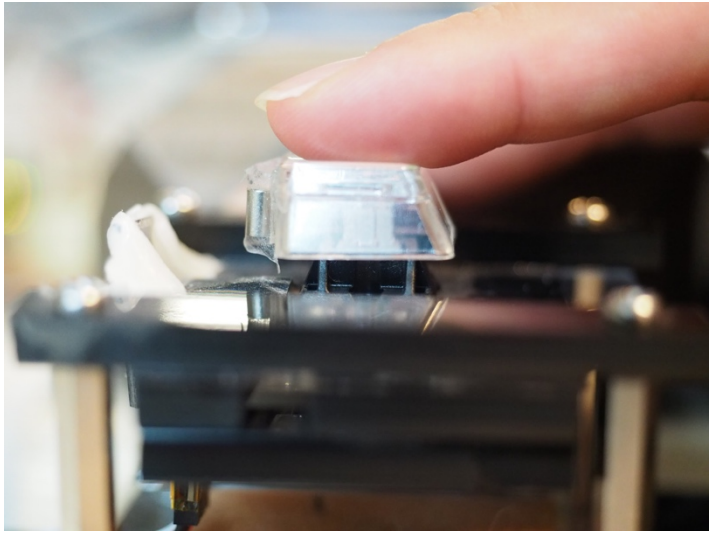
Aalto University

Engineering for Humans: Introduction

ELEC-D7010
April 20, 2021
Antti Oulasvirta
Aalto University

Hi!

I lead the User Interfaces group at the Aalto University School of Electrical Engineering. I'm also part of FCAI, the Finnish Center for Artificial Intelligence (fcai.fi)



We model human performance in human-technology interaction

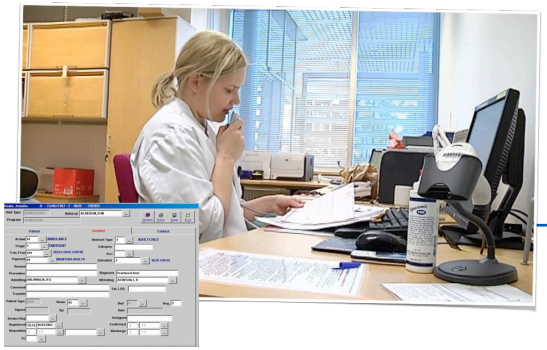
... and develop **new algorithmic principles** of design and interaction

...in order to **improve** user interfaces for human use

Welcome!

Contents today

1. Motivation
2. Human Factors Engineering
3. Course Organization
4. Failures and Epic Failures
5. Design Heuristics
6. Assignment 1



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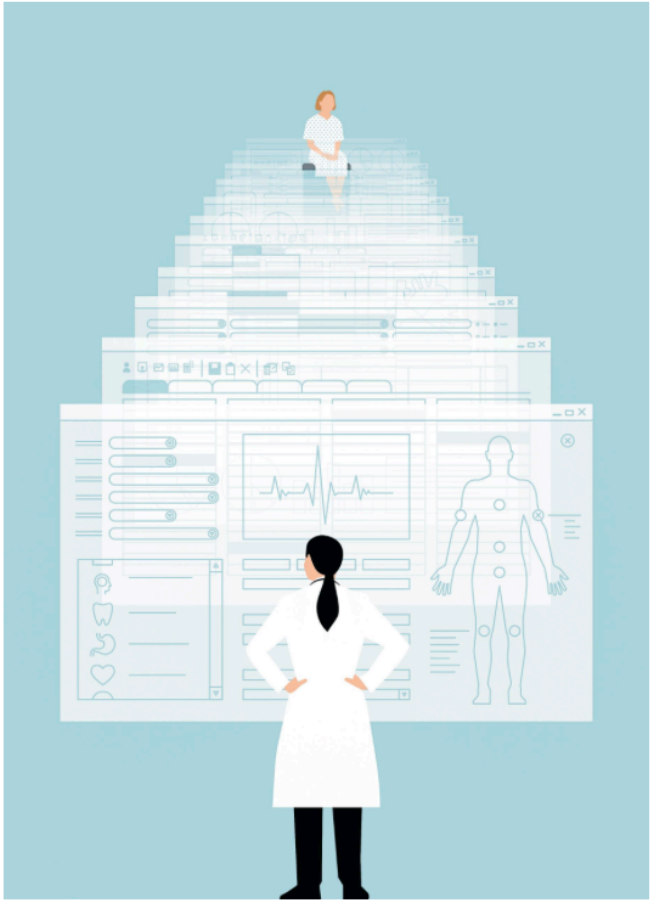
Motivation

In random order

Understanding users is a top 3 reason for failure/success of IT projects

Also: 10-30% of R&D budgets goes to user interfaces (2021)

Design of technology affects well-being



ANNALS OF MEDICINE NOVEMBER 12, 2018 ISSUE

WHY DOCTORS HATE THEIR COMPUTERS

Digitization promises to make medical care easier and more efficient. But are screens coming between doctors and patients?

By Atul Gawande

November 5, 2018

Humans are beyond intuition

Can you read this?

> **Aoccdrnig to rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a total mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.**

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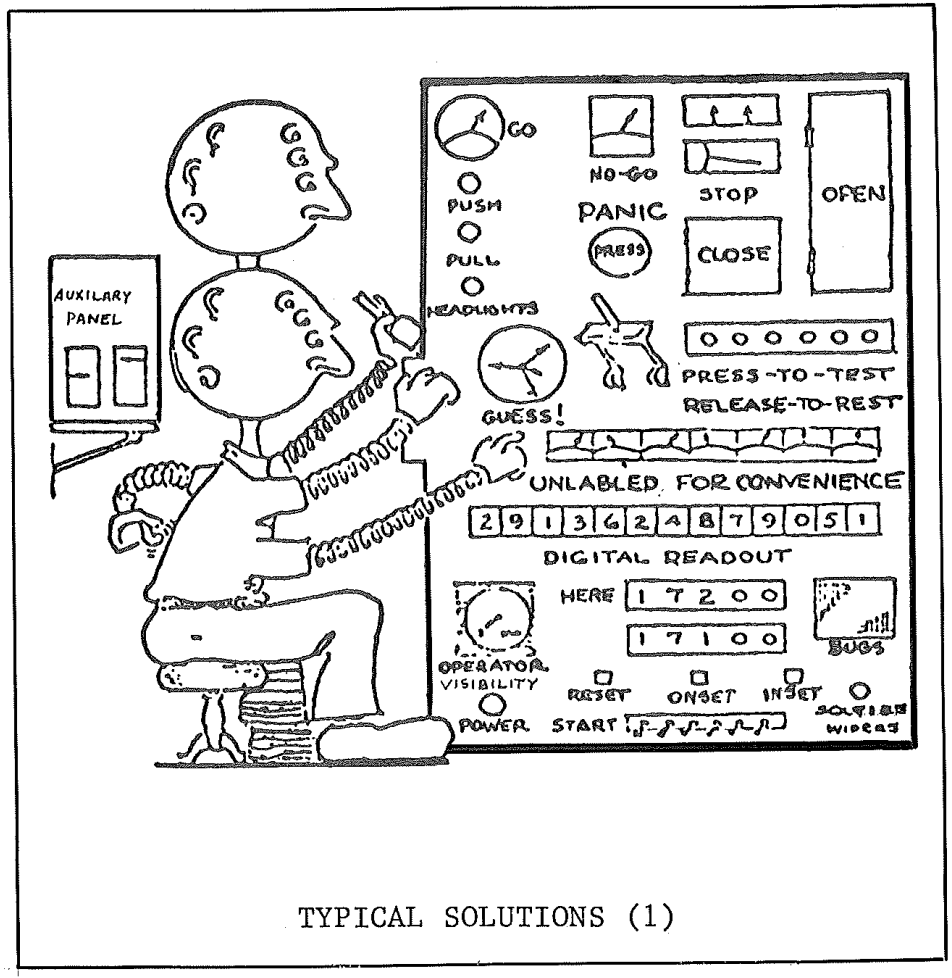
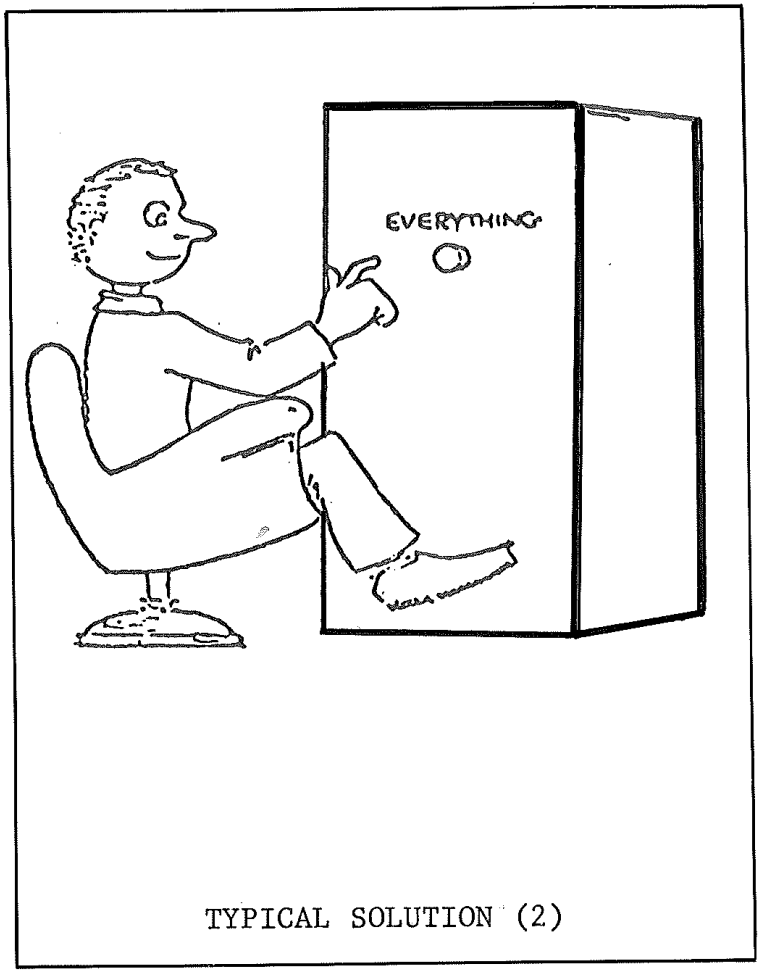
People are different

Good design reduces complexity



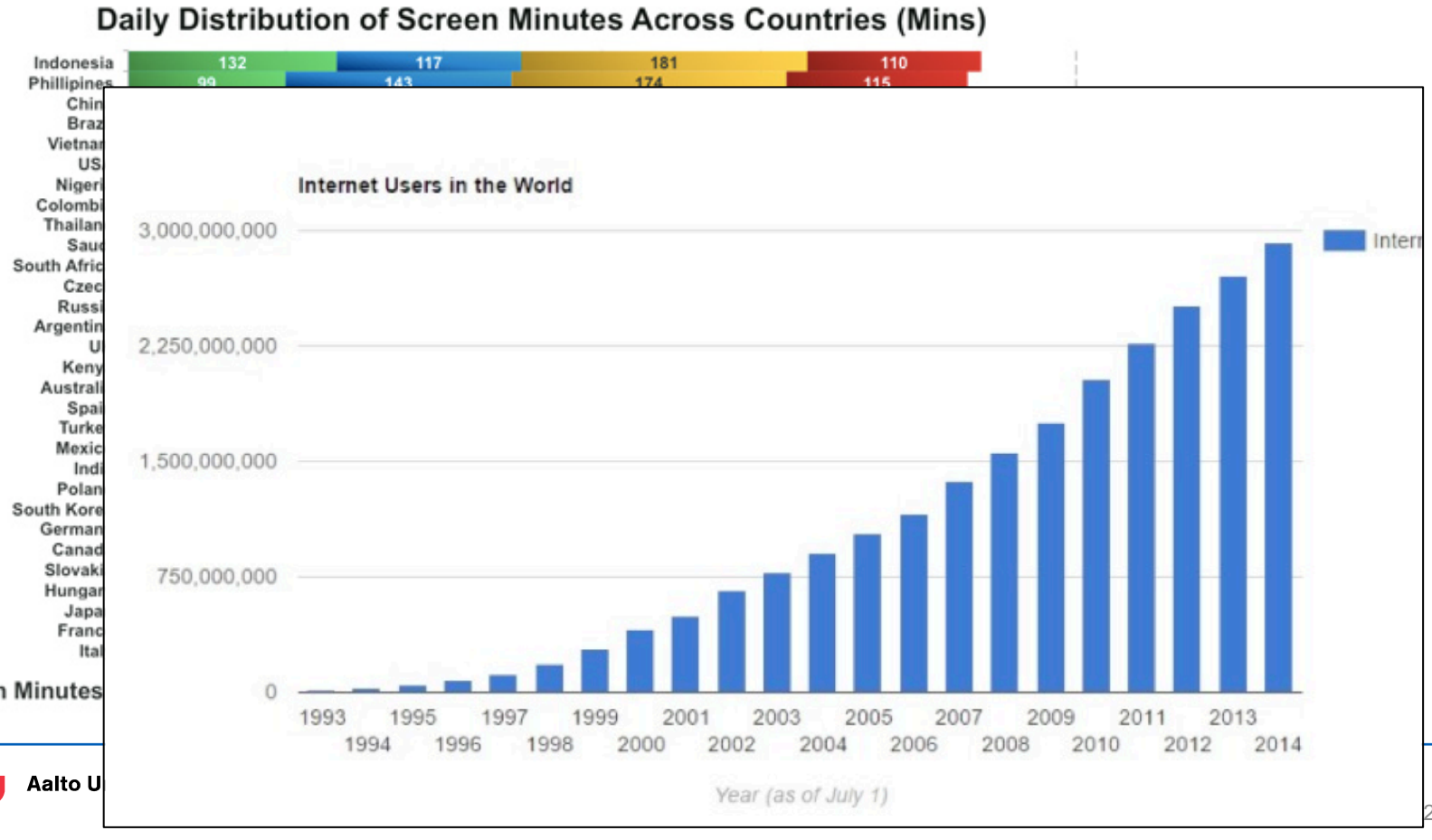
TYPICAL SOLUTIONS (1)



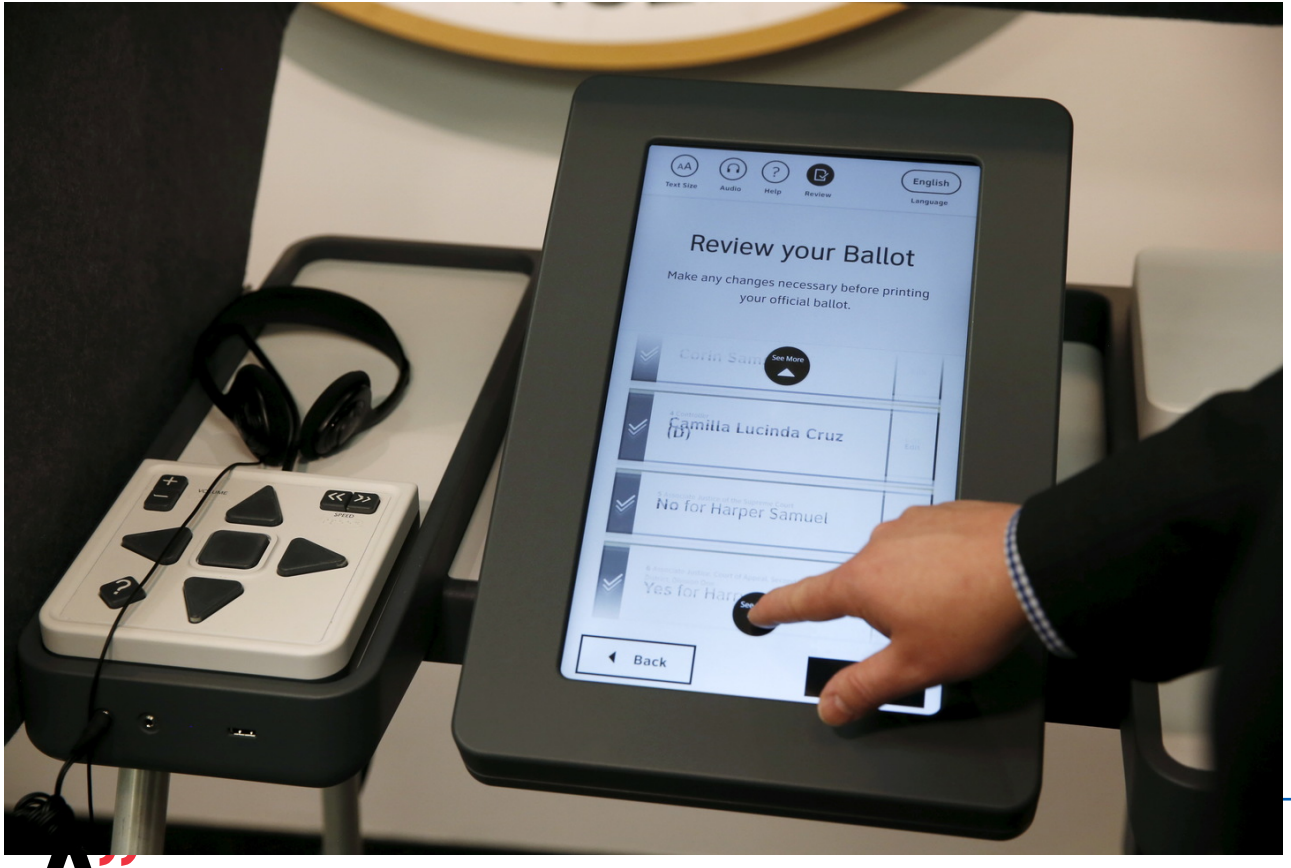
TYPICAL SOLUTION (2)

Poor design is a cause of death

Design impacts a large number of people

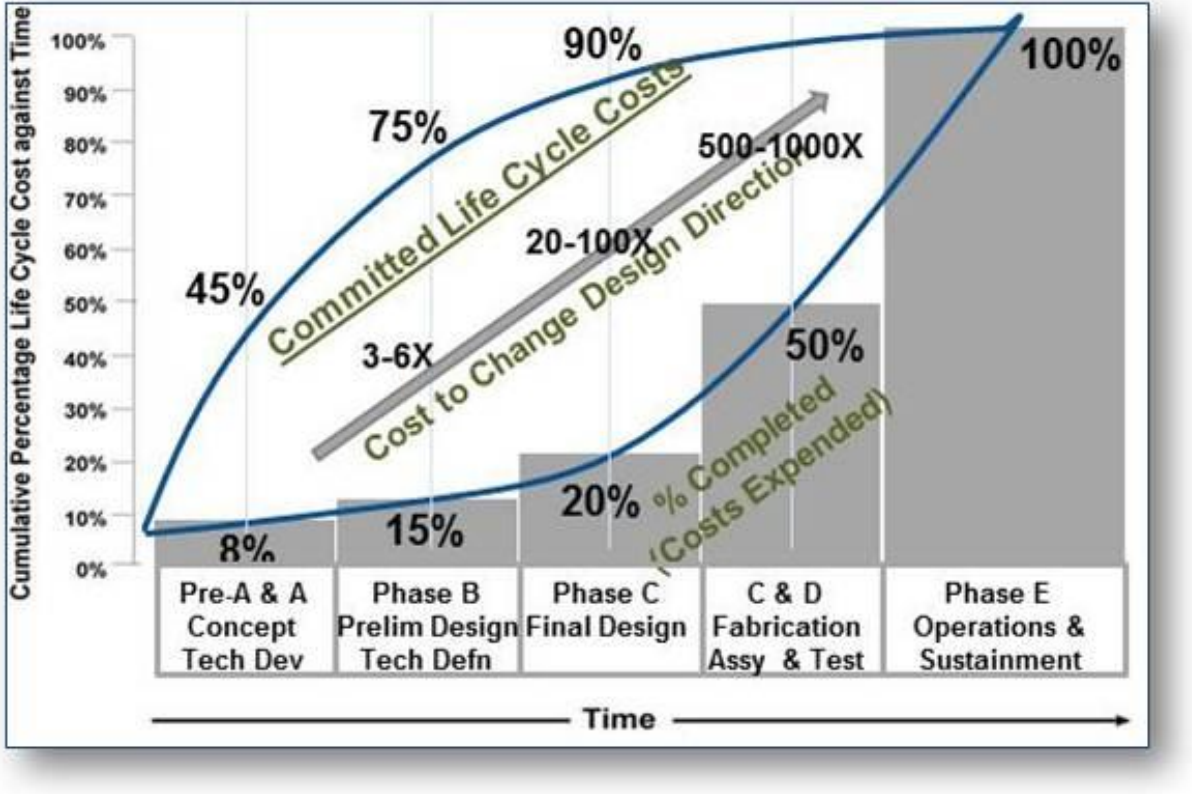


Legal responsibility



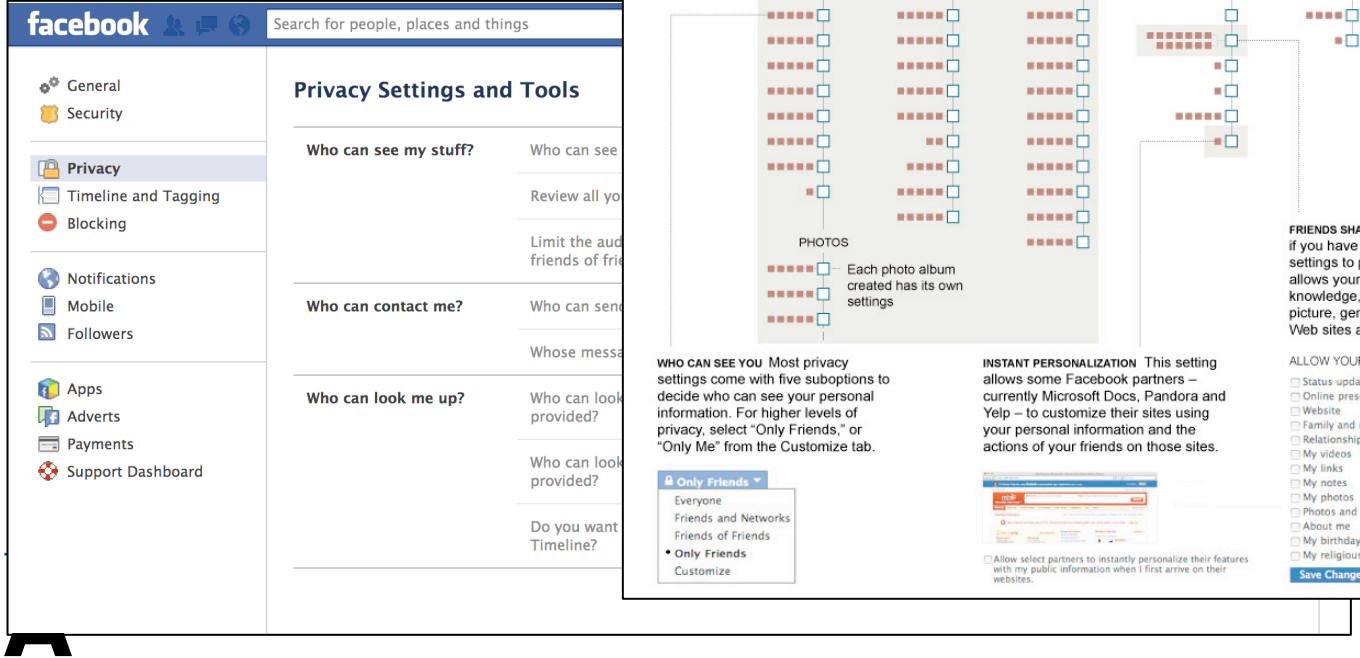
Reduce development costs

The later you account for human factors, the more it costs



“Locked in costs”

Fight dark patterns



conferencing. XMPP proponents, on the other hand, tout an XML-based data transport technology that is built to manage IM and presence.

As it now stands, real-time communications in the enterprise is in its infancy. The long-term goal is to develop a single protocol that not only unifies real-time messaging with the tracking and notification of worker presence and availability but also allows for those functions to be performed across corporate boundaries and on a vast range of devices.

[Take control of your Mac with 30 essential MacOS command-line tips. | Cut to the key news in technology trends and IT breakthroughs with the InfoWorld Daily newsletter, our summary of the top tech happenings.]

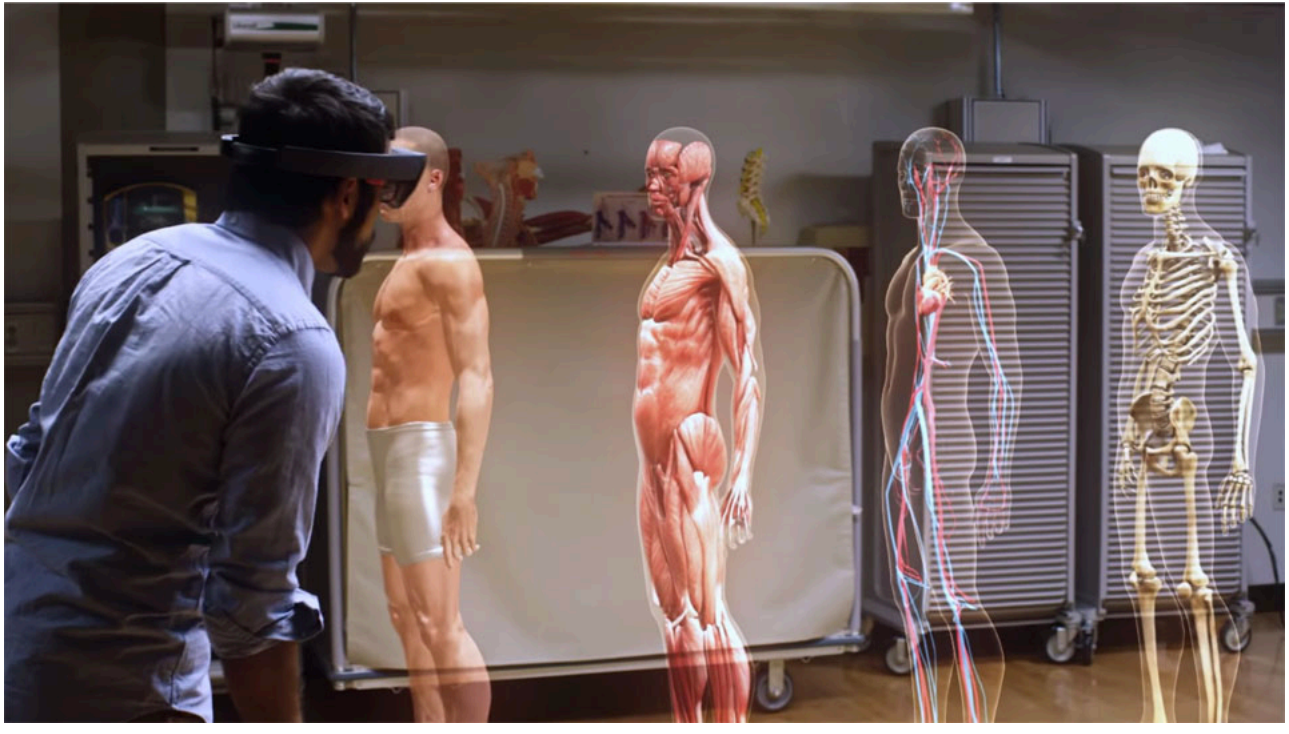
Beyond basic IM system interoperability, a common protocol for IM and presence holds the key for unlocking valuable state awareness from the tethers of a stand-alone system. The challenge of stitching availability awareness into a variety of systems — both within and between enterprises — is piquing the interest of heavy hitters. IBM and Microsoft have stepped up to the plate to declare standards compliance, regardless of whether the market or the protocols themselves are ready.

"It is very important here at this [early] stage of enterprise IM [for vendors] to say, 'We are compliant with these standards.' It is more important to say it than to do it," says Robert Mahowald, research manager at IDC in Framingham, Mass.

The favored SIMPLE

Innovate new experiences

Reinvision work practices



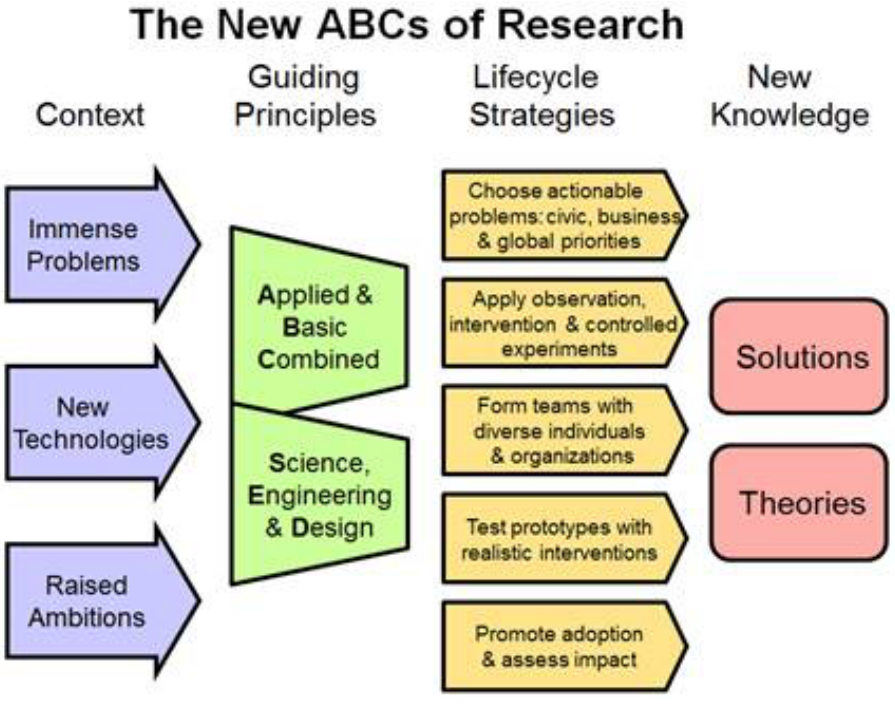
Compete with usability

Improve performance

Illuminate emerging human-related phenomena

Case in point: Zoom fatigue

Human factors engineering is part of modern innovation



Summary: Why study human factors?

1. Increase efficiency, enjoyability, and robustness of technology
2. Avoid catastrophies and loss of life
3. Offer proofs and guarantees for design
4. Improve the hit rate of user-centered design
5. Reduce development time of ICT
6. Harness new technological innovations quicker

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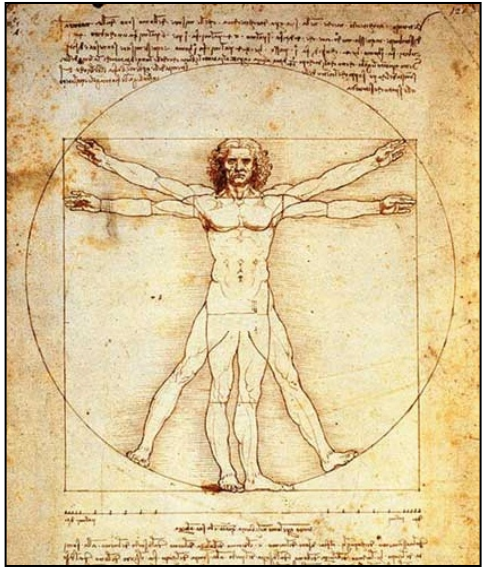
Human factors engineering

Human is the criterion for decisions

Human factors starts from human needs, limitations, and capabilities

- Perception
- Attention
- Motor control
- Reasoning
- Sensory capabilities
- Working memory
- Long-term memory and learning
- Biomechanics and anthropometrics
- Needs, motivations
- …



Formulate measurable objectives related to people

Key objectives for engineering

Improve effectiveness

Improve efficiency

Improve safety

Improve satisfaction

Improve experience

Decrease errors

Reduce fatigue

Reduce the learning curve

Ensure operability and usability

Meet user’s needs and wants

Positive perception of product

This course: Key design goals

Product fit

- Does the product meet the users needs and expectations? Are the right features included, do they—and can they—use those features?

Errors

- Objective measure provided by the overall task error rate and the frequency and severity of the error. How many users make mistakes and are they able to recover?

Efficiency

- Objective measure yielded by time on task. How long does it take the user to complete the task? Often correlated with satisfaction.

Satisfaction

- Satisfaction measures are subjective measures provided by the user.

Learnability

- How easy the system is to learn. Can be expressed by a learning curve and typically is associated with error and efficiency rates over time to show trending

A multi-disciplinary field

Human Factors Engineering (HFE)

- **Integrates** human considerations within the system development process
- **A comprehensive**, multidisciplinary, technical and management process
- **Ensures** that the human contribution toward system performance is consistently addressed throughout the system life cycle

Beyond luck and intuition

Understanding: Identify factors behind human performance, error, behavior and experience

Analysis: Identify solutions with desirable properties

Quality guarantees: Offer guarantees for solutions, implement them in standards and methods

Insight: Facilitate idea-generation

Multiple levels of analysis

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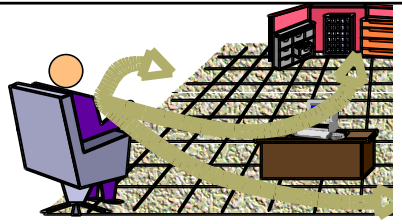
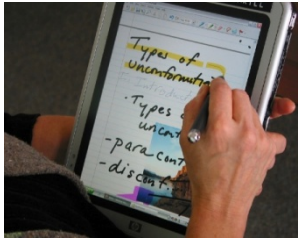
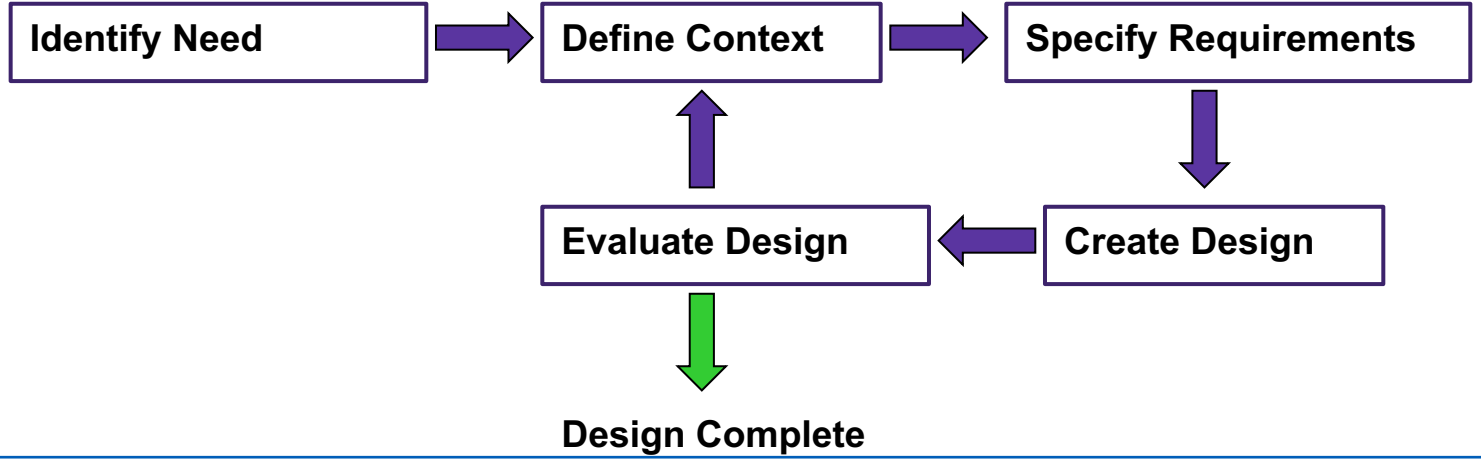
10^4 (hours) 10^3 10^2 (mins)	RATIONAL	Adaptive Behavior	
10^1 10^0 (sec) 10^{-1}	COGNITIVE	Immediate Behavior	
10^{-2} 10^{-3} (msec) 10^{-4}	BIOLOGICAL	Physiological events	

A human-centred design process

There are 4 fundamental steps to the process:

- **Define** the context of use: what are the tasks or objectives associated with the design.
- **Specify** requirements: what expectations or requirements must the design accommodate
- **Create** design solutions: prototyping, rendering, mockup building
- **Evaluate** designs: modeling, usability testing, and ergonomic assessment



Example: NASA's HFE process

a. Operation and scenario development

b. Task analyses

c. Function allocation between humans and systems

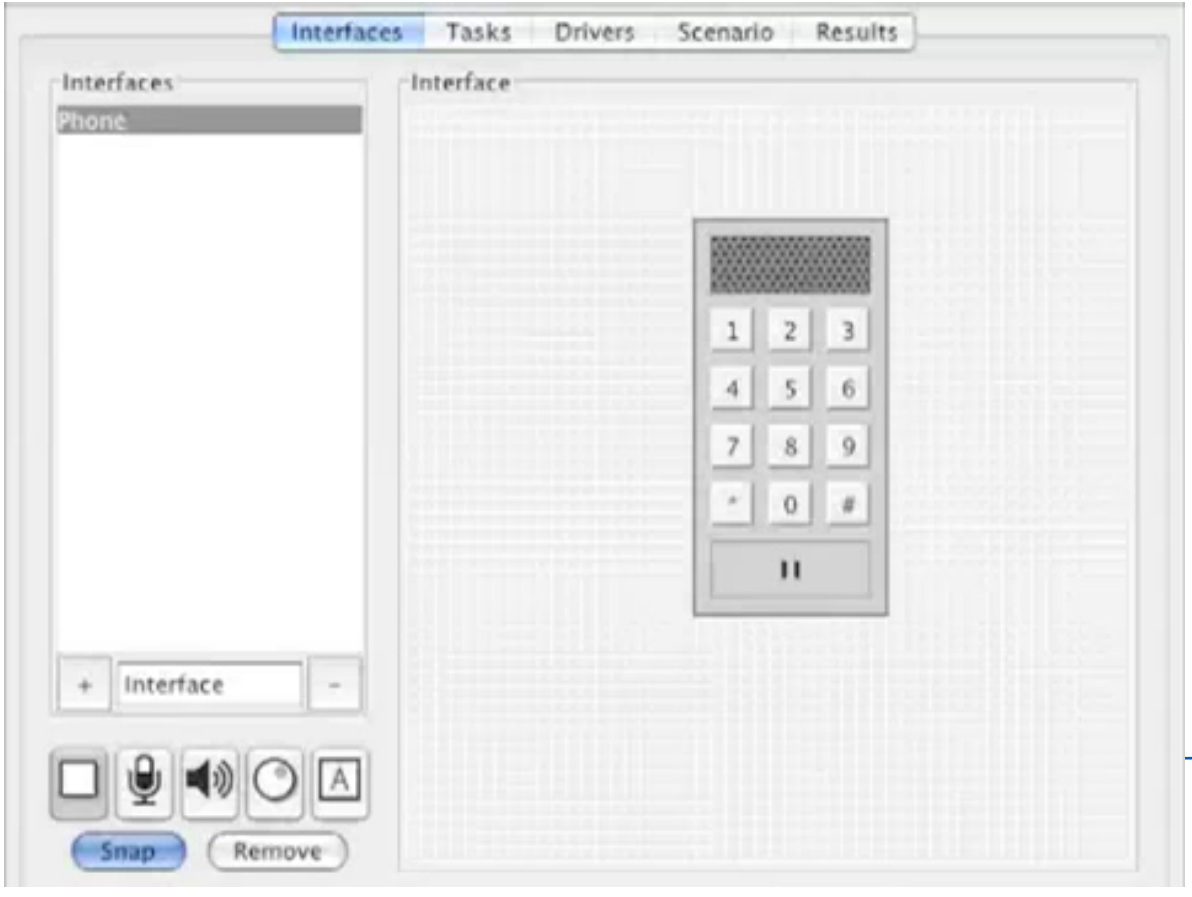
d. Allocation of roles and responsibilities among humans

e. Iterative conceptual design and prototyping

f. Empirical testing, e.g., human-in-the-loop, testing with representative population, or model-based assessment of human-system performance

g. In-situ monitoring of human-system performance during flight.

Models and simulations example: Distract-r



Dario Salvucci

This course

1. Design as problem-solving: Finding the best solution for a given problem definition systematically, either via models or via empirical research

2. Models and theories of human performance

3. Empirical methods for evaluating designs

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Course organization

Learning objectives

First touch with human factors engineering

1. **Understand** basic human factors, behavior and experience
2. **Formulate** tractable questions concerning design
3. **Solve** them using models, theories, and empirical methods
4. **Analyze** the strengths and weaknesses of solutions
5. **Gather** information to assist in analysis
6. **Assess** design solutions critically
7. **Familiarize** with standards and processes (more on other courses)
8. ***Learn to learn***

Example student project: HSL card reader redesign case 2017

Opiskelijat: Näin HSL:n matkakortinlukijasta tulisi looginen ja nopea

18.1.2017 09:35:02 EET | Aalto-yliopisto

Jaa

Toimivamman käyttöliittymän suunnittelussa hyödynnettiin käyttäjien ideoita ja matemaattista mallinnusta.

Activities overview

Lectures

Tuesdays 10.15am-12pm (Zoom)

Thursdays 12.15pm-2pm (Zoom)

No dedicated exercise sessions (contrary to Oodi)!

Assignments: Typically 1 mandatory and 1 optional per lecture

Released Tuesday evening → Due by following Mon at 21.59

Released Thursday evening → Due by following Wed at 21.59

Course participation

Lectures: mandatory (up to 3 absences are OK)

Assignments: 1 mandatory task *per lecture* worth 5 points,
1-2 optional tasks (each 5 points)

Readings are optional unless otherwise mentioned

Exam is mandatory. Materials announced in early May

Grading (1-5)

Exam (40%):

Maximum 50 points

Minimum for passing: 20 points

Assignments (60%):

Maximum: 100 points

Minimum for passing: 40 points

Note

- Points cannot be moved between categories

About assignments

- **One assignment sheet** per lecture, consisting of one mandatory and 1-2 optional tasks (each 5 points)
  - Types: design problems, theoretical problems, numerical problems, empirical tasks, (maybe) essays
- **Points** you can earn per lecture: 0-10 or 0-15
  - **If you miss an assignment or get a poor score, that's fine!** You can compensate by doing optional tasks
- **All submissions via MyCourses: Deadline always at 21.59**
  - *We recommend submitting in advance due to issues with last minute congestion*
- **Grades will appear in MyCourses** (after 1-2 weeks)

Tips for assignments

Start early, don't leave this to the last hours. Ensure you have tried a solution

Pre-allocate sufficient time each week for assignments

Choose optional assignments by assessing (critically) which you can solve within your time budget

Report your solutions well!

Try hard. If you bump into an obstacle, you can:

- Email teachers
- Give up early and do some other task

Note that assignments will take a bit more time in the beginning of the course

Exam (MyCourses)

Duration: 3 hours

Readings will be announced in early May in MyCourses

Scoring: Max 50 points, minimum for passing: 20

Tasks: 10 tasks, one per page, 5 points each

Types: definitions, essays, identifications, analyses, and simple numerical tasks. Focus on conceptual understanding and applications

Grading: 0-5 per task. Answers must base on course materials only. Story-telling will be penalized

Equipment: An open book exam

We will do a practice exam in May

Course policies 1/2

! **ALL EXERCISES are to be done on your own. Do not do them in pairs or groups.**

! **PLAGIARISM**: In cases of plagiarism, we will follow the policy of Aalto University. While we recommend talking with other students and learning from the Internet, exercise solutions must be executed individually and by the student. The student must be ready to explain his/her solution when requested.

Course policies 2/2

- **INACTIVITY**: A student who is inactive for two or more weeks may be removed from the course. Students who have already reached the assignment point minimum are exempted.
- **DEADLINES**: Please observe the deadlines for returning the exercises. No extensions will be granted.
- **EQUIVOCATION**: When grading exercises and exams, we may punish for "fishing" points by equivocating in answers. If you do not know the answer, just say so.

Changes from last year

One lecture changed

Some materials have been dropped

Changes in guest lecturers

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Fails and Epic Fails

ELEC-D7010 Engineering for Humans

Antti Oulasvirta
Aalto University

Learning objectives

1. Epic Fails
And how **design heuristics** would have stopped them

Knows and can apply basic design heuristics

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When Design Fails

Trivial design failures are unacceptably too common

In the following, I will

- Present cases of desing failures, asking for your input on what went wrong
- Present **design heuristics** that would have fixed these issues

Heuristics, or rules-of-thumb, describe good practices and objectives in design

- ”Design wisdom” in a verbal, actionable form
- We will see many of them later...

Warm-up: What was wrong with this UI?


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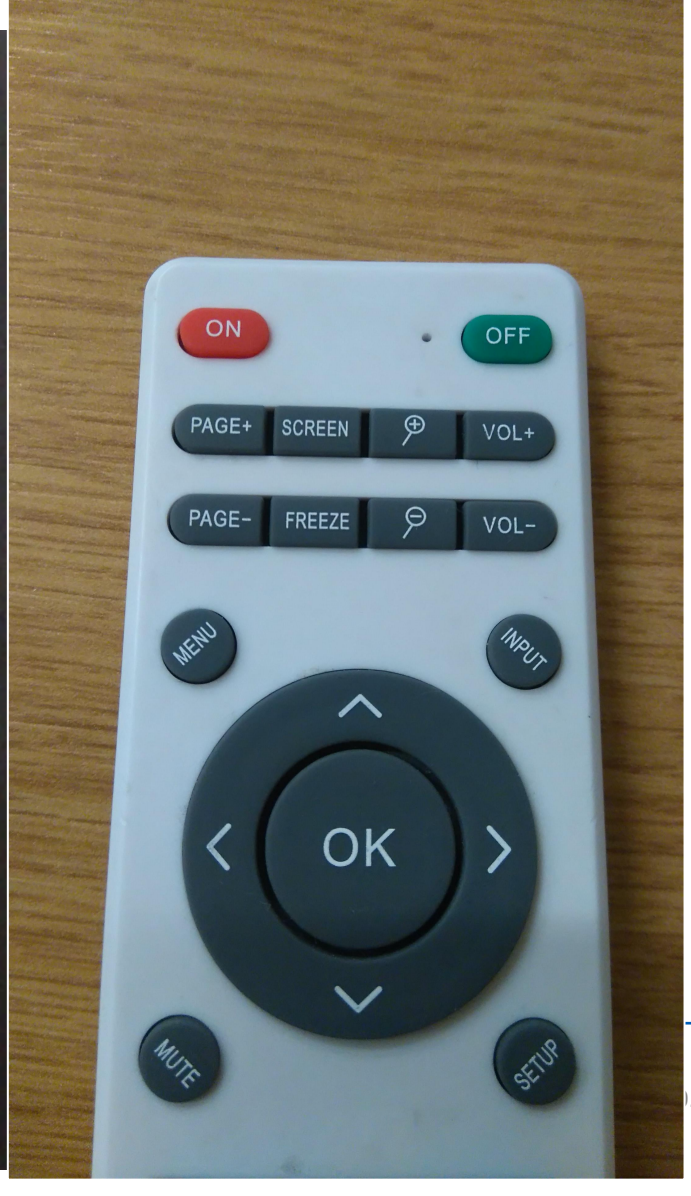
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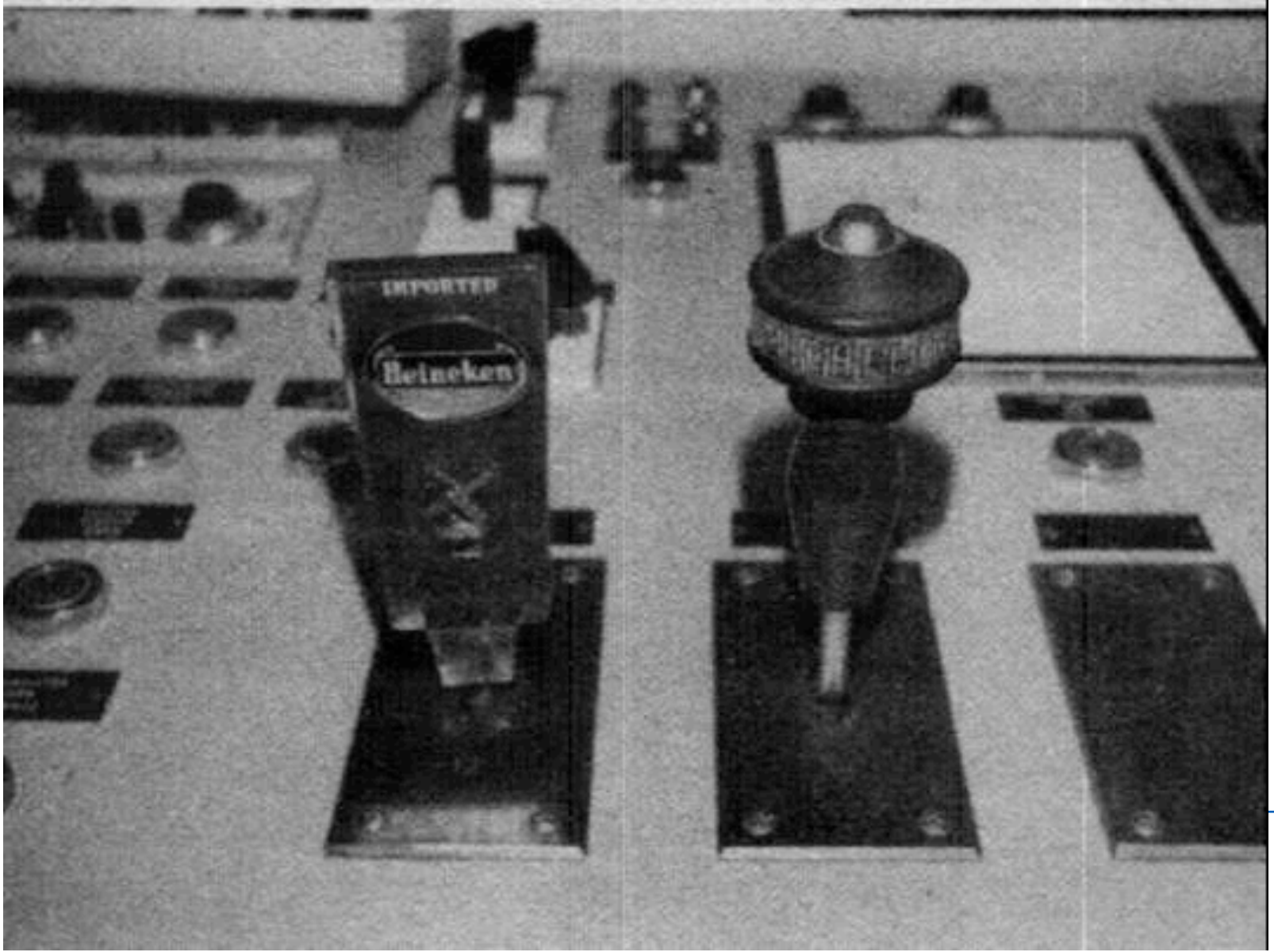
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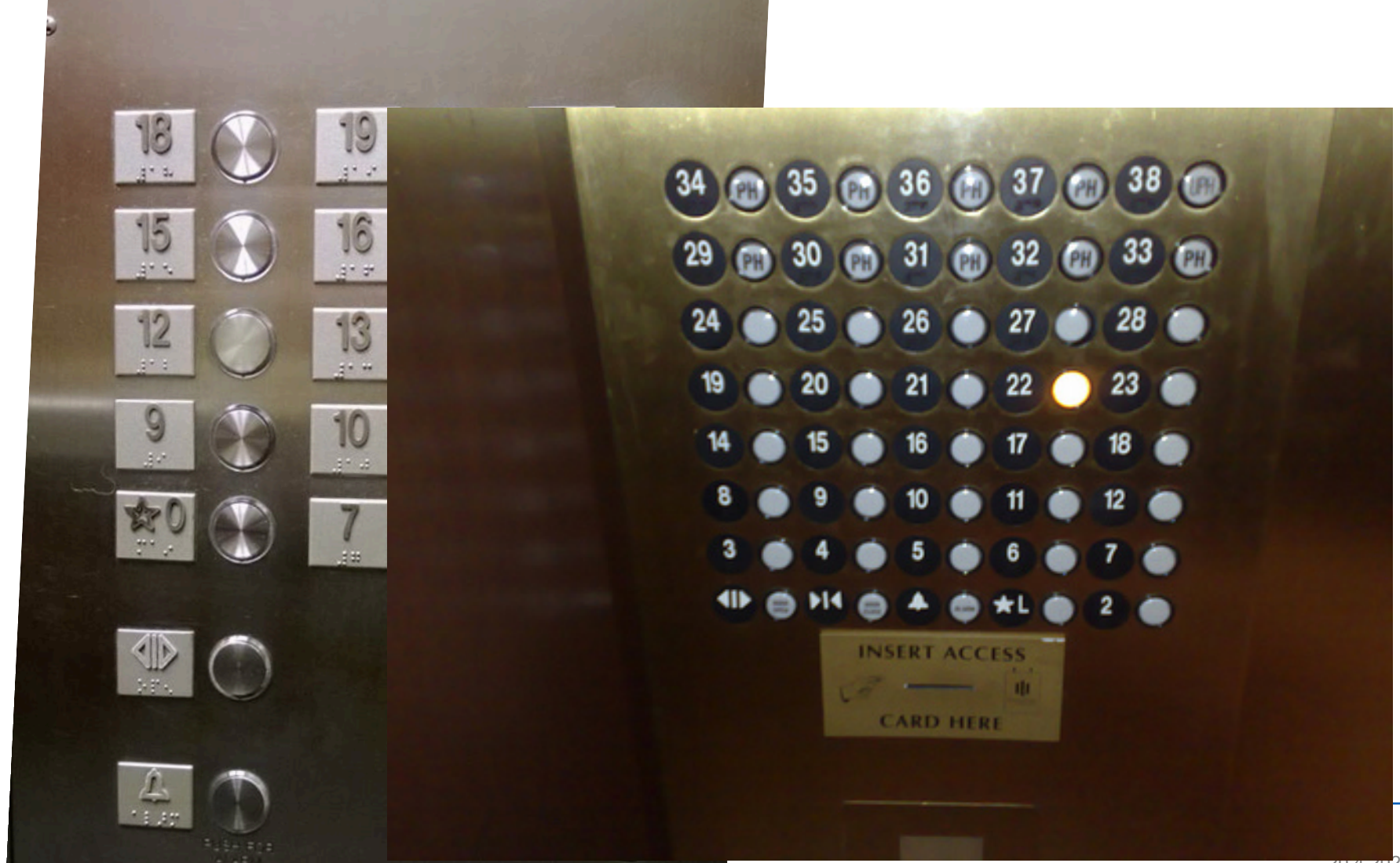
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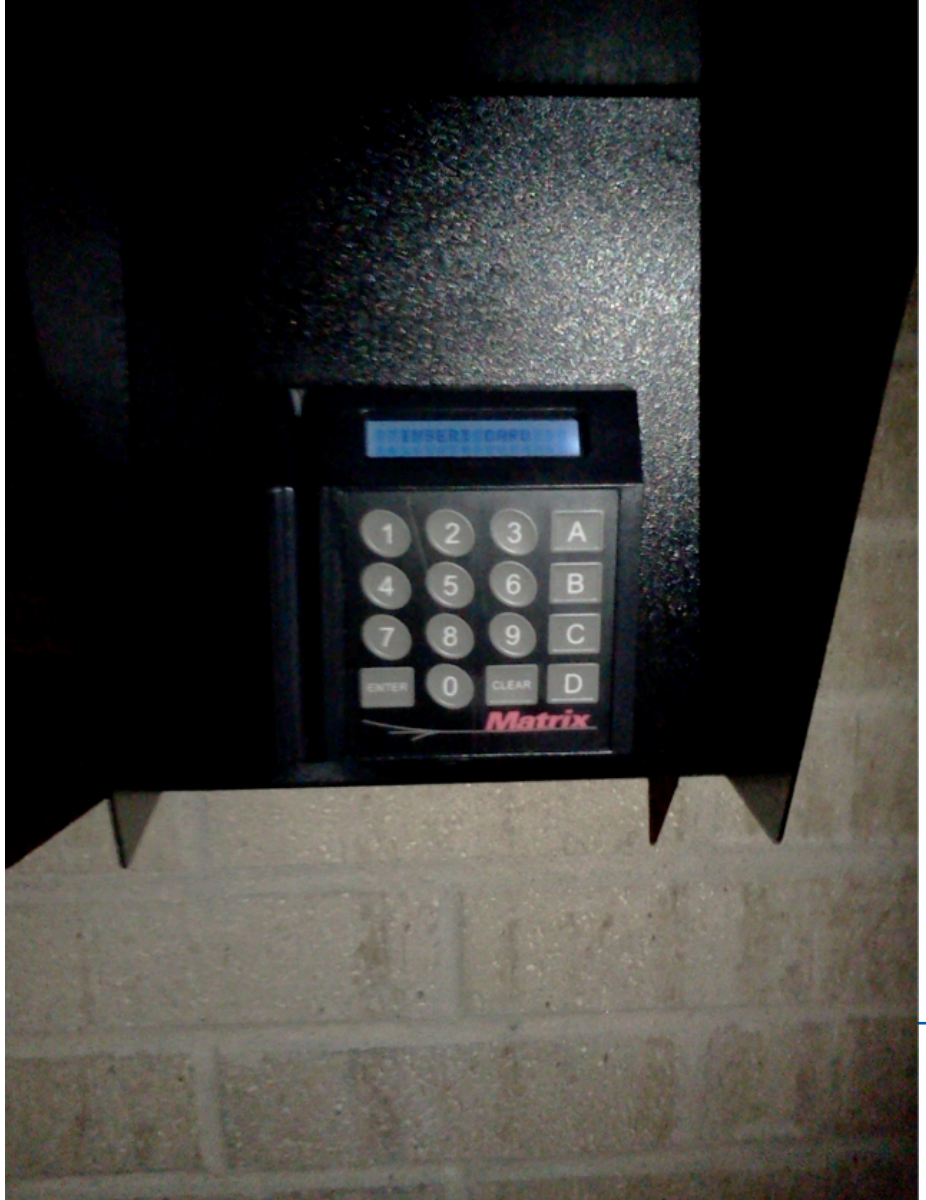
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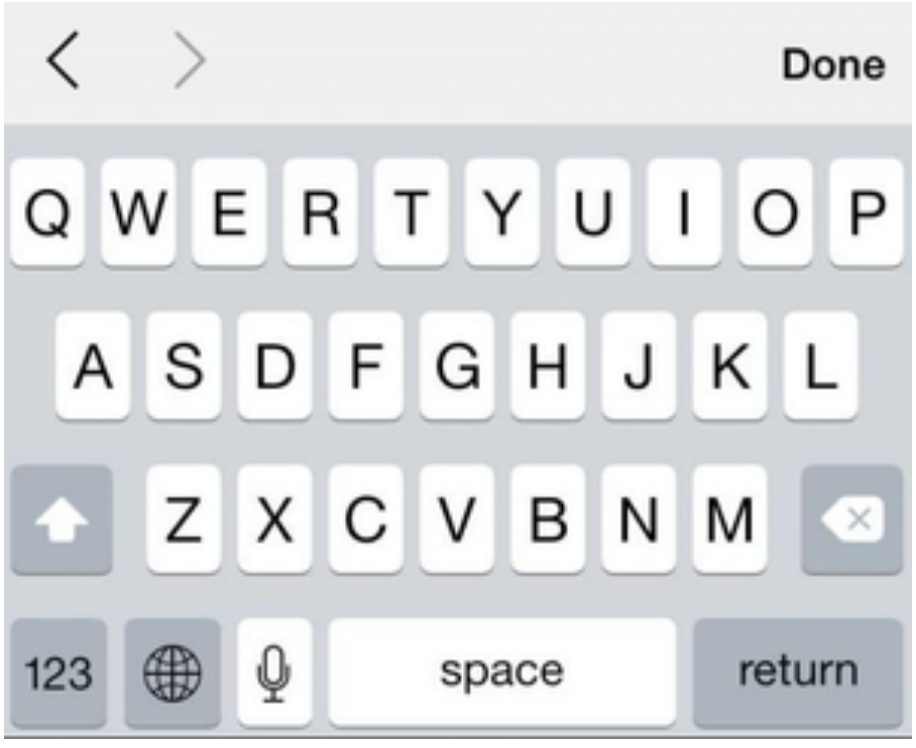
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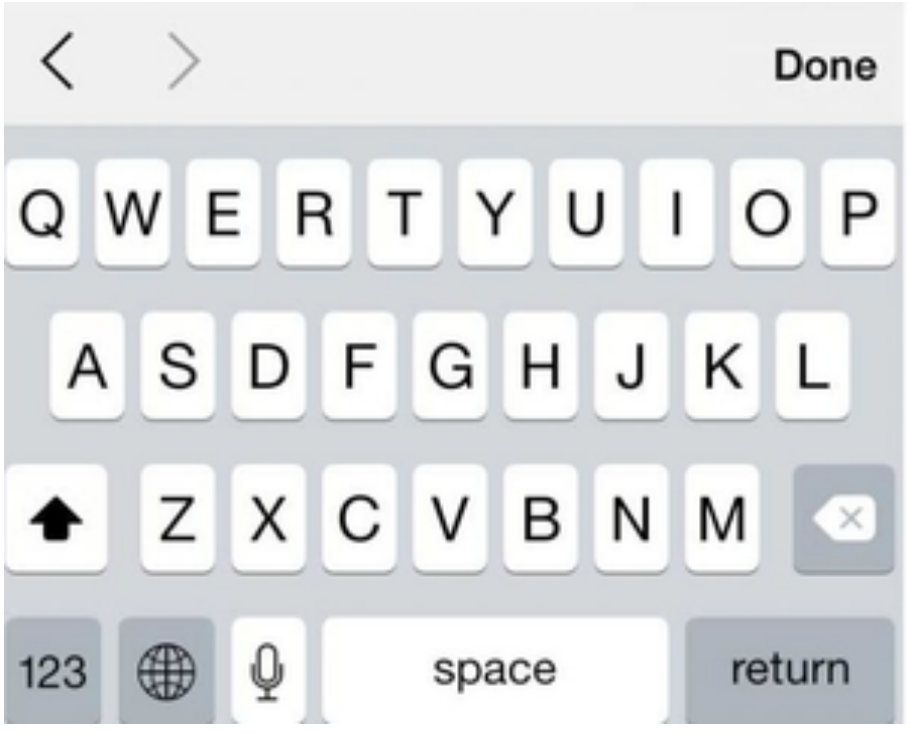
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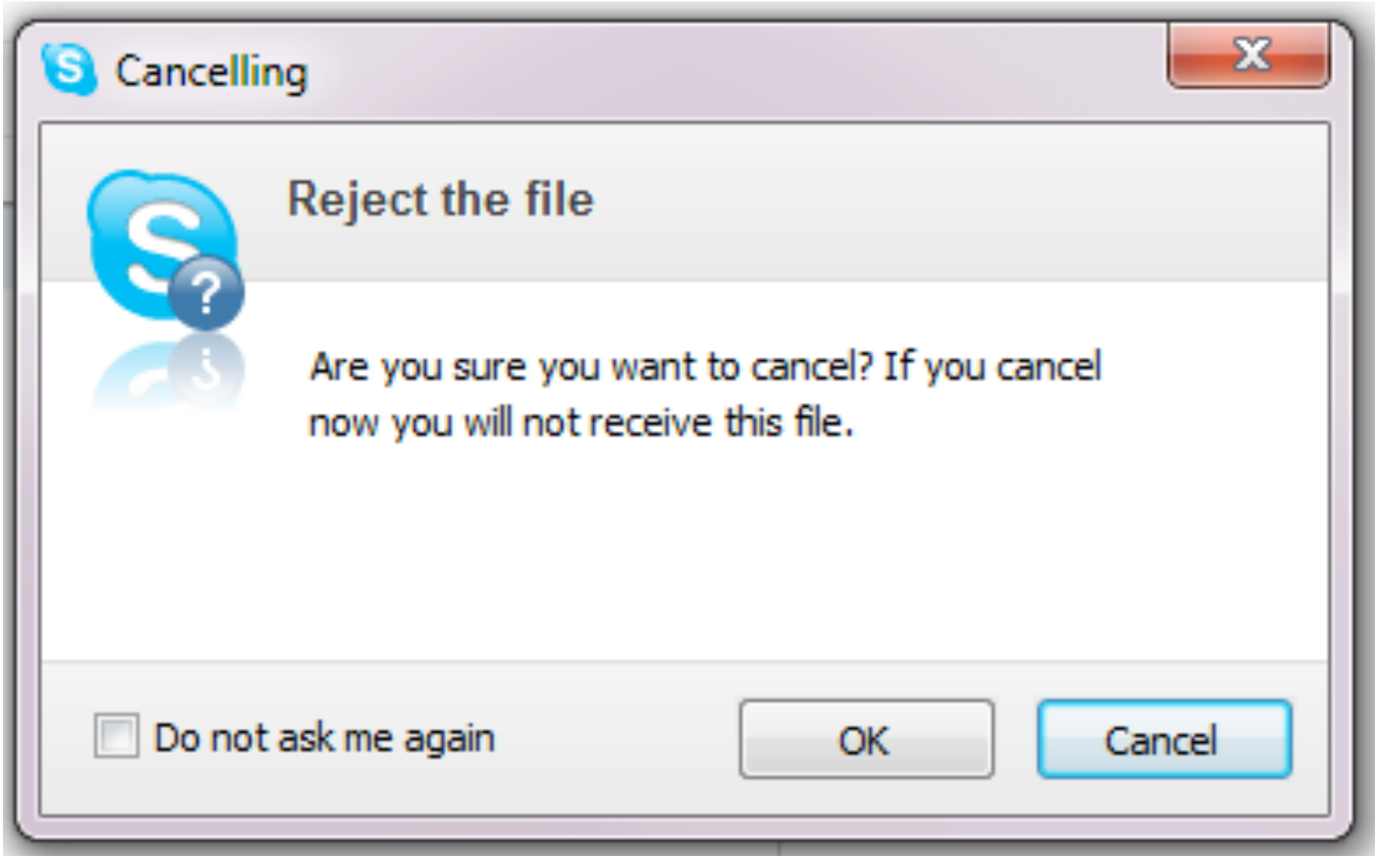
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Reject the file
Are you sure you want to cancel? If you cancel now you will not receive this file.
Do not ask me again
OK
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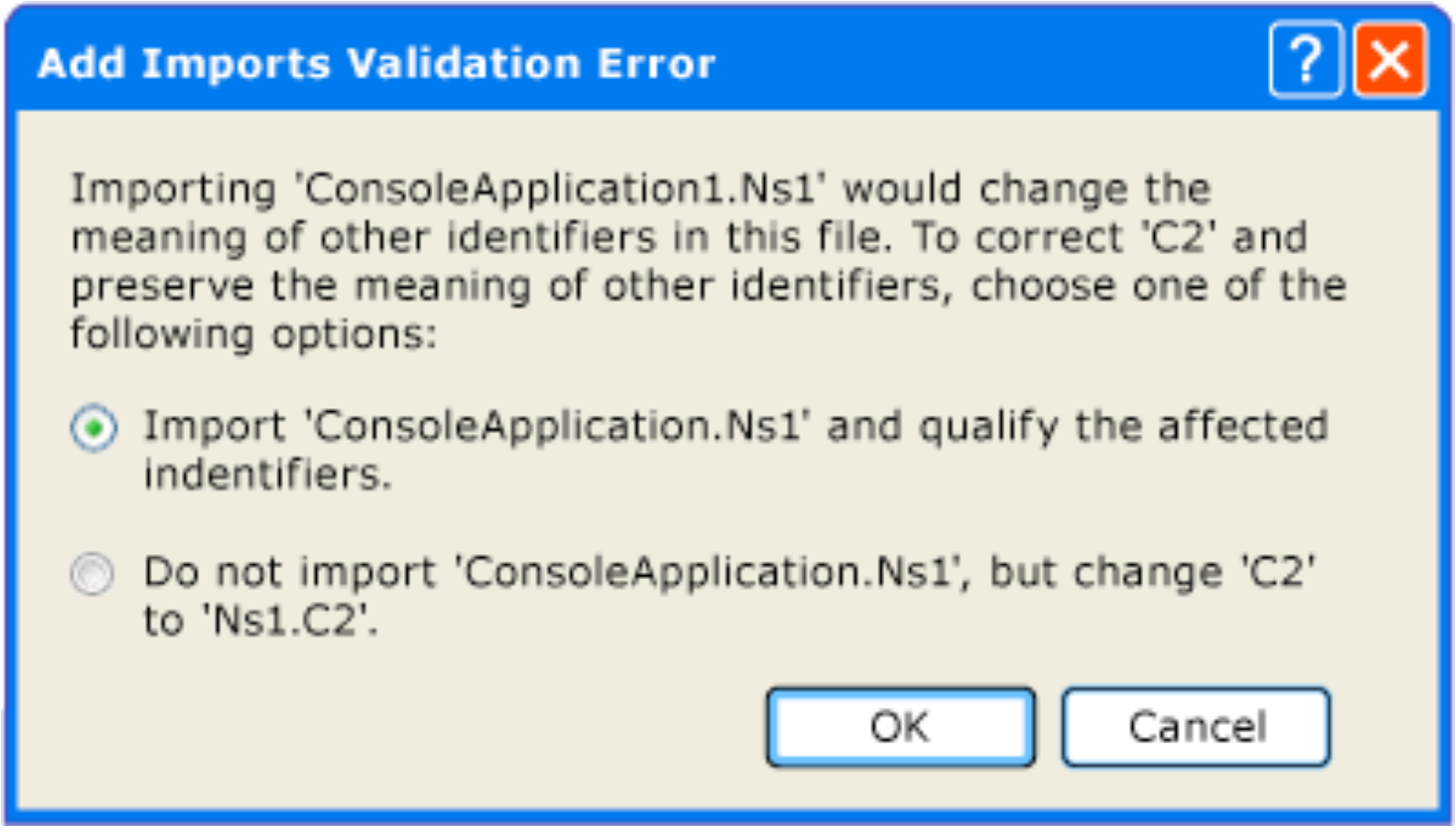
Add Imports Validation Error
Importing 'ConsoleApplication1.Ns1' would change the meaning of other identifiers in this file. To correct 'C2' and preserve the meaning of other identifiers, choose one of the following options:
Import 'ConsoleApplication.Ns1' and qualify the affected indentifiers.
Do not import 'ConsoleApplication.Ns1', but change 'C2' to 'Ns1.C2'.
OK
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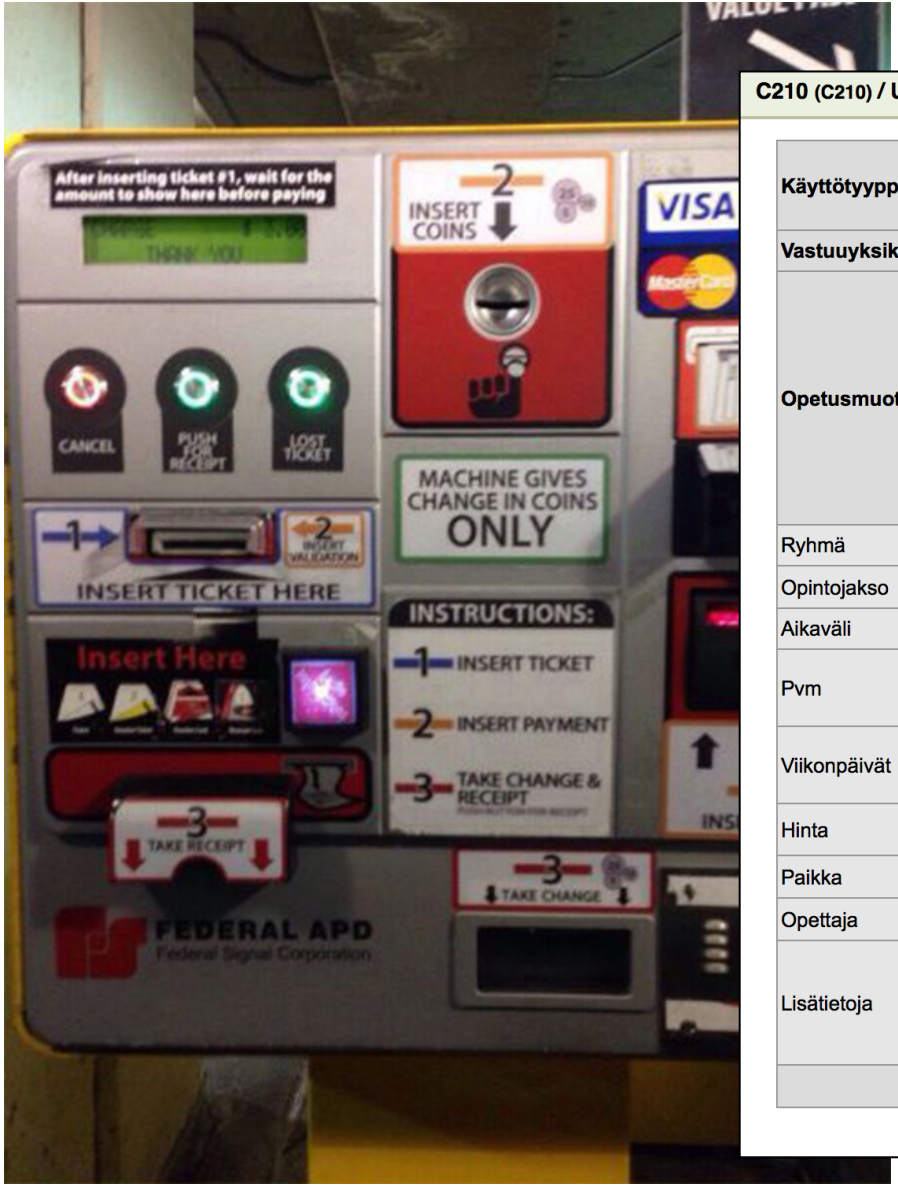
Nathan, to start a program just click on it.
To see the programs in this room, hold down the F1 key.
Other options
EXIT



C210 (C210) / Uusi tapahtuma / Ti 25.04.2017 ? Su

Käyttötyyppi	○ Ulkopuoliset	◉ Opetus	○ Ylioppilaskunta
	○ Sisäiset		
Vastuuyksikkö	T40700 ELEC / Communications and Networking		
Opetusmuoto	○ Ei luokitusta	○ ATK-harjoitus	○ Avoin yliopisto
	○ Case-Työskentely	○ Demonstraatio	○ Harjoitus
	○ Itseopiskelu	○ Kongressi	◉ Kurssi
	○ Luento	○ Monimuoto-opetus	○ Muu tilaisuus
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	○ Tentti	○ Verkko-opetus	○ Väitöstilaisuus
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Opintojakso	Hae Tyhjennä Ohje		
Aikaväli	10:00 - 12:00	Vahvistustila	Vahvistettu
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Lisätietoja			
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Having trouble viewing this email?
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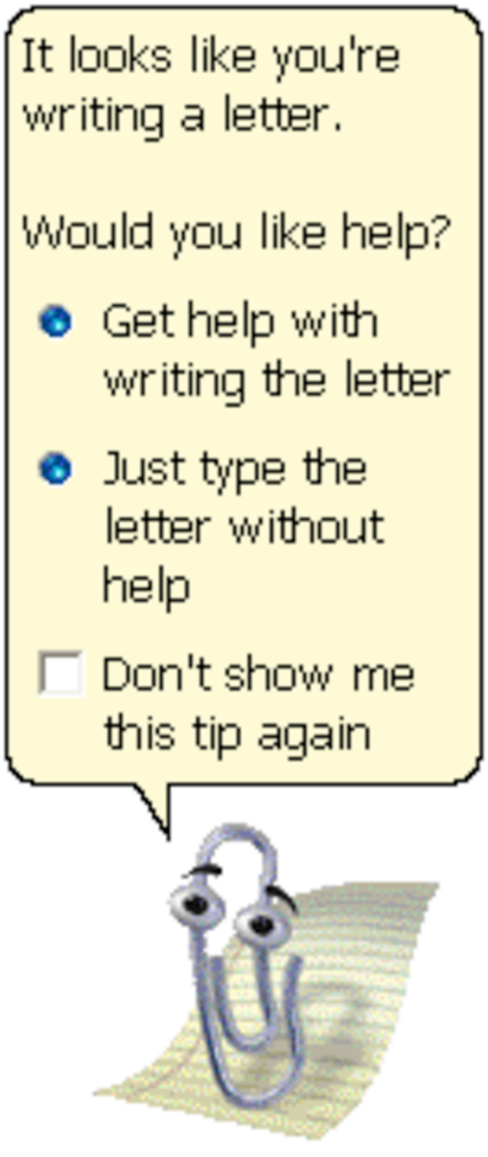
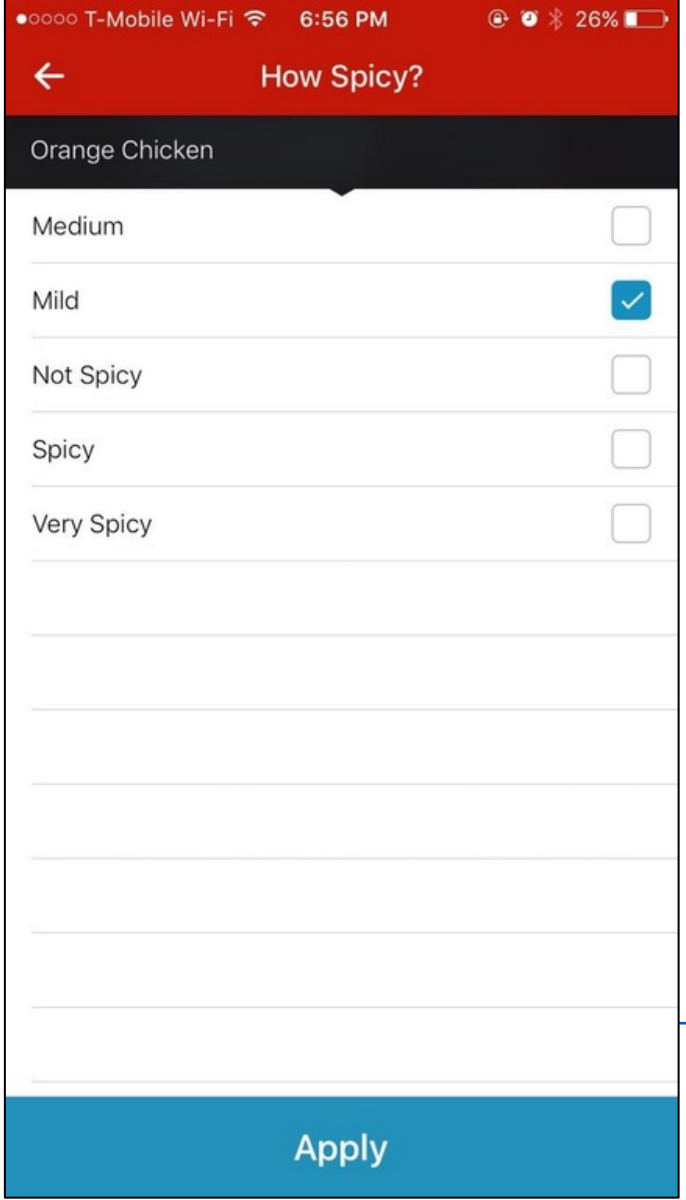
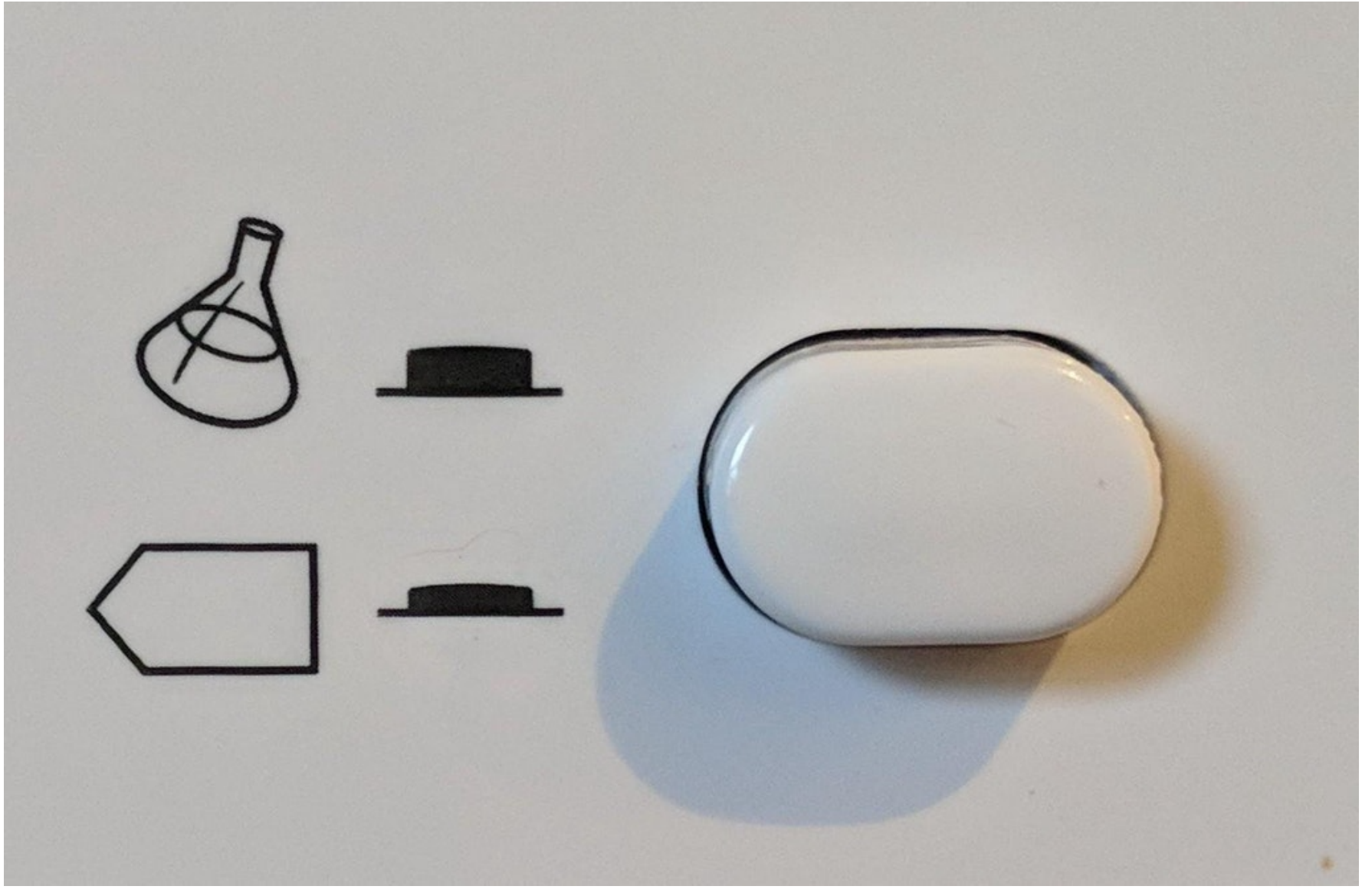
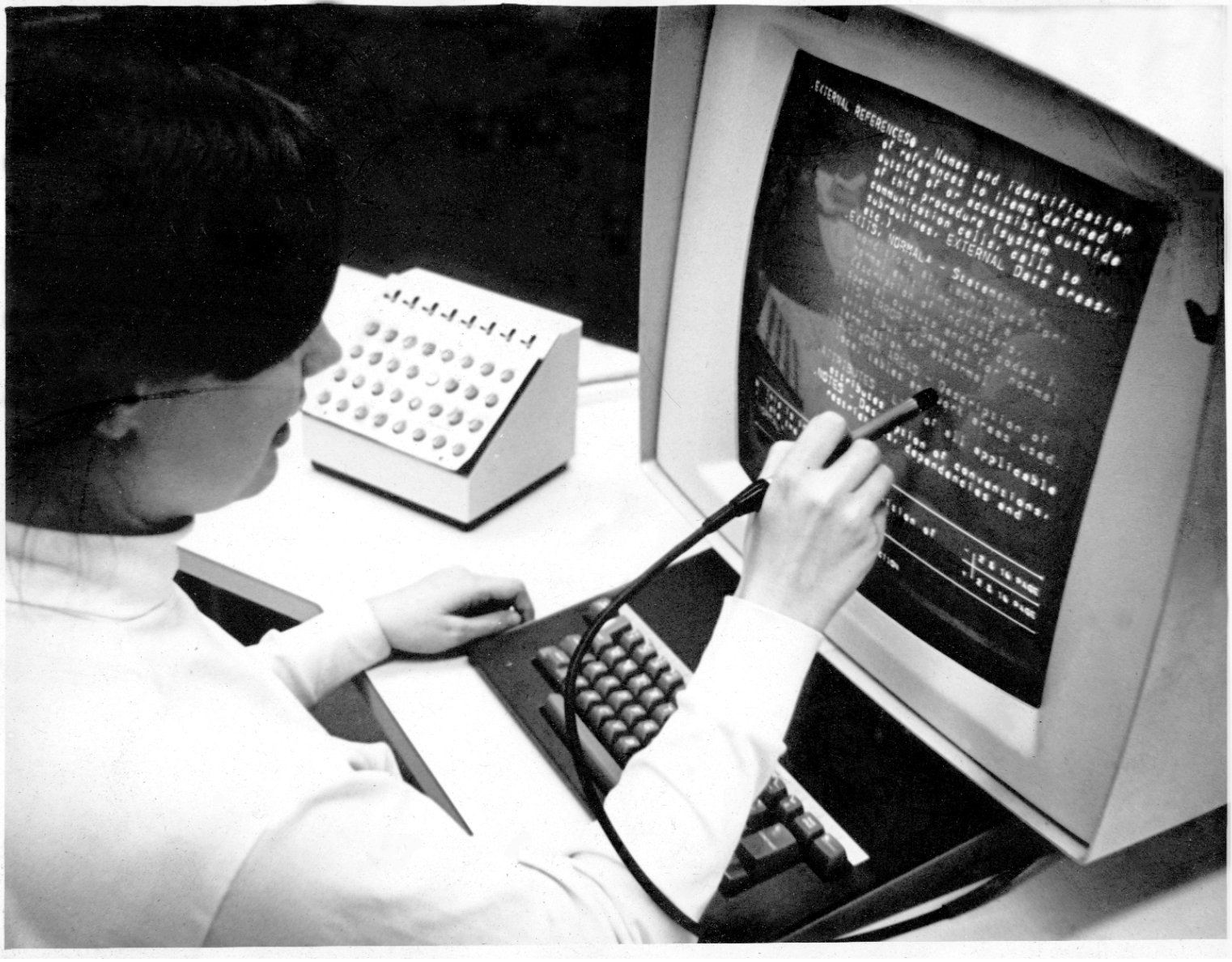

It looks like you're writing a letter.
Would you like help?
Get help with writing the letter
Just type the letter without help
Don't show me this tip again


T-Mobile Wi-Fi
6:56 PM
26%
How Spicy?
Orange Chicken
Medium
Mild
Not Spicy
Spicy
Very Spicy
Apply


NO SMOKING
SAFETY FIRST



Too high latency


EXTERNAL REFERENCES


AIR FRANCE
AIR FRANCE KLM
services
Sortie de documents
Retirez documents
Carte
Card
Entrée billet
Insert ticket
Sortie de documents
Retirez documents


IMPORTANT INFORMATION
1. To ensure your privacy, push switch to locked position.
2. Before leaving, please push switch to unlocked position otherwise switch remains in locked position and door will not open from outside.
3. If door is locked, contact Facilities service call desk on extension 55900.
LOCK
PRESS
TO
OPERATE DOOR


SANEI
吐水・止水方法
ダイヤルを回して吐水・止水します。
■ 通常吐水
吐水→「OPEN◀」方向に回し、目盛を「FULL」に合わせると水(湯)が出ます。
止水→「▶STOP」方向に回し、目盛がない位置に合わせると止まります。
■ 定量吐水
吐水→「OPEN◀」方向に回し、目盛を「FULL」に合わせます。
次にダイヤルを戻しながら希望の吐水量に合わせます。
ダイヤルが回り、自動で水(湯)が止まります。
水栓の使い方
ダイヤル
ポイント
OPEN◀▶STOP
FULL
止水
吐水
ポイント
①「FULL」に合わす。
②希望の吐出量に合わす。
シャワーの切替え
シャワー
吐水口
温度調節
高温
低温
安全ボタン：
高温にしたい時はボタンを押してまわします。
注意
●シャワーをお使いになる前に、必ず手で適温であることを確かめてください。
●高温の湯をお使いの後は、必ず温度を40℃以下に戻してください。
●ハンドルは、ゆっくり回してください。
AOE
OPEN
STOP
飲料水
Drinking Water
飲用水
THE AMENITY
BODY SOAP
ボディーソープ
SHISEIDO
40

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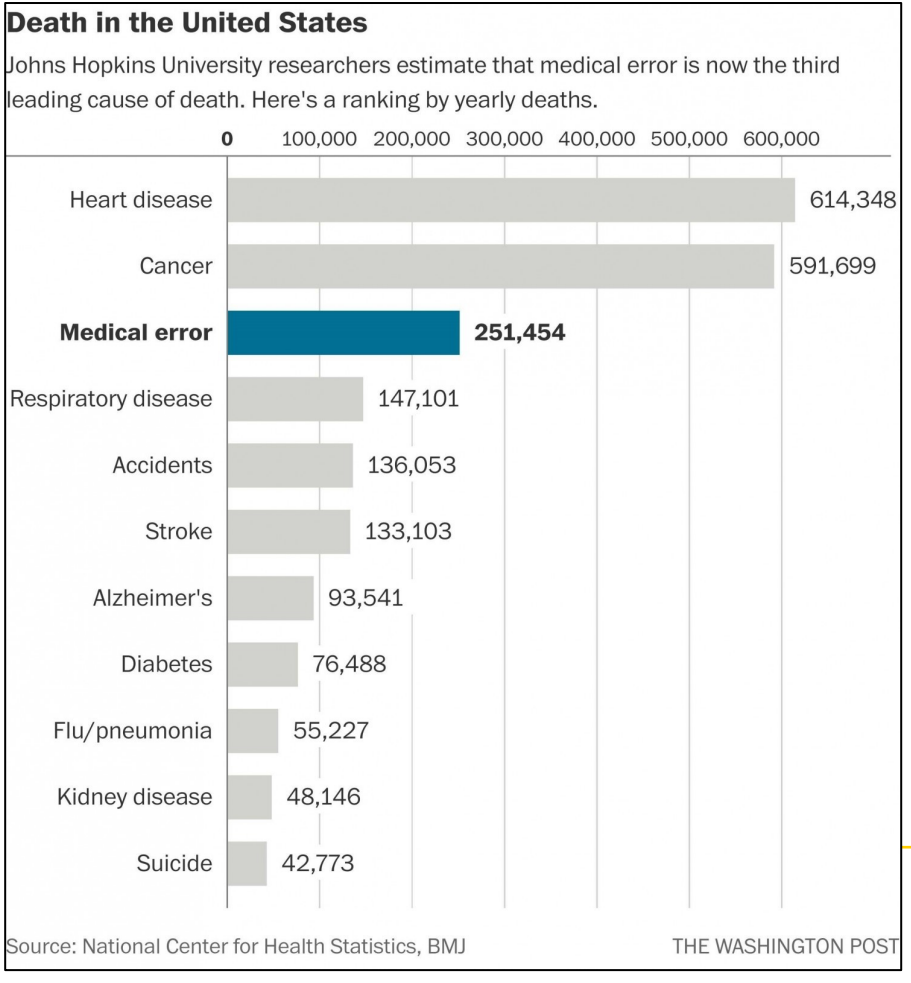
How will you die?

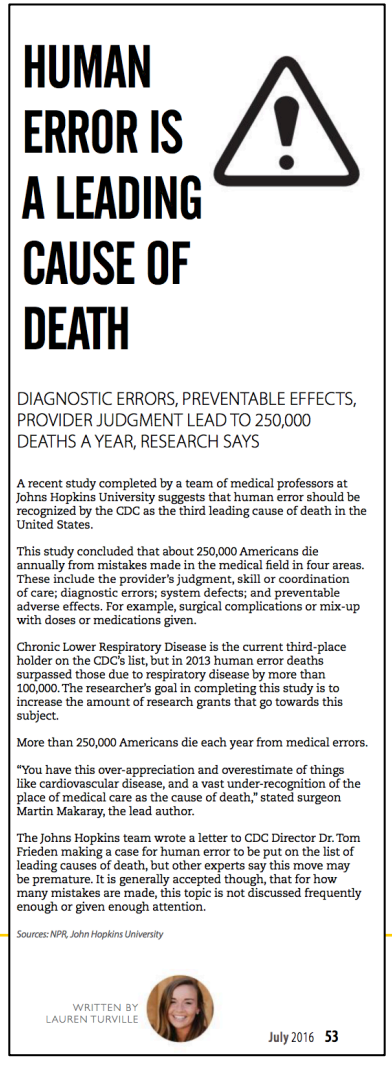
Human error

- **An inappropriate or undesirable human decision or behavior that reduces or has the potential to reduce effectiveness, safety, or system performance**
- **A human action/decision that exceeds system tolerances**
- ***"An action is taken that was 'not intended by the actor; not desired by a set of rules or an external observer; or that led the task or system outside its acceptable limits"***

(Senders & Moray, 1991, p. 25 as cited in Proctor & van Zandt, 1994, p. 43).

How will you die?





HUMAN ERROR IS A LEADING CAUSE OF DEATH

DIAGNOSTIC ERRORS, PREVENTABLE EFFECTS, PROVIDER JUDGMENT LEAD TO 250,000 DEATHS A YEAR, RESEARCH SAYS

A recent study completed by a team of medical professors at Johns Hopkins University suggests that human error should be recognized by the CDC as the third leading cause of death in the United States.

This study concluded that about 250,000 Americans die annually from mistakes made in the medical field in four areas. These include the provider's judgment, skill or coordination of care; diagnostic errors; system defects; and preventable adverse effects. For example, surgical complications or mix-up with doses or medications given.

Chronic Lower Respiratory Disease is the current third-place holder on the CDC's list, but in 2013 human error deaths surpassed those due to respiratory disease by more than 100,000. The researcher's goal in completing this study is to increase the amount of research grants that go towards this subject.

More than 250,000 Americans die each year from medical errors.

"You have this over-appreciation and overestimate of things like cardiovascular disease, and a vast under-recognition of the place of medical care as the cause of death," stated surgeon Martin Makaray, the lead author.

The Johns Hopkins team wrote a letter to CDC Director Dr. Tom Frieden making a case for human error to be put on the list of leading causes of death, but other experts say this move may be premature. It is generally accepted though, that for how many mistakes are made, this topic is not discussed frequently enough or given enough attention.

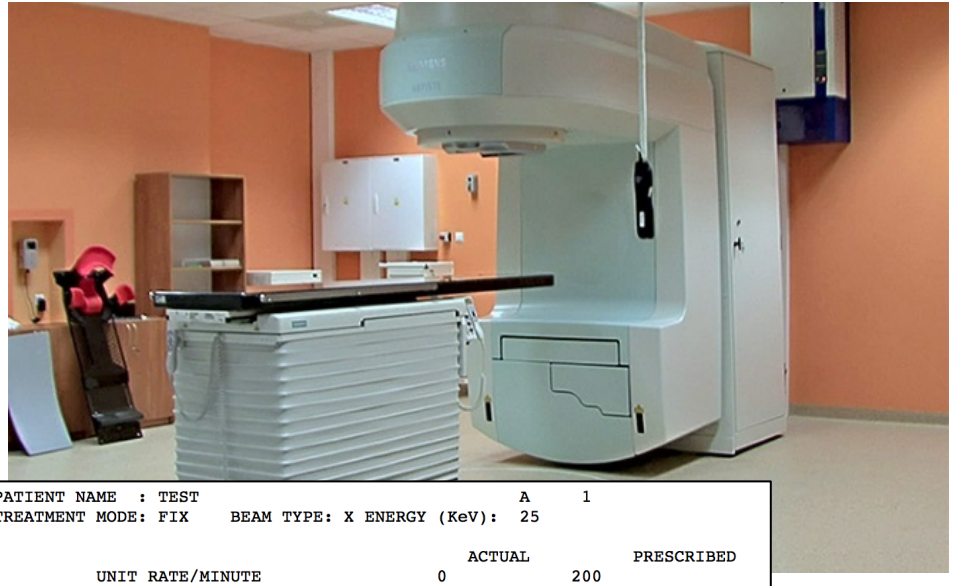
Sources: NPR, John Hopkins University

WRITTEN BY LAUREN TURVILLE

July 2016 53

Note: This claim – originally published in BMJ 2013 - has been contested on methodological grounds

Therac-25 Medical Accelerator - 1985-7



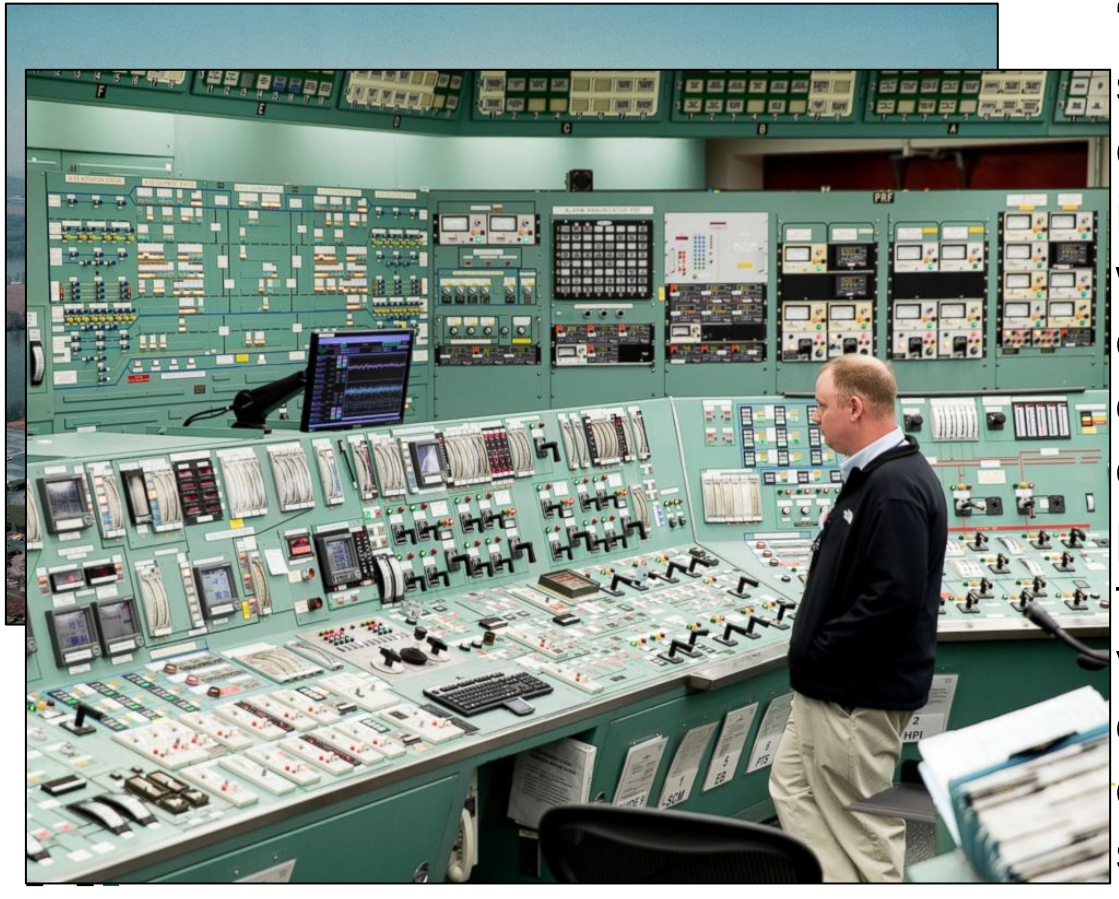
```
PATIENT NAME  : TEST                                  A     1
TREATMENT MODE: FIX    BEAM TYPE: X ENERGY (KeV):  25

                                          ACTUAL          PRESCRIBED
         UNIT RATE/MINUTE                    0             200
         MONITOR UNITS              50   50              200
         TIME (MIN)                           0.27            1.00

GANTRY ROTATION (DEG)              0.0               0   VERIFIED
COLLIMATOR ROTATION (DEG)    359.2               359  VERIFIED
COLLIMATOR X (CM)                   14.2             14.3  VERIFIED
COLLIMATOR Y (CM)                   27.2             27.3  VERIFIED
WEDGE NUMBER                           1                1  VERIFIED
ACCESSORY NUMBER                       0                0  VERIFIED

DATE  : 84-OCT-26  SYSTEM: BEAM READY   OP.MODE: TREAT   AUTO
TIME  : 12:55. 8   TREAT : TREAT PAUSE          X-RAY     173777
OPR ID: T25VO2-RO3 REASON: OPERATOR     COMMAND:
```

Figure A. Operator interface screen layout.

"An operator involved in an overdose accident testified that she had become insensitive to machine malfunctions. Malfunction messages were commonplace, most did not involve patient safety. Service technicians would fix the problems or the hospital physicist would realign the machine and make it operable again."

http://courses.cs.vt.edu/professionalism/Therac_25/Therac_1.html

Three Mile Island accident - 1979



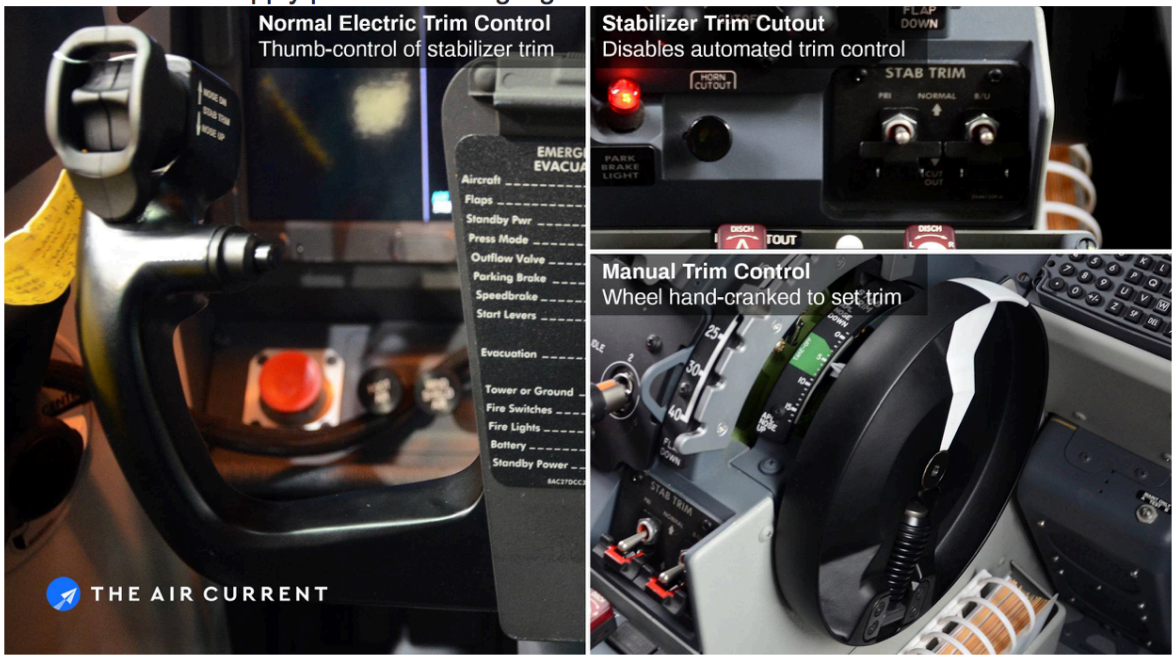
"Despite the valve being stuck open, a light on the control panel ostensibly indicated that the valve was *closed*. In fact the light did not indicate the position of the valve, only the status of the solenoid being powered or not, thus giving false evidence of a closed valve. As a result, the operators did not correctly diagnose the problem for several hours."

Grounding of Royal Majesty - 1995

moment at high angles of attack that did not meet FAA longitudinal stability and stick force certification standards. The easiest fix was to automatically apply a little nose down trim at high angles of attack.

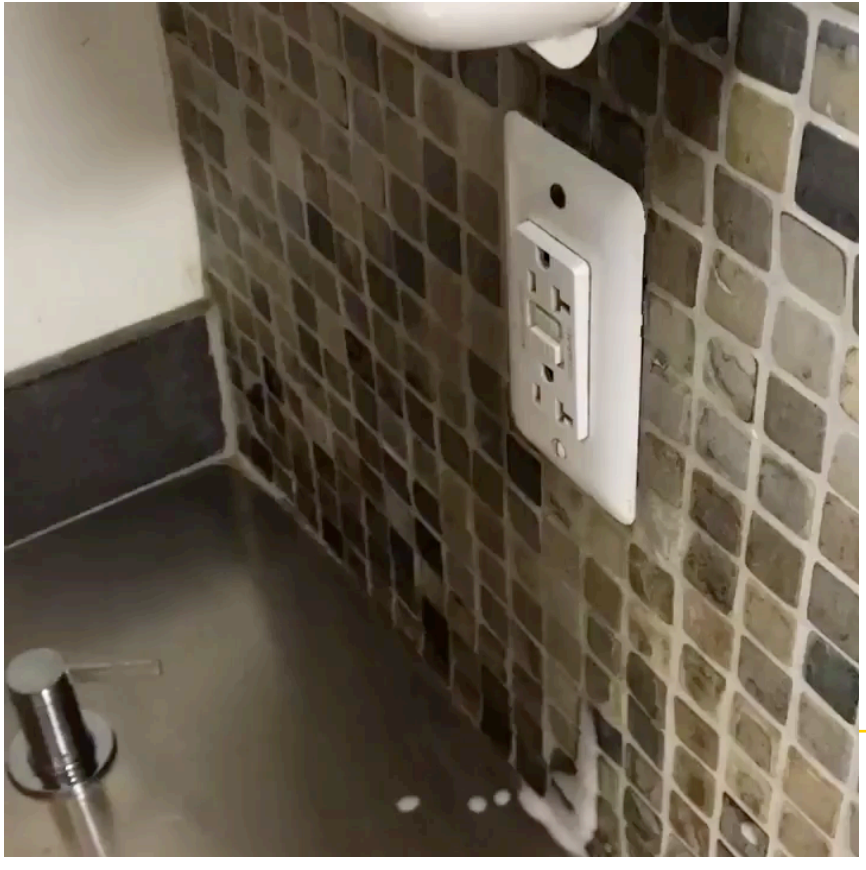
A few things that *should* disable it (with caveats)

1. **Lower the flaps**. It is intended to work only if the flaps are up.
2. **Turn the Stab Trim switches to OFF**. This disables the horizontal stabilizer's trim completely, and reverts to manual trim (there are two guarded stabilizer trim switches in the aisle stand, see Windshear's answer). This means that the pilots must move/rotate the trim wheels in order to apply pitch trim during flight.



The manual pitch trim appears to be what a few crews did prior to the LionAir crash in October 2018. It is unclear how many of the crews knew that it was MCAS, versus any other trim or pitch anomaly. The previous LionAir crews on the accident aircraft ended up flying to

Poor design is a preventable and therefore unacceptable cause of death



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Design Heuristics

Design Heuristics

Simple rules-of-thumbs for design

Example: “In system error, give a error message that helps the user to recover from the error”

“Do this” and “Don’t do this”

Based on personal experience rather than rigorous empirical data

Visibility
Feedback
Natural mapping
Affordances
Constraints

Visibility and Feedback

Heuristic #1: Make relevant parts visible.

Heuristic #2: Give each action an immediate and obvious effect

Visibility and Feedback

Sound can be used to provide similar information.

When the electric engine is engaged, the Prius is quieter than a vacuum cleaner.

Natural Mappings

***Mapping* = the relationship between two things**

***Natural mappings* can be**

- Cultural
- Biological
- Spatial

Heuristic #3: Capitalize on the concept of natural mappings

Natural Mappings

Natural Mappings

Affordances

Affordance is a property of the object. They provide strong clues to the operation of things.

Suggest how the object should be used

- “Verb”-able

Users know what to do just by looking at the object.

- No instructions needed!

Examples

- Door plates
- Knobs
- Button

Affordances

Affordances

Heuristic #4: Use the affordances of objects to help infer their use

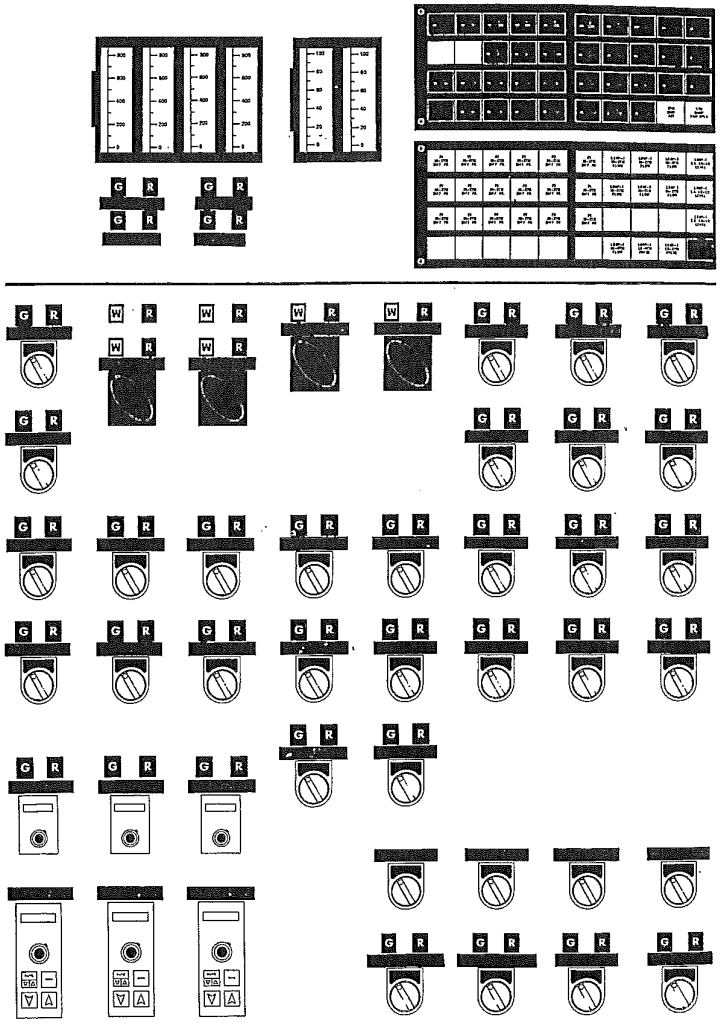
Constraints

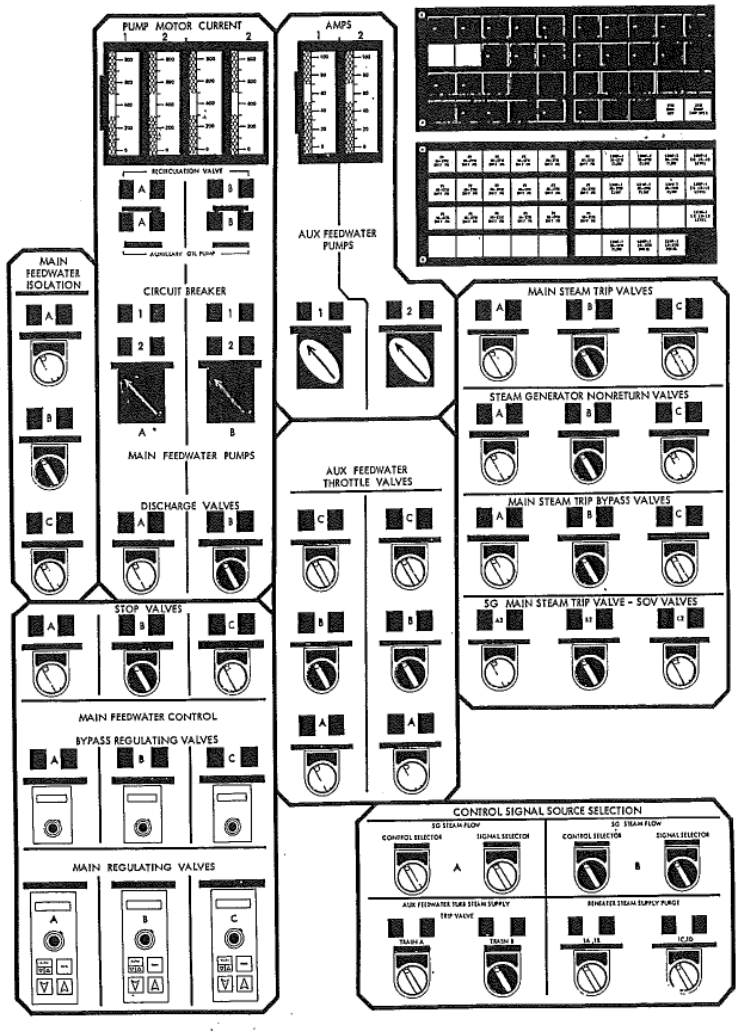
Constraints limit how the design can be used

Types:

- Physical
  - *Square object and round hole*
- Cultural
  - *Light switches*
- Logical
  - *Order (1,2,3 or a, b, c)*

Heuristic #5: Restrict the kind of interaction that can take place at a given moment





Many other heuristics...

Jakob Nielsen’s 10 heuristics

Ben Shneiderman’s Golden heuristics

Several domain and company specific heuristics

Shneidermann's 8 Golden Rules

1. *Strive for consistency*
2. *Cater to Universal Usability (Enable frequent users to use shortcuts)*
3. *Offer informative feedback*
4. *Design dialogs to yield closure*
5. *Offer error prevention and simple error handling*
6. *Permit easy reversal of actions*
7. *Support internal locus of control*
8. *Reduce short-term memory load*

We will learn more about heuristics in the home assignment

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Assignment 1

Assignment 1

One mandatory task related to this lecture

A1-1. Analysis of a UI using design heuristics (5 points)