

Design Principles

Human Computer Interaction

Luigi De Russis

Academic Year 2024/2025

Hall of Fame or Shame?

Did we make you smile?

Based on your shopping experience,
how likely are you to recommend us on
a scale of 0 - 10?

Extremely unlikely



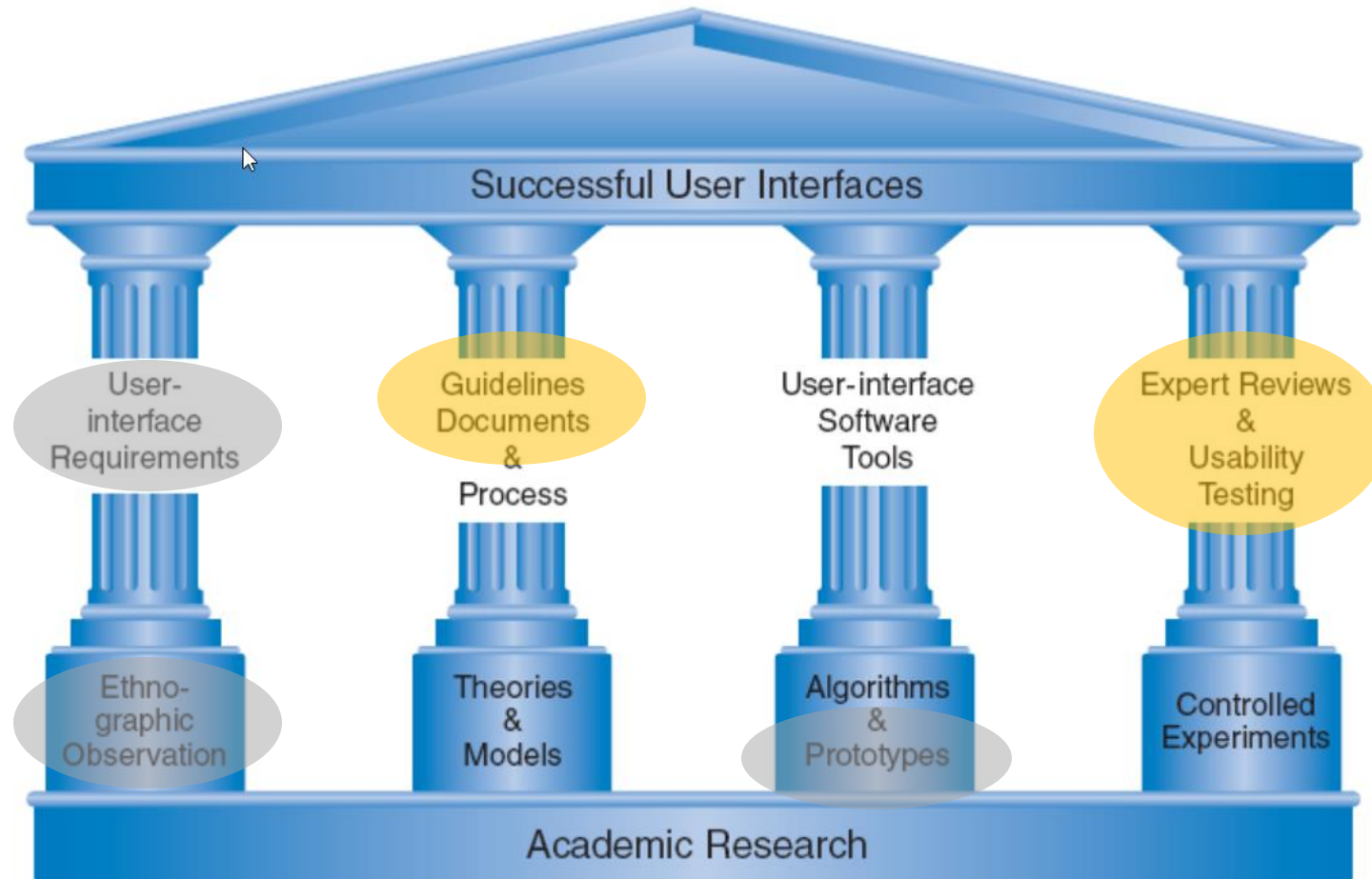
0 1 2 3 4



5 6 7 8 9 10

Extremely likely

The Four Pillars of Design



Ben Shneiderman & Catherine Plaisant, Designing the User Interface: Strategies for Effective Human-Computer Interaction

Goals

Generating design solutions

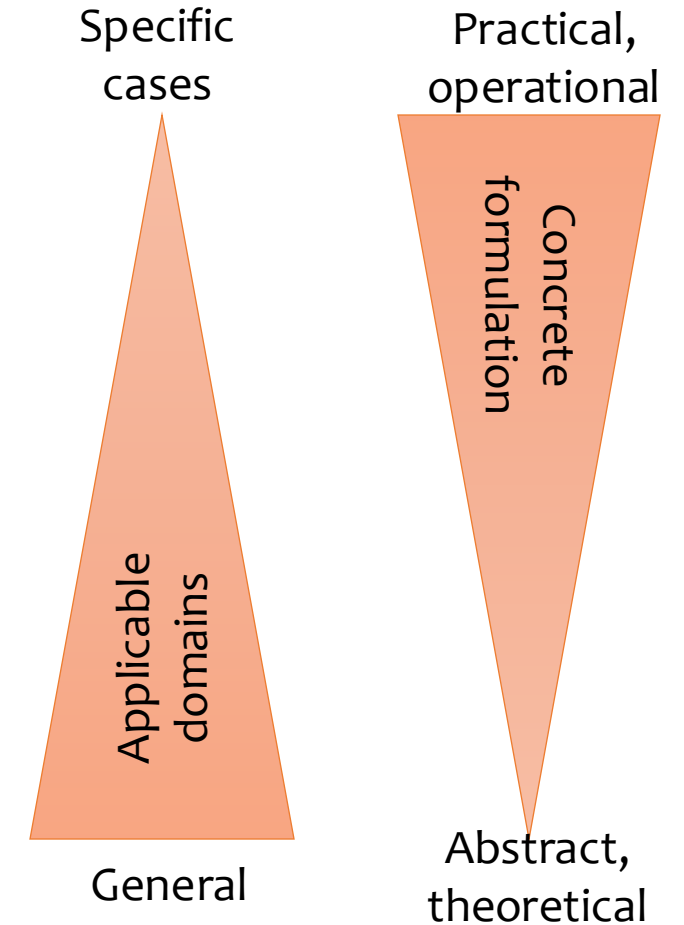
- Guidelines
- Principles
- Theories

Evaluating generated designs

- Expert reviews and heuristics
- Usability testing
- Controlled experiments

Generating Design Solutions

- **Guidelines:** Low-level focused advice about good practices and cautions against dangers
- **Principles:** Mid-level strategies or rules to analyze and compare design alternatives
- **Theories:** High-level widely applicable frameworks to draw on during design and evaluation, as well as to support communication and teaching



Design Theories

Theoretical frameworks enabling foundational research

The “Why”

Design Theories

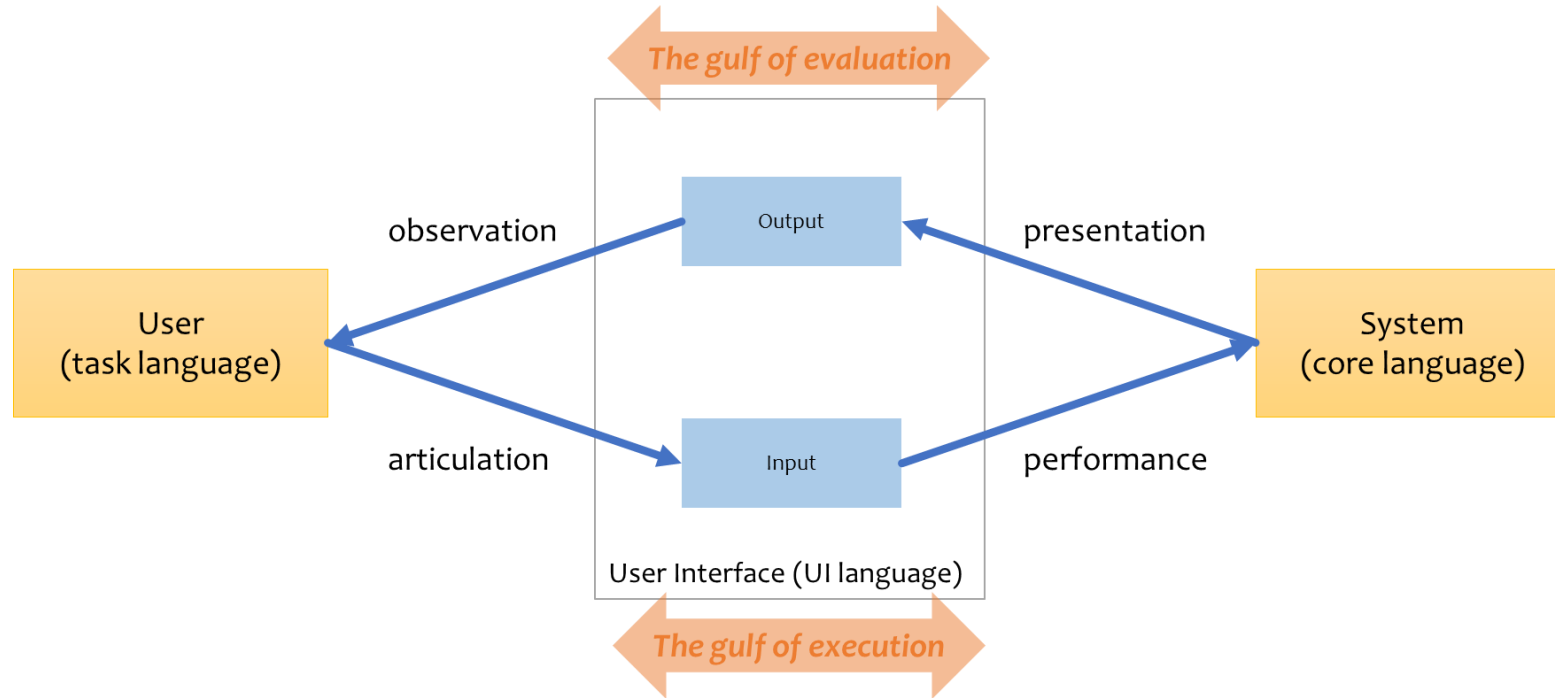
Types of theories

- Descriptive
 - UI elements, terminology, semantics
- Explanatory
 - Sequences of events with causal relationships
- Prescriptive
 - Guidelines for designers to make decisions
- Predictive
 - Comparison of design alternatives based on performance figures

Human capacity

- Motor task
 - Skill in pointing, clicking, ... movements
- Perceptual
 - Sensory inputs
- Cognitive
 - Problem-solving, short-/long-term memory

Norman's Action Models (Explanatory)



1. **Goal** (form the goal)
2. **Plan** (the action)
3. **Specify** (an action sequence)
4. **Perform** (the action sequence)
5. **Perceive** (the state of the world)
6. **Interpret** (the perception)
7. **Compare** (the outcome with the goal)

Consistent

delete/insert character

delete/insert word

delete/insert line

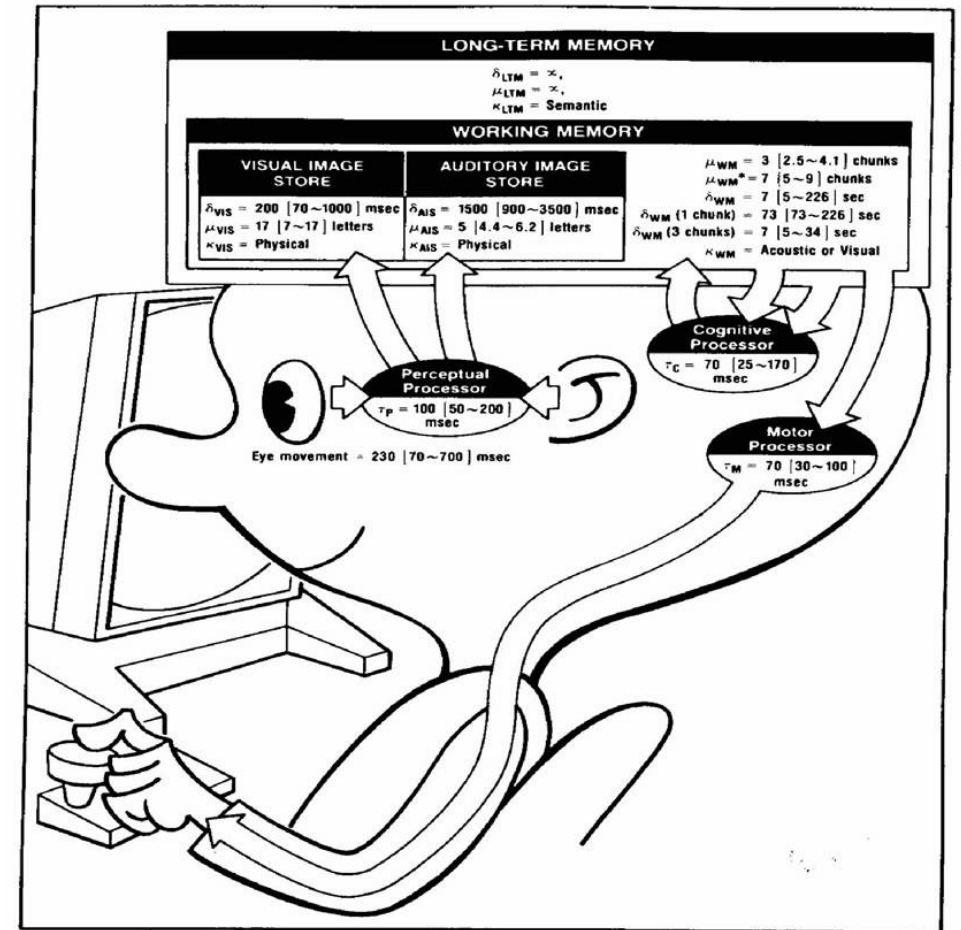
delete/insert paragraph

Consistency Theories (Prescriptive)

- **Consistency** of nouns (objects) and verbs (actions)
 - Reduces learning time and errors
- Consistency of
 - Color
 - Layout
 - Icons
 - Fonts and Font sizes
 - Button sizes
 - ...
- Inconsistencies might be used (sparingly!) for drawing attention

Human Processor Model

- Cognitive modelling method used to **calculate** how long it takes to perform a given task
 - prediction the system's performance (time to complete a task)
 - analogy between processing and storage areas of a computer with the perceptual, motor, cognitive and memory areas (working and long-term) of a person
- The calculations can be also used to determine the probability of a user remembering an item encountered during the task
- Underlies other usability techniques (GOMS, KLM, ...)



Card, Stuart K.; Moran, Thomas P; and Newell, Allen. Human-computer interaction – Psychological aspects, Erlbaum Associates, 1983, ISBN: 9780898592436

Memory

- Working memory (short-term)
 - small capacity ($7 \pm$ “chunks”)
 - +393475812632 vs. (+39) 347 581 2632
 - FGIHHJLMQ vs. FGI HHJ LMQ
 - rapid access ($\sim 70\text{ms}$) and decay ($\sim 200\text{ms}$)
 - pass to long-term memory after a few seconds of continued storage
- Long-term memory
 - huge (unlimited, almost)
 - slower access time ($\sim 100\text{ms}$) with little decay

Fitts's Law

- Demonstration: <https://fww.few.vu.nl/hci/interactive/fitts/>
- “The amount of time required for a person to move a *pointer* to a target area is a function of the distance to the target divided by the size of the target”
 - the longer the distance and the smaller the target's size, the longer it takes
 - created by psychologist Paul Fitts in 1954 examining the human motor system
- Widely used in HCI:
 - influenced the convention of making interactive buttons large (especially on finger-operated mobile devices)
 - the distance between a user's task/attention area and the task-related button should be kept as short as possible

Design Principles

The important aspects that we need to consider when creating a design.

The “What”

Design Principles

- More practical than Theories
- More fundamental, widely applicable, and enduring than Guidelines
- Fundamental principles (→ from Needfinding)
 - Determine user's skill levels
 - Identify the tasks
- 5 primary interaction styles
- 8 golden rules of interface design
- Prevent errors
- Automation and human control

Interaction Styles

- Direct manipulation
- Menu selection
- Form fill-in
- Command language
- Natural language

Advantages

Direct manipulation

Visually presents task concepts
Allows easy learning

Allows easy retention
Allows errors to be avoided
Encourages exploration
Affords high subjective satisfaction

Menu selection

Shortens learning
Reduces keystrokes
Structures decision making
Permits use of dialog-management tools
Allows easy support of error handling

Form fill-in

Simplifies data entry
Requires modest training
Gives convenient assistance
Permits use of form-management tools

Command language

Flexible
Appeals to "power" users

Supports user initiative
Allows convenient creation of user-defined macros

Natural language

Relieves burden of learning syntax

Disadvantages

May be hard to program
May require graphics display and pointing devices

Presents danger of many menus
May slow frequent users
Consumes screen space
Requires rapid display rate

Consumes screen space

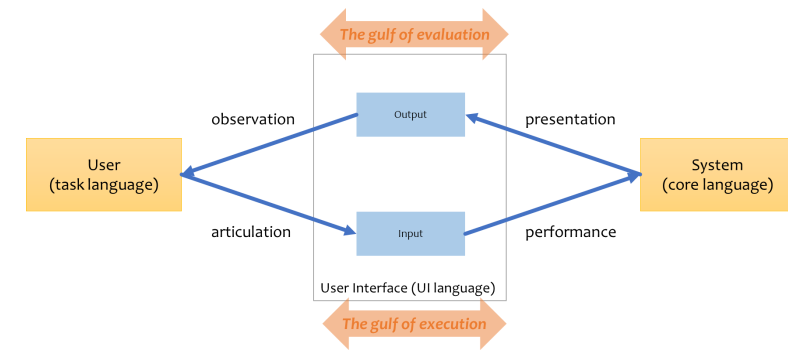
Poor error handling
Requires substantial training and memorization

Requires clarification dialog
May not show context
May require more keystrokes
Unpredictable

Norman's Principles from Action Models

Principles of good design

- State and the action alternatives should be visible
- Should be a good conceptual model with a consistent system image
- Interface should include good mappings that reveal the relationships between stages
- User should receive continuous feedback



User failures can occur

- Users can form an inadequate goal
- Might not find the correct interface object because of an incomprehensible label or icon
- May not know how to specify or execute a desired action
- May receive inappropriate or misleading feedback

The 8 Golden Rules of Interface Design

- Strive for consistency
- Cater to universal usability
- Offer informative feedback
- Design dialogs to yield closure
- Prevent errors
- Permit easy reversal of actions
- Keep users in control
- Reduce short-term memory load

The 8 Golden Rules of Interface Design

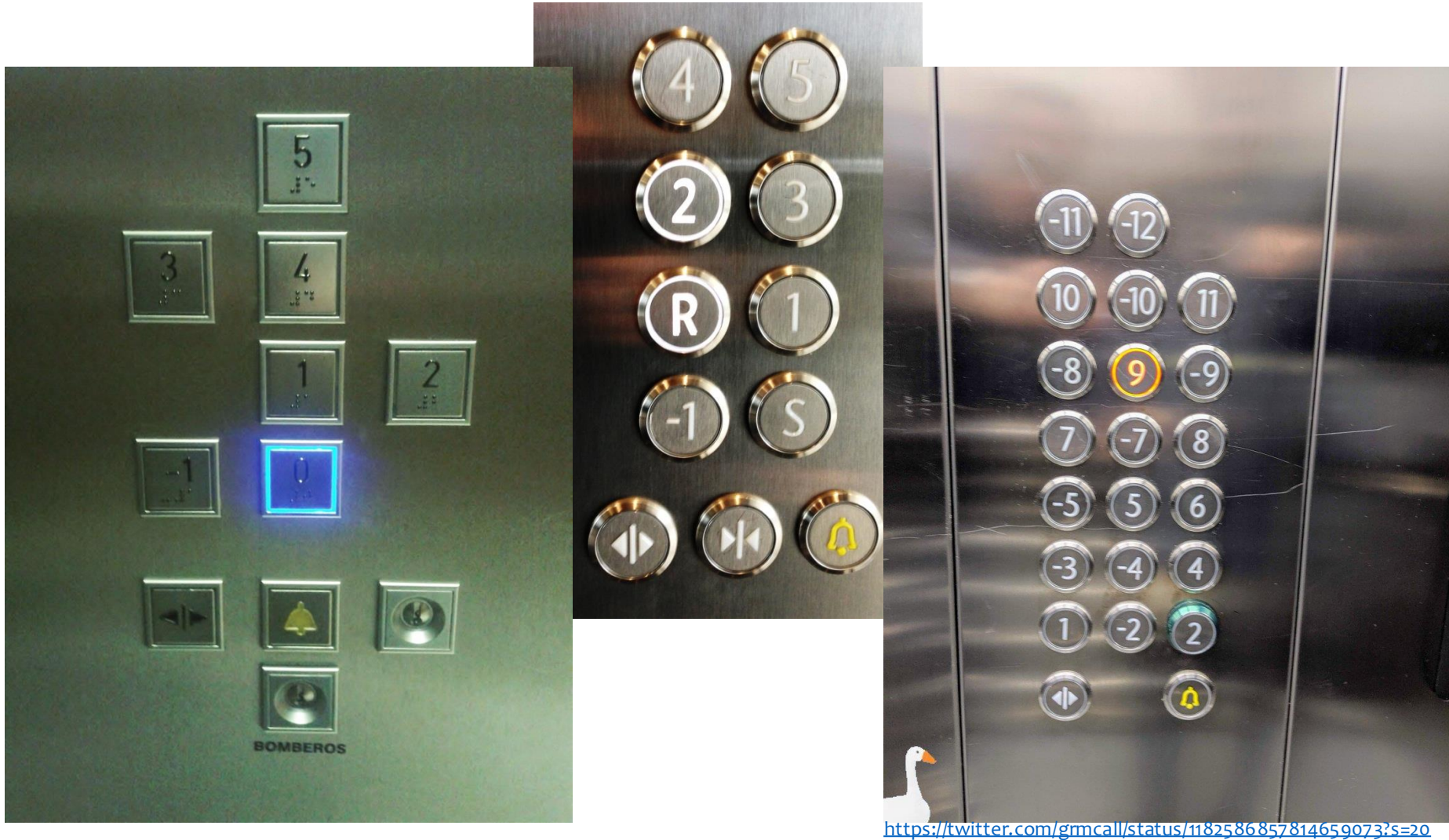
▪ Strive for consistency

- Cater to universal usability
- Offer informative feedback
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- Keep users in control
- Reduce short-term memory load
- Similar situations should lead to similar sequences of actions
- Same terminology in prompts, menus, help
- Color, layout, capitalization, fonts, ...
- Exceptions should be comprehensive and limited
 - E.g., delete, password echo

Internal Consistency



Consistency with mental models



Consistency of Interpretation

Order Timing:



- Which one is the selected one?
 - Color codes are ambiguous
 - No further internal clues
 - No external clues
- Does it represent the current status?
- Does it represent the status that we want to achieve?

Inconsistency for Drawing Attention

The border color and button text color in the “danger zone” are deliberately different than the rest of the page

Merge button

When merging pull requests, you can allow any combination of merge commits, squashing, or rebasing. At least one option must be enabled.

- ☒ **Allow merge commits**
Add all commits from the head branch to the base branch with a merge commit.
- ☒ **Allow squash merging**
Combine all commits from the head branch into a single commit in the base branch.
- ☒ **Allow rebase merging**
Add all commits from the head branch onto the base branch individually.

After pull requests are merged, you can have head branches deleted automatically.

- ☐ **Automatically delete head branches**
Deleted branches will still be able to be restored.

GitHub Pages

GitHub Pages is designed to host your personal, organization, or project pages from a GitHub repository.

- Source**
GitHub Pages is currently disabled. Select a source below to enable GitHub Pages for this repository. [Learn more.](#)
- None ▾
- Theme Chooser**
Select a theme to publish your site with a Jekyll theme using the master branch. [Learn more.](#)
- Choose a theme

Danger Zone

- Make this repository private**
Please [upgrade](#) [TdP-prove-finali](#)
- Transfer ownership**
Transfer this repository to another user or to an organization where you have the ability to create repositories. [Transfer](#)
- Archive this repository**
Mark this repository as archived and read-only. [Archive this repository](#)
- Delete this repository**
Once you delete a repository, there is no going back. Please be certain. [Delete this repository](#)

The 8 Golden Rules of Interface Design

- Strive for consistency
 - **Cater to universal usability**
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 - Keep users in control
 - Reduce short-term memory load
- Users with different needs: let the interface *adapt*, let content be *transformed*
 - Novices vs. experts. Young vs elderly. Web vs. mobile. Users with disabilities (→Accessibility)
 - **Responsive** design
 - International (and cultural) variations

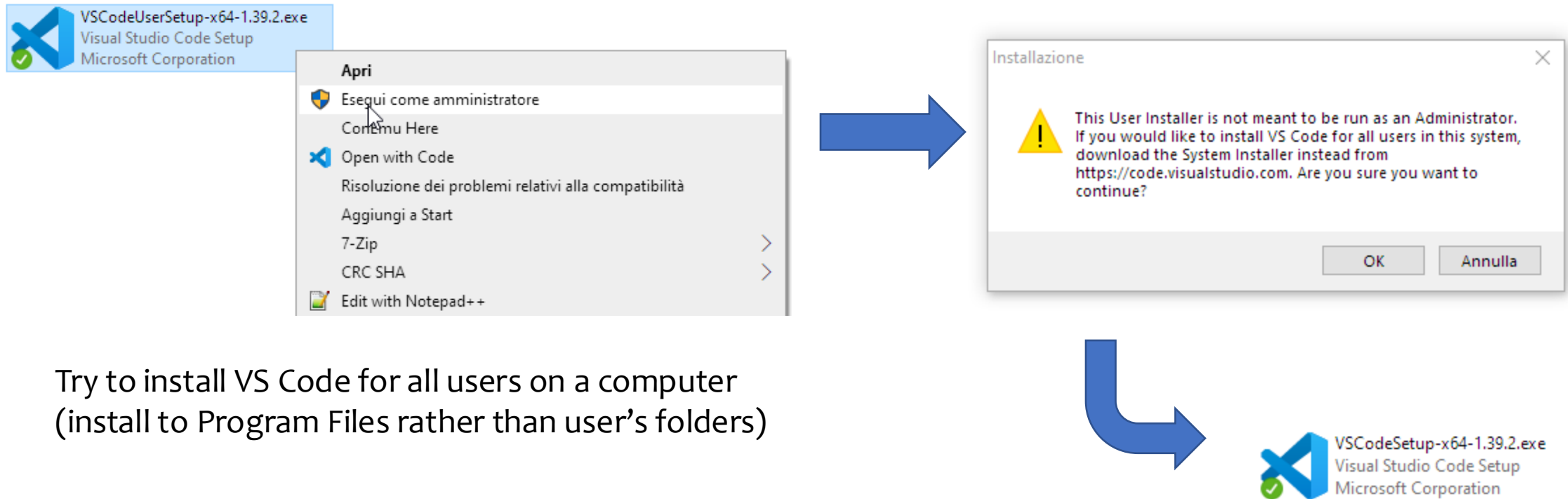
The 8 Golden Rules of Interface Design

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- For ***every*** human action, there should be an interface feedback
- Frequent and minor actions: light feedback
- Infrequent and major actions: stronger feedback
- Visual presentation of objects helps showing the changes (e.g., dim, highlight, grey out, ...)

Example



Example



Try to install VS Code for all users on a computer
(install to Program Files rather than user's folders)

The 8 Golden Rules of Interface Design

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- **Design dialogs to yield closure**
- Prevent errors
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- Keep users in control
- Reduce short-term memory load
- Every sequence of actions should have
 - Beginning
 - Development
 - End
- Provide clear feedback at end
 - Satisfy users
 - 'Delete' current task from their working memory, prepare for the next

Clear Dialog Sequence

SPORTELLLO ON LINE

ID STUDENTE: 447623

LA TUA RICHIESTA
SCADRA' TRA

66:23:52:23
gg hh mm ss

BANDO DI CONCORSO

Integrazione

ATTENZIONE:

Dal momento che hai dichiarato di esserti immatricolato nell'a.a. 2017/2018 e stai richiedendo i benefici EDISU per il settimo semestre puoi aggiungere la richiesta anche per il primo anno di laurea magistrale. Sei interessato?

☐ SI ☐ NO

REGIONALE PER IL DIRITTO ALLO STUDIO UNIVERSITARIO DEL PIEMONTE

OK

Submit

Confirm

Next

...?

The 8 Golden Rules of Interface Design

- Strive for consistency
- Cater to universal usability
- Offer informative feedback
- Design dialogs to yield closure
- **Prevent errors**
 - Permit easy reversal of actions
 - Keep users in control
 - Reduce short-term memory load
- Avoid the possibility of making errors
- Disable menu items, buttons, links, ... that are not applicable
- Prevent entering illegal characters
- Offer simple, constructive and specific instructions for recovery
 - Repair only the faulty part
- Errors should not alter application state (or make it easy to restore)

Error Prevention

ACCEDI ALL'AREA RISERVATA

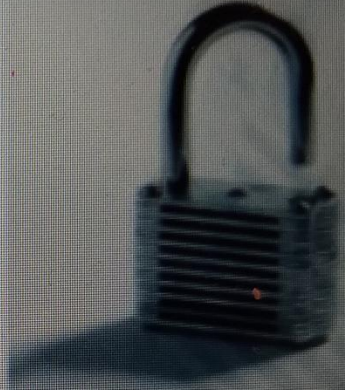
Attenzione: se la username è un codice fiscale inserirlo con le lettere MAIUSCOLE

Username

Password

Hai dimenticato la password? Clicca [QUI](#)

Sei un professionista della salute? [Registrati](#)



The 8 Golden Rules of Interface Design

- Strive for consistency
 - Cater to universal usability
 - Offer informative feedback
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 - Prevent errors
 - **Permit easy reversal of actions**
 - Keep users in control
 - Reduce short-term memory load
- Actions should be reversible (at the cost of extra development effort)
 - Relieves anxiety
 - Encourages exploration
 - Different levels of reversibility
 - A single action
 - A data-entry task
 - A complete group of actions

The 8 Golden Rules of Interface Design

- Strive for consistency
 - Cater to universal usability
 - Offer informative feedback
 - Design dialogs to yield closure
 - Prevent errors
 - Permit easy reversal of actions
 - **Keep users in control**
 - Reduce short-term memory load
- The interface should *always* respond to user actions
 - Minimize the tedious and lengthy tasks
 - Avoid surprises or changes in familiar behavior
 - Provide undo/redo, cancel/confirm

Example

*Come docente, quali problemi hai avuto nello svolgimento degli esami?

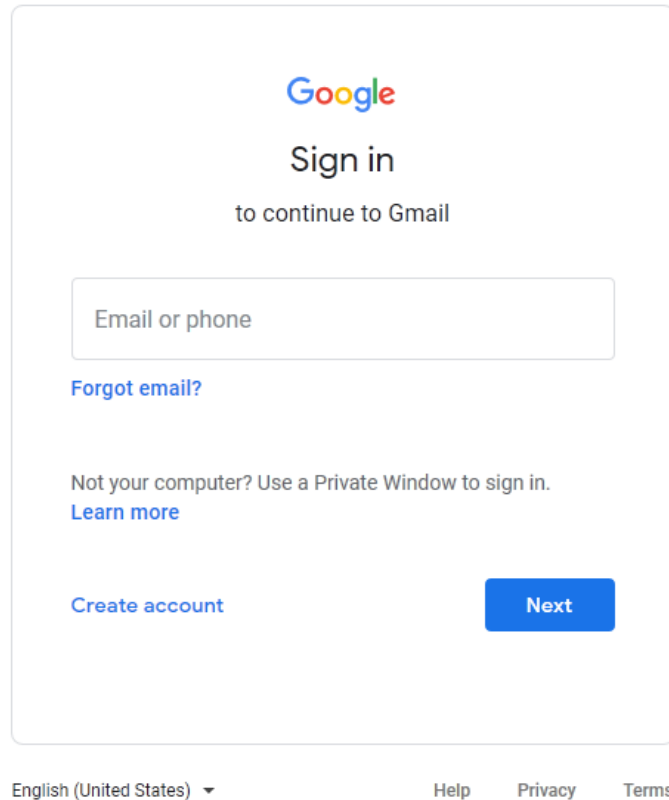
! Scegliere una o più delle seguenti opzioni

- ☒ Non ho avuto problemi
- ☒ Organizzazione dell'esame (poca chiarezza nella spiegazione delle modalità, sovrapposizione di date, procedure troppo confuse, deposito e consultazione documentazione complesso, ecc.)
- ☐ Dispongo di hardware/software inadeguato
- ☐ La connessione che uso è lenta/non continua
- ☐ Problemi ambientali (troppo rumore, confusione, scarsa possibilità di concentrazione)

The 8 Golden Rules of Interface Design

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 - Design dialogs to yield closure
 - Prevent errors
 - Permit easy reversal of actions
 - Keep users in control
 - **Reduce short-term memory load**
- Rule of thumb:
 - People can remember 7 ± 2 chunks of information
 - Information on a screen should not be needed (remembered) in the next screen
 - No entry of phone numbers (collect from addressbook), show website location, fit long forms in a single page, ...

Discussion – An Exception?



Google

Sign in
to continue to Gmail

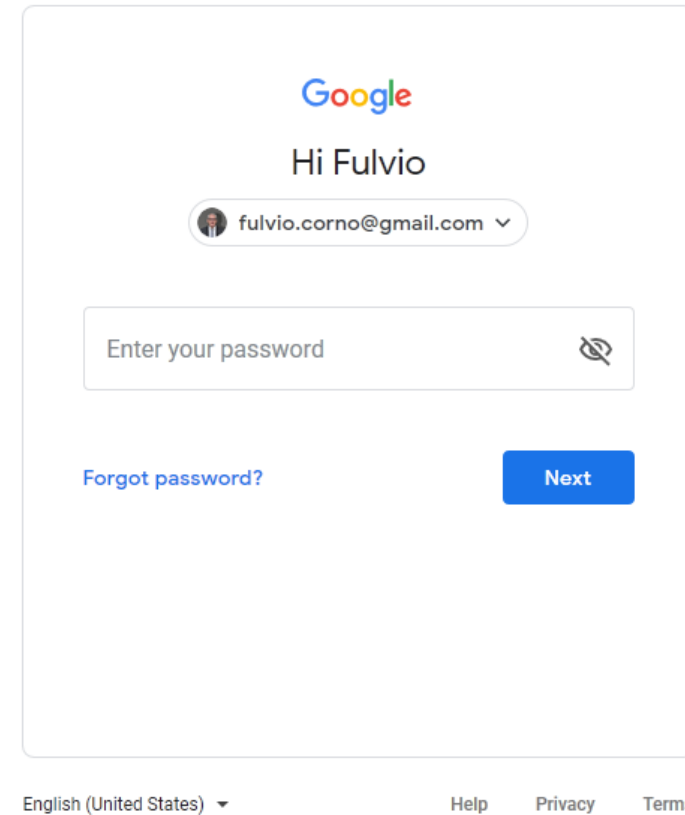
Email or phone

[Forgot email?](#)

Not your computer? Use a Private Window to sign in.
[Learn more](#)


[Create account](#) [Next](#)


English (United States) ▼ Help Privacy Terms



Google

Hi Fulvio

 fulvio.corno@gmail.com ▼

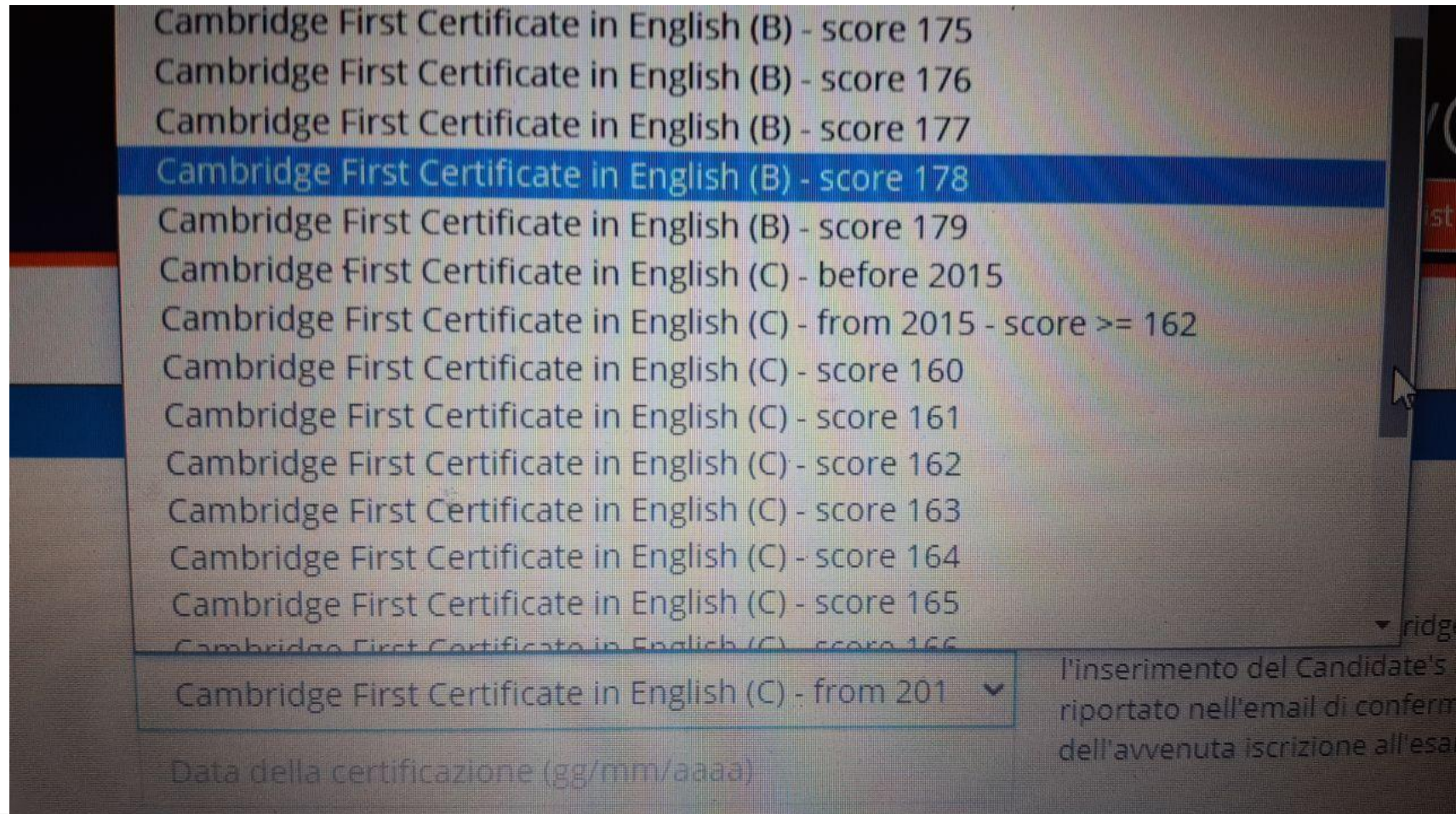
Enter your password 

[Forgot password?](#) [Next](#)

English (United States) ▼ Help Privacy Terms

Exceptions...

sometimes entering is better than selecting



Design Principles by Benyon (I)

(adapted from Norman, Nielsen and others)

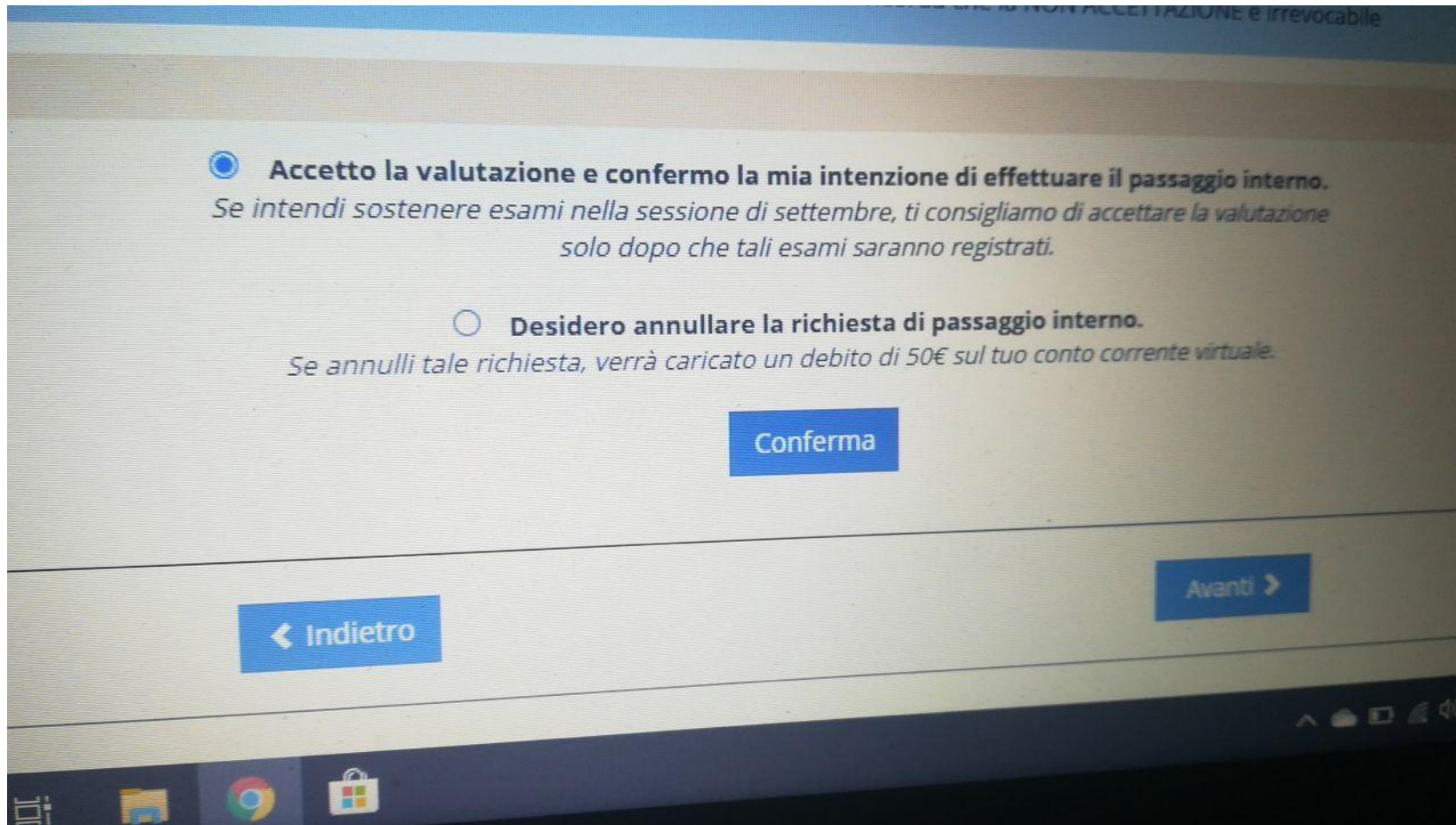
- **Learnability** – helping people access, learn and remember the system
 - *Visibility* – ensure that things are visible, so users can see what functions are available and what the system is currently doing
 - *Consistency* (→above)
 - *Familiarity* – use language and symbols that the intended audience will be familiar with
 - *Affordance* – design things so it is clear what they are for (e.g., buttons should be pushed). Maps the (perceived) properties of the objects with how they can be used

Design Principles by Benyon (II)

(adapted from Norman, Nielsen and others)

- **Effectiveness** – giving users the sense of being in control, knowing what to do and how to do it
 - *Navigation* – support people in moving around the different sections: maps, directional signs, information signs
 - *Control* – who is in control for the next interaction? Clear and logical mapping between controls and their effect. Relationships with the “side effects” in the real world
 - *Feedback* (→feedback above)

Example: Navigation and Control?



Design Principles by Benyon (III)

(adapted from Norman, Nielsen and others)

- **Safety and Security**
 - *Recovery* (→error recovery)
 - *Constraints* (→prevent errors)
- **Accommodation** – offer an interaction way that suits the users
 - *Flexibility* (→universal usability)
 - *Style* – stylish, attractive, nice-looking
 - *Conviviality* – polite, friendly, pleasant. No abrupt interruptions

Norman's Seven Principles for Transforming Difficult Tasks into Simple Ones

- Use both knowledge in the world and knowledge in the head
- Simplify the structure of tasks
- Make things visible
- Get the mappings right
- Exploit the power of constraints, both natural and artificial
- Design for error
- When all else fails, standardize



<https://asktog.com/atc/principles-of-interaction-design/>

First Principles of Interaction Design (Bruce Tognazzini, 2014)

AskTOG
Interaction Design
Solutions for the
Real World

Home Interaction Design Section Living Section About Bruce Tognazzini - NN/g

First Principles of Interaction Design (Revised & Expanded)
5 Mar 2014 in First Principles, HCI Design, Human Computer Interaction (HCI), Principles of HCI Design, Usability Testing

The following principles are fundamental to the design and implementation of effective interfaces, whether for traditional GUI environments, the web, mobile devices, wearables, or Internet-connected smart devices.

Help!

This is a huge revision. I expect I have made mistakes. Please leave corrections and suggestions in the Comments at the end. If you have better examples than I'm using, please include them as well, but give me enough information about them, including links or cites, that I can make use of them.

This revision features new examples and discussion involving mobile, wearables, and Internet-connected smart devices. However, the naming and organization remains the same except for three changes: I have shortened the name of one principle to extend its reach: "Color Blindness" is now simply Color and includes more than just color blindness. I've added one new principle, Aesthetics, and brought back two old principles, Discoverability and Simplicity. I dropped them from the list more than a decade ago when they had ceased to be a problem. Problems with Discoverability, in particular, have come roaring back.

What has changed greatly is the level of detail: You will find many new sub-principles within each category, along with far more explanation, case studies, and examples.

Previous Version & Its Translations. (Google's machine translator for the latest edition, to your right). I'm continuing access to the original version of First Principles because it is cited in many scientific papers.

- Belarusian
- Dutch
- English
- German
- Italian
- Portuguese
- Spanish
- Russian
- Ukrainian

Introduction

Effective interfaces are visually apparent and forgiving, instilling in their users a sense of control. Users quickly see the breadth of their options, grasp how to achieve their goals, and can settle down to do their work. Effective interfaces do not concern the user with the inner workings of the system. Work is carefully and continuously saved, with full option for the user to undo any activity at any time. Effective applications and services perform a maximum of work, while requiring a minimum of information from users.

Because an application or service appears on the web or mobile device, the principles do not change. If anything, applying these principles—all these principles—becomes even more important.

I Love Apple, But It's Not Perfect

I've used many example drawn from Apple products here, often as examples of bad interface practices. Apple has made many revolutionary breakthroughs in interaction technology, a trend I fully expect will

First Principles

- Aesthetics
- Anticipation
- Autonomy
- Color
- Consistency
- Defaults
- Discoverability
- Efficiency of the User
- Explorable Interfaces
- Fitts's Law
- Human-Interface Objects
- Latency Reduction
- Learnability
- Metaphors
- Protect Users' Work
- Readability
- Simplicity
- State: Track it
- Visible Interfaces

My Upcoming Courses/Conferences

My Interaction Design course: Build a firm foundation in interaction design with this three day course. Spring 2014 schedule:

New York: March 9-11, 2014
Atlanta: April 28-30, 2014
Chicago: May 12-14, 2014
London: June 1-3, 2014
San Francisco: June 22-24, 2014

You may be coming in cold from engineering, graphic design, psychology, or beyond. You may already be an interaction designer wanting to "fill in the blanks," establishing a more solid theoretical and practical base. You may be taking on the management of a group of HCI designers. I've designed this course for each one of you.

[Aesthetics](#)
[Anticipation](#)
[Autonomy](#)
[Color](#)
[Consistency](#)
[Defaults](#)
[Discoverability](#)
[Efficiency of the User](#)
[Explorable Interfaces](#)
[Fitts's Law](#)
[Human-Interface Objects](#)
[Latency Reduction](#)
[Learnability](#)
[Metaphors](#)
[Protect Users' Work](#)
[Readability](#)
[Simplicity](#)
[State: Track it](#)
[Visible Interfaces](#)

References and Acknowledgments

- Ben Shneiderman, Catherine Plaisant, Maxine S. Cohen, Steven M. Jacobs, and Niklas Elmqvist, Designing the User Interface: Strategies for Effective Human-Computer Interaction
 - Chapter 3: Guidelines, Principles, and Theories
- David Benyon: Designing Interactive Systems, Pearson, 2014
 - Section 4.5: Design Principles
- COGS120/CSE170: Human-Computer Interaction Design, videos by Scott Klemmer, https://www.youtube.com/playlist?list=PLLssT5z_DsK_nusHL_Mjt87THSTlgrsyJ
- Fitts' Law: <https://www.interaction-design.org/literature/topics/fitts-law>
- Thanks to Fulvio Corno, past teacher of the course, for his work on some of these slides

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