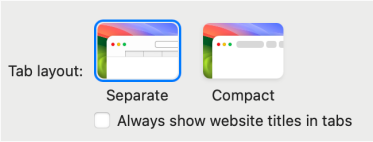


Figure 1: Example of a Discrete Control for setting the preferred tab layout in the Safari web browser.

离散控件适用于有限选项的情况，用户只能从中选择特定的选项，而不能在选项之间进行微调（如开关 Wi-Fi、选择页面布局）

Continuous Controls

- Allow for a range of values.
- E.g. sliders, knobs, dials. 滑块,旋钮,拨盘

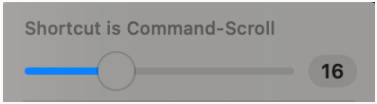


Figure 2: Example of a Continuous Control for setting the font size.

连续控件适用于需要细微调整的情况允许用户在一个范围内选择值，而不仅仅是几个固定的选项。
适用于需要精细调整的参数，如音量、亮度、字体大小等（如音量控制、字体大小调整）

Factors to Consider in Control Design (1/2)

- **Feedback**:
  - Information received, from both outside and inside the body which helps the operator assess their performance .
- **Control Resistance**:
  - Particularly valuable in continuous controls as aids precision movement;
  - Prevents accidental activation;
  - Causes fatigue;
  - Consider physical capacities of the operator.
- **Size**
  - Surface control area relative to relevant bodily dimensions (think of awkward mobile phone keypads you may have used);
  - What kind of action is required e.g., push, grip etc.

Figure 3: A DJI drone controller. Image Source

Factors to Consider in Control Design (2/2)

- Weight
  - Think about hand-tools and how we evaluate mobile devices.
- Texture
  - For grip.
  - Need to avoid abrasion in repetitive use scenarios.
- Coding
  - There is value in highlighting different aspects or areas of an interface for ease of use.
  - Do the eyes need to be looking elsewhere?
  - Coding can be by: Colour, Sound, Shape, Size, Texture, Temperature.

Figure 4: Consider why this GPS device: 1) Doesn't use a touchscreen; 2) Is bright yellow; 3) Is optimised for single hand use.

Factors that Influence Control Effectiveness

- **Handedness**:
  - Logical sequencing;
  - Grip strength and orientation.
- **Clothing and Protective clothing**:
  - What environment is this interface being used in?
- **Control shapes**:
  - Shape of control will affect how it can be handled;
  - Work organisation/flow of work.

Figure 5: What considerations would you need to make when designing an interactive device for this type of user?

Example: A Bad Apple

Apple has released official advice for iPhone 4 owners to overcome the problem of the device losing signal when held by the lower left corner. Steve Jobs responded to a query about the problem from one owner by saying: "Just avoid holding it in that way." The official advice is to "avoid gripping it in the lower left corner in a way that covers both sides of the black strip in the metal band".

BBC News

Figure 6: Imagine being told how to hold your phone ...

Ambiguous and Unambiguous Selector Switches 模糊和清晰的选择开关

- Ambiguous selectors are confusing and lead to errors.
- In safety critical systems, ambiguous selectors are naturally to be avoided.

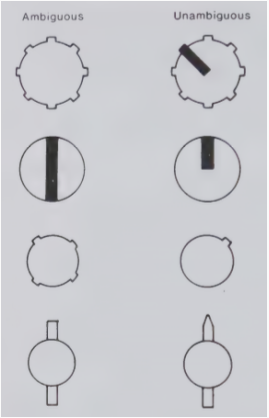


Figure 7: Ambiguous and Unambiguous Selectors from Oborne (1995).

Sequence of Use Principle

Time sequence

"This principle suggests that if controls or displays are normally operated in some sequence – for example switching on a lathe, increasing its speed, moving spindles together etc. – then they should be arranged in that sequence."

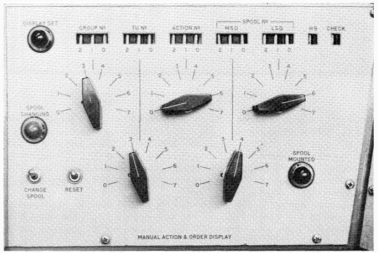
(Oborne, 1995, p. 198)

Functional sequence

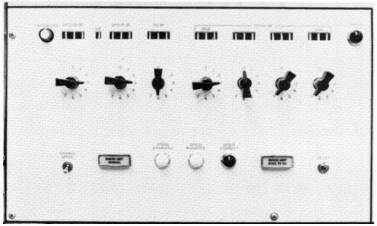
"Having arranged the panel components according to a temporal sequence, it is also possible to arrange them in terms of their function."

(Oborne, 1995, p. 198)

Sequence of Use Principle



(a) The Prototype Control Panel



(b) The Production Control Panel

Figure 8: This example (and the quote below), are from Shackel (1962), P.235.

"The previous example (Figure 8a above) also required a change in layout. If asked to set a five-digit number with the knobs, most operators would immediately set the first this is exactly what the engineer who had designed the panel did when he was asked to make a setting. Closer inspection, however, shows that the correct sequence is in the shape of the letter W. The re-design, with smaller knobs, allows more of the same switches to be placed in one horizontal row (Figure 8b above)."

Frequency of Use Principle

"Principle suggests that controls and displays should be arranged in terms of how frequently they are used by the operator."

(Oborne, 1995, p. 199)

- A caveat – Importance
  - Rarely used but highly important controls – alarms / emergency stops etc. should not be hidden away.
  - Example: The emergency stop button on a lathe.

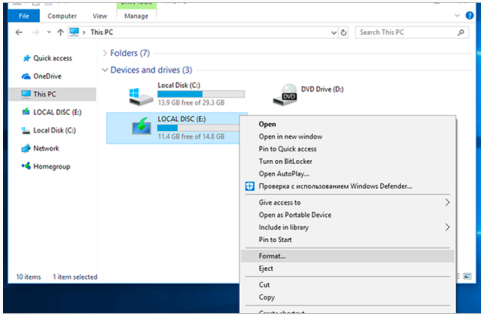


Figure 9: Positioning of menu items likely to be used more frequently at the top of the menu.

Position of Controls (Relative to other Controls)

Spacing

- Once we've done broad placement, we need to do specific relative alignment and spacing.
- Minimum spacing depends on type of control.
- And how it's operated! E.g., by hand, by foot, by mouse.
  - Obviously using mice and pointers potentially requires less space.
  - But you need to think about target acquisition and how easy you are making this… and you need to avoid accidental operation.

Accidental Operation

- Can be prevented by:
  - Recessing the control;
  - Orienting the control (so if it's knocked from one direction it can't be moved in that direction);
  - Covering the control;
  - Locking the control;
  - Operationally sequencing controls;
  - Increasing control resistance.
- What are the ways of doing this in a digital GUI?

Grouping Controls (1/3)

- Aircraft instruments:
  - Check Reading is a common activity and requires checking a reading is within a certain range (rather than “reading off a value”).
  - Therefore, displays must be immediately readable as this is a mission-critical task.
- Control pointer symmetry is a influential factor in the design of displays and derives from human perceptual processes.
- Analysis of 460 pilot’s interactions with displays showed significant numbers of errors (Fitts & Jones, 1947).

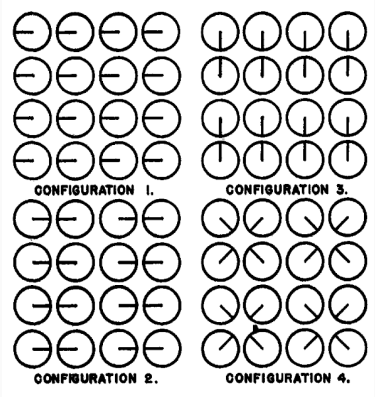


Figure 10: Which of these displays is easier to read? Image from Johnsgard (1953).

Grouping Controls (2/3)

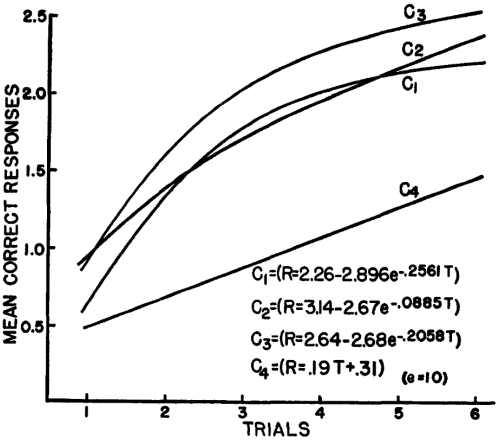


FIG. 2. Mean error dials located in each of the four configurations with each abscissa point representing the mean values of blocks of three trials.

Figure 11: Figure from Johnsgard (1953), shows the mean number of errors per dial shown in Figure 10.

Grouping Controls (3/3)

- For check reading
  - Extensor lines;
  - The human eye and brain are excellent at looking for patterns;
  - Here we exploit some principles of Gestalt perception;
  - “In this study, efficiency in a similar task was rendered 85 more efficient by continuing the line formed by the pointers across the entire panel face.” (Dashevsky, 1964).

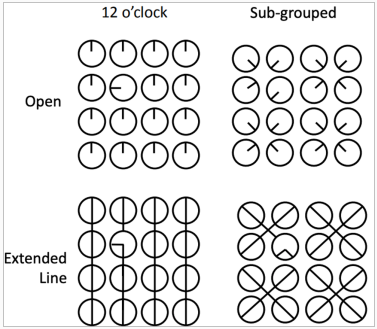


Figure 12: Utilises Gestalt’s principle of continuity to aid in identify readings. Image from Dashevsky (1964).

The Affordances of Control Types

- Control types afford different ways of interacting.
  - To afford means to “give a clue” (Norman, 2013).
  - Related to perceptual aspects e.g., Gestalt features of controls.
  - Affordances are about potentialities.
- Affordances of a mouse.
  - Shape – hand-sized.
  - Button placement when hand rests on mouse invites clicking.
  - Produced through interaction between human and object.
- Real versus perceived properties.
  - Perceptually obvious – relies upon physicality.
  - Purely perceived affordances must be learned.
  - GUIs have no real affordances; interaction must be learned.
    - E.g., through convention,
    - Thus makes ‘no sense’ to talk of real affordances for digital interfaces.

Natural Mapping

- Warrick's principle (Warrick, 1947):
  - The indicator is expected to move in the same direction as the point on the control closest to the display.
  - Only applies when control is located to side of display.
- Other mappings:
  - Convention: clockwise is more, anti-clockwise is less.
  - E.g., volume control, temperature control.

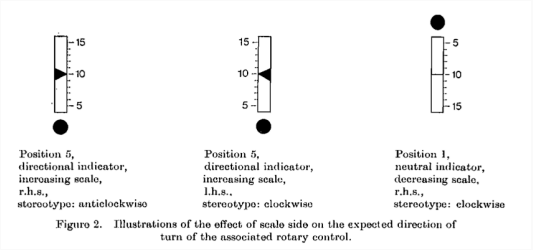


Figure 13: Natural Mapping of a control to a display. Image from Brebner & Sandow (1976).

Conclusion

Distilling the Principles of Control Design

- Think about the appropriateness of controls for the actions to be achieved.
- Avoid ambiguity of representation.
- Support logical sequencing of activity.
- Separate out functional groupings.
- Give feedback to the user (system state etc.).
- Think about context of use.
- Prevent accidental activation.
- Exploit perceptual processes.
- Use natural mappings.

Summary

- Reviewed key concepts in graphical interface design, focusing on control types and design factors.
- Discussed the importance of user-centred design principles, including natural mapping and affordances.
- Analysed real-world case studies to highlight the impact of thoughtful design on user experience.

Web Articles

- Input Controls for Parameters: Balancing Exploration and Precision with Sliders, Knobs, and Matrices
  - https://www.nngroup.com/articles/sliders-knobs/
- User Interface Design Basics
  - https://www.usability.gov/what-and-why/user-interface-design.html
- Design-Pattern Guidelines: Study Guide
  - https://www.nngroup.com/articles/design-pattern-guidelines/

References i

Brebner, J., & Sandow, B. (1976). The effect of scale side on population stereotype. *Ergonomics*, *19*(5), 571–580.

Dashevsky, S. G. (1964). Check-reading accuracy as a function of pointer alignment, patterning, and viewing angle. *Journal of Applied Psychology*, *48*(6), 344.

Fitts, P., & Jones, R. (1947). *Analysis of factors contributing to 460 "pilot-error" experiences in operating aircraft controls*.

Johnsgard, K. W. (1953). Check-reading as a function of pointer symmetry and uniform alignment. *Journal of Applied Psychology*, *37*(5), 407.

Norman, D. (2013). *The design of everyday things: Revised and expanded edition*. Basic books.

Oborne, D. J. (1995). *Ergonomics at work* (3rd ed.). Wiley.

References ii

Shackel, B. (1962). Ergonomics in the design of a large digital computer console. *Ergonomics*, *5*(1), 229–241.

Warrick, M. J. (1947). *Direction of movement in the use of control knobs to position visual indicators*. Army Air Forces, Air Materiel Command.