Designing Interactive Systems I
Lecture 4: Knowledge, Feedback, Errors, 7 Principles of Design

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3 Levels of Processing

(originally from *Emotional Design*)

1. Visceral Level

- Fast, totally subconscious
- Reflex action, impulse
- E.g., vertigo, feeling of warmth and happiness when basking in the sun
- Not exactly 'emotions', more like hard-coded responses

2. Behavioral Level

- The level of "classic usability"
- "Learned responses", triggered by situations matching a pattern
- Mostly subconscious, fast, lower level of emotions
- E.g., sports, walking, etc.
- Behavioral action is associated with an expectation
  - *Hope* or *fear*: Am I doing the right set of actions? (feedback)
  - *Relief* or *despair*: Did things work out in the way I intended? (conceptual model)

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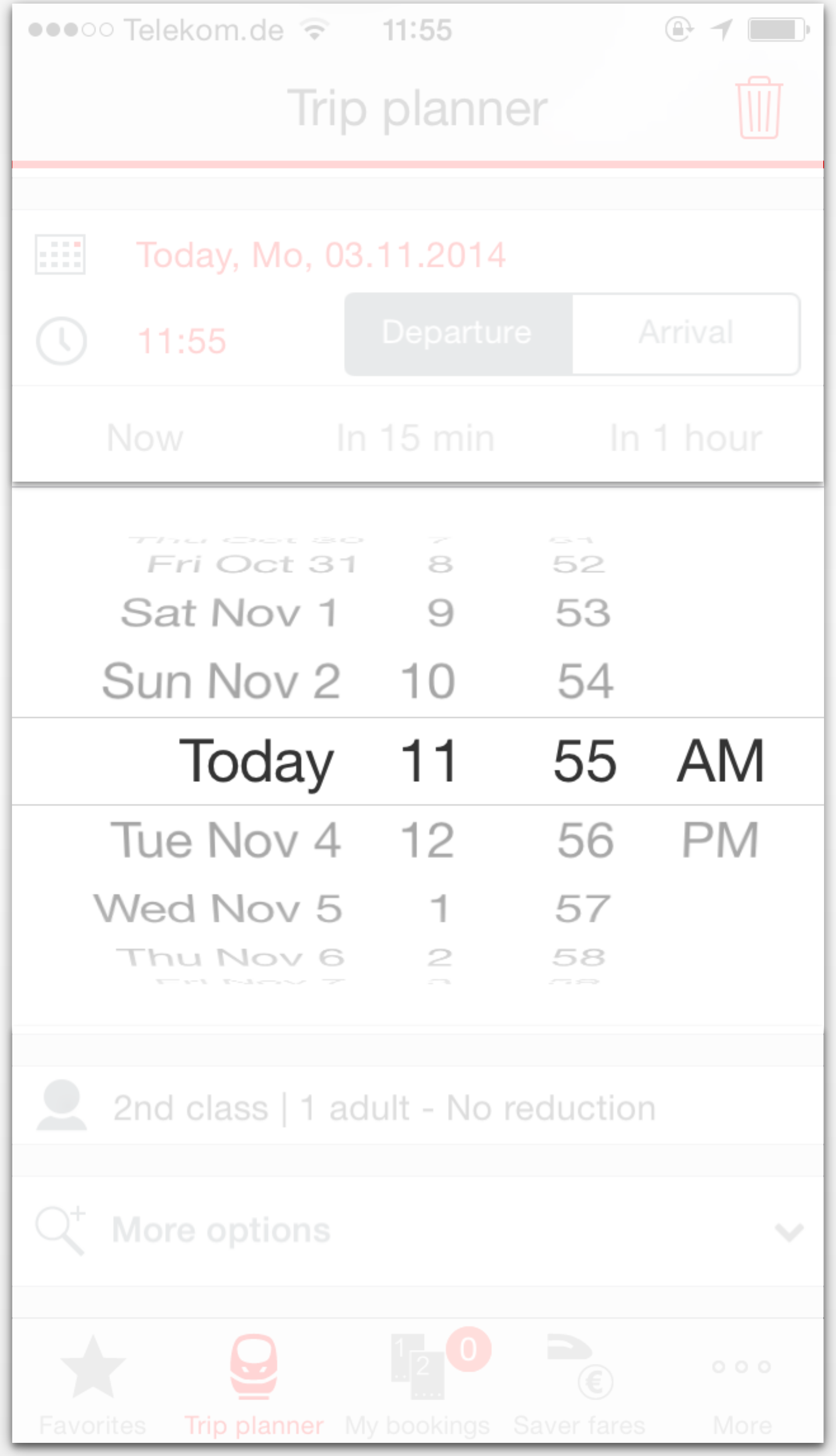
3. Reflective Level

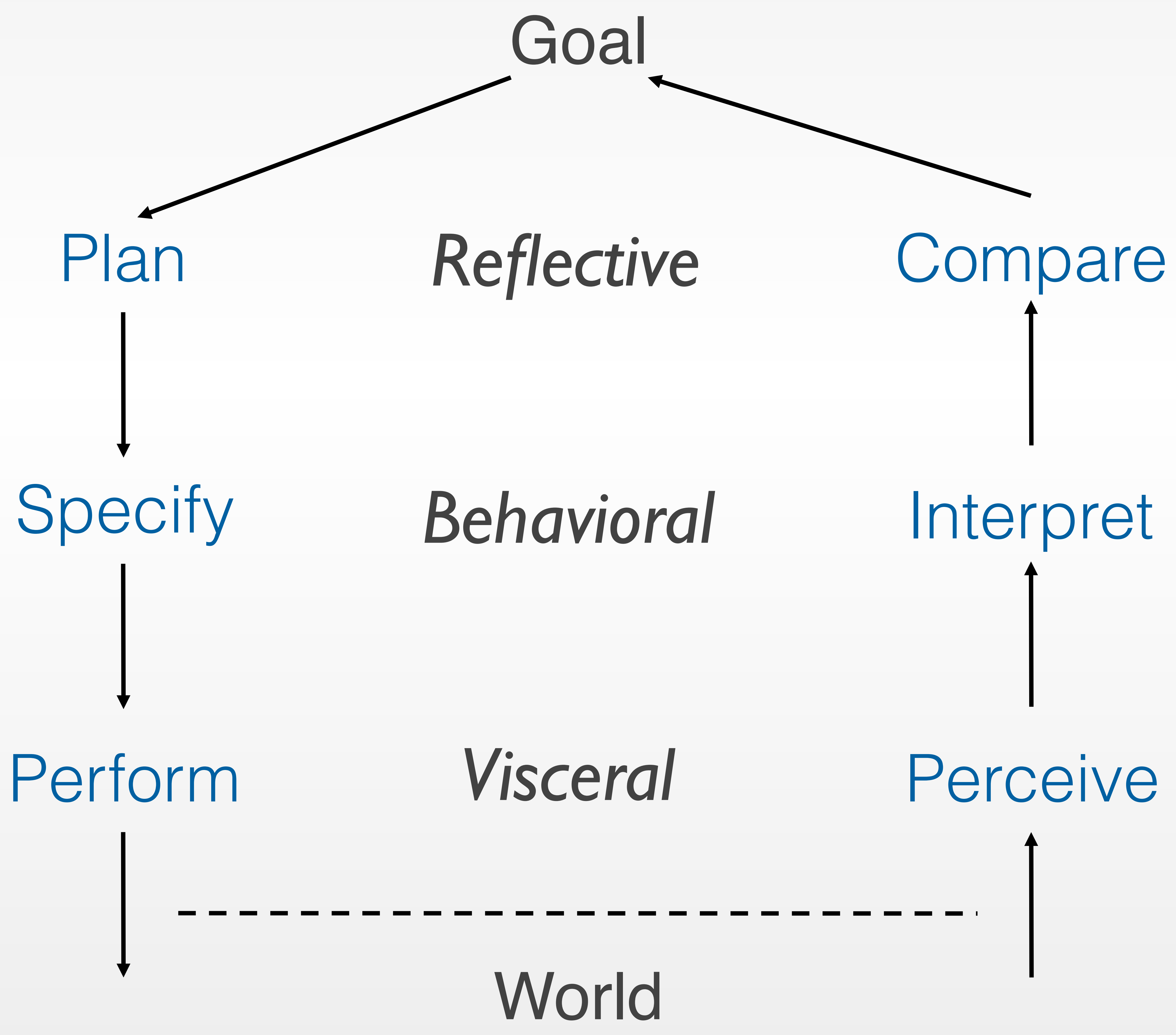
- Conscious thinking on events that have occurred
- Slow, deep thinking
- Highest level of emotions e.g., *guilt*, *pride*, *blame*, *praise*, etc.
- Retained in memory (⇒ most important)

Design in 3 Levels of Processing

- Visceral design: make products "feel" attractive
- Behavioral design: follow typical cognitive "usability" rules
- Reflective design: create a prestigious brand
- Excellent visceral and reflective design will make users forgive you small usability mistakes

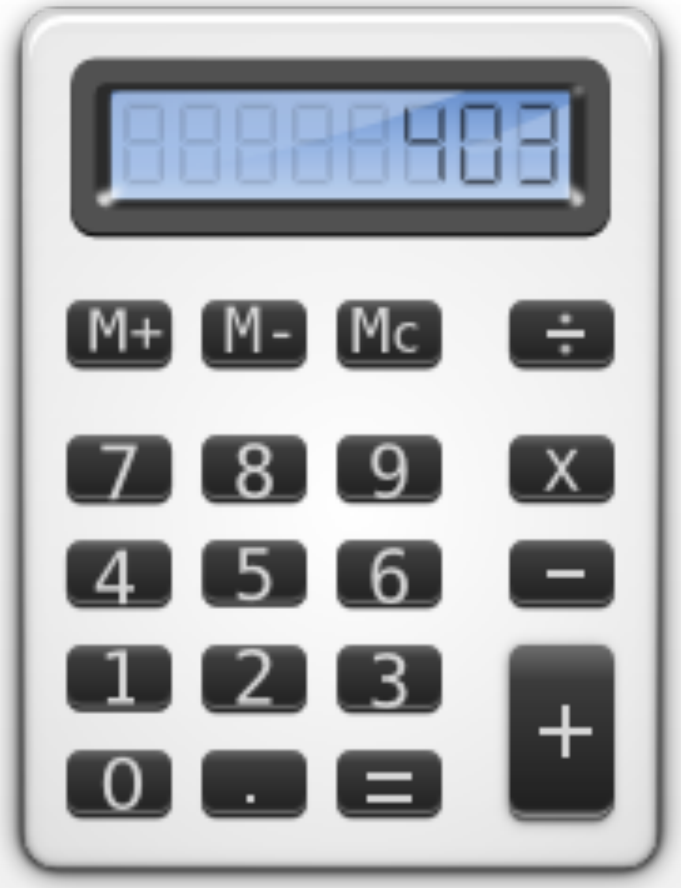


Interplay with the Seven Stages of Action



Knowledge in the World and in the Head

- Experiment:
  - Write down the digit layout of a telephone and a calculator keyboard



OQO

Knowledge in the World and in the Head

- Much knowledge is not in the head but in the world
- Despite less-than-perfect knowledge, precise behavior is possible—how?
- Behavior is determined by combination of knowledge in the world and in the head
- High precision of knowledge in the head is unnecessary
  - We only need knowledge to be precise enough to distinguish the right behavior from the others possible
  - Example: What is on the front and the back of the German 1 cent coin?

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More Reasons Why This Works

- Constraints are in effect
  - Physical constraints limit the actions possible
  - Example: What can be moved / combined / manipulated how when repairing your toaster?
- Cultural constraints are in effect
  - Social rules are learned once and are then applicable in many situations
  - Example: What to do upon entering a restaurant?
  - But: Cultural differences!

Knowledge in the Head & Constraints

- Traveling poets were able to recite poems with thousands of lines
  - Rhyme works as "linguistic constraint", and story works as semantic constraint
- Constraints limit the amount of knowledge that needs to be learned
- Humans can minimize the amount/precision/depth of information to remember by arranging their environment and copying people's behavior
  - This can even help people cover missing abilities (dyslexia) or mental disabilities

Example: Typing

- Exercise:
    - What kind of knowledge do beginners/intermediate/expert typists use?
- Beginner: Knowledge in the world (keyboard labeling)
- Intermediate: Knowledge in the world (peripheral vision, feeling keys) and in the head (knowing location of important keys by heart)
- Expert: All knowledge in the head, no eye contact to keyboard necessary anymore (cost/benefit tradeoff)

Example: City Map

- Exercise:
  - Try to write down exactly how to get from this building to the main university building
- Result:
  - Nobody has a perfect street/building map in their head; often entire parts are forgotten in route descriptions
  - Nevertheless we can get from A to B safely
  - Why? Signage and constraints (e.g., street numbers) supply external knowledge

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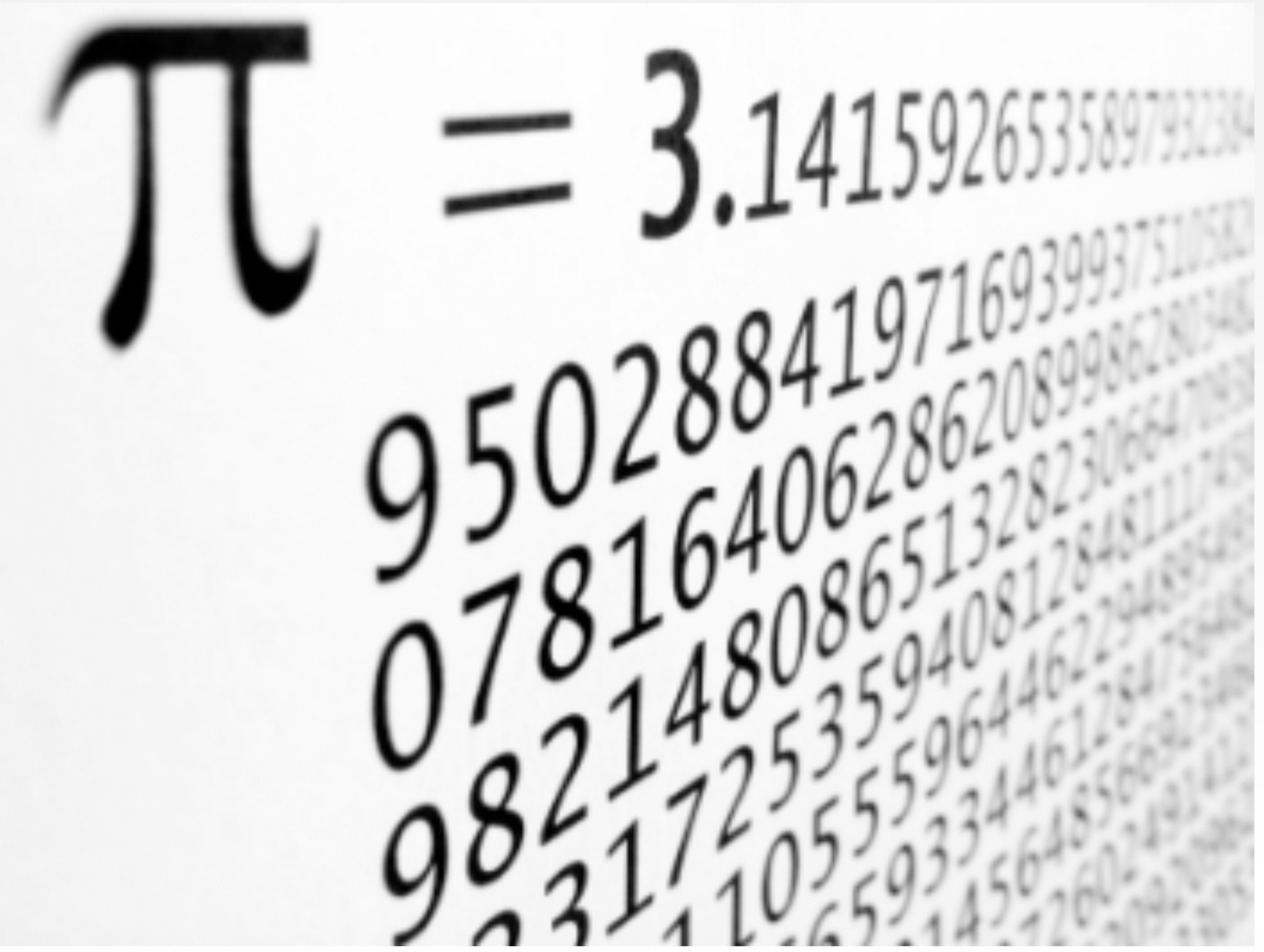
Types of Knowledge

- Declarative knowledge (“what”)
  - Facts (Bonn is southeast of Aachen)
  - Rules (stop at red traffic lights)
  - Easy to write down and teach (not learn!)
- Procedural knowledge (“how”)
  - How to play an instrument
  - Hard to write down, subconscious
  - Hard to teach, best by demo/training
- Design can easily convey declarative knowledge

How Much Can We Remember?

- Random unconnected facts: little
  - “Press Ctrl-Alt-Delete to log on”
  - Not learnable per se, only via associations
  - Example: First 1,000 digits of Pi
  - If your recipe fails, you are lost
- Connected facts: more
  - Using associations
  - Example: motor bike directional indicator



- Explained/understood facts: very much
  - A *Conceptual Model* emerges in the head
  - Can be reconstructed if needed
  - Very valuable in new situations where recipe fails

The Daily Struggle

- Exercise:
  - How many online accounts with passwords do you have?
  - How many of these can you remember the passwords to?
  - For how many of them do you use the same password?
- Credit cards, bank accounts with bank codes, number plates, phone numbers/addresses/birthdays/age of friends, clothing sizes,…
- As the password requirements become more complex, the system becomes less secure, why?
  - We tend to move these things from the head into the world

Knowledge in the World: Characteristics

- Nothing to remember
- But: only there while you see it
- Especially difficult with things that are not very important to you
- Solution: Reminders
  - Paper agenda vs. PDA
  - Signal vs. message

Comparing Knowledge in the World and in the Head

- In the world:
  - Available as soon as visible
  - No learning needed
  - Low efficiency (interpreting needed)
  - High initial usability
  - Aesthetics difficult with much to display
- In the head:
  - Less available
  - Less suitable for beginners
  - Harder to learn
  - But efficient
  - Invisible (less labels)
- Remember: Natural mappings can save both learning and labeling

Decision Structures

- To reduce chance of error, use either shallow or narrow decision trees
  - Shallow: No planning required, e.g., ice cream parlor menu
  - Narrow: No deep thinking required, e.g., cook book instructions, start your car, motorway exits
- Wide *and* deep structures:
  - Games like chess, etc.
  - Designed to occupy the mind
- Subconscious thought is effortless, associative, pattern-matching
- Conscious thought is slow, serial, demanding

Feedback

Feedback

- Feedback communicates to the user the current system state, success or failure of actions, and results of actions
- Good feedback:
  - Immediate
  - Informative and clear
  - The right amount
  - Prioritized

Sound

- Exercise:
  - Listen to everyday objects and their acoustic feedback (or think about it if not readily available in class)
- Examples: Pen cap, hard drive, bike lock, car door, telephone, software
- Sound is a unique information channel
  - Omnidirectional: blessing and curse
- But use to convey meaning if possible!
- More on sound in DIS II!

Visibility and Feedback

- Invisible On/Off switch on the rear
- VCRs without on-screen programming required lengthy programming instructions without much visible feedback
- A good display is great to improve visibility, and therefore often usability
- This becomes more feasible as technology progresses (—Augmented Reality / Ubicomp)

Visibility: A Bonus Feature

Feedforward

- Feedforward is to execution as feedback is to evaluation
- Information that helps you know what you can do
- Uses signifiers, constraints, and mappings
- Visual, but also haptic
    - Example: feeling keys before typing eyes-free on real vs. onscreen keyboard

Human Errors

Errors

- People make errors using everyday objects all the time
  - Especially when distracted, multitasking, interrupted, tired, under stress,…
- Often blame themselves (untypical!)
- Not only "dumb folk" have misconceptions of everyday life, and often those "wrong" models work better for everyday life
  - E.g., thermostats
- Perform root cause analysis
  - Analyze why error occurred
  - Human error is just the end of a causal *chain*
- Slips vs. Mistakes

Mistakes

- Result of conscious decision/thinking
- Often major events
- Reasons: Wrong goal, wrong plan, leaping to wrong conclusions, false causalities
- Hard to detect

Classes of Mistakes

- Memory-lapse: memory fails during goal-setting, planning, or evaluation
  - E.g., a mechanical failure because the mechanic was distracted while troubleshooting
- Knowledge-based: wrong evaluation of the situation because of incomplete knowledge
  - E.g., reporting the weight of an item in pounds instead of kilograms
- Rule-based: correct evaluation of the situation, but wrong course of action

Rule-based Mistakes

- Often made by skilled people
- Selecting the wrong rule (procedure) to apply in a situation
- Reason 1: Misinterpreting situation, invoking wrong plan, applying wrong rule
  - E.g., blocking night club attendees from an emergency exit assuming they are avoiding payment
- Reason 2: Selecting correct rule, but rule is faulty
  - E.g., raising the temperature of a thermostat for it to heat faster
- Reason 3: Selecting correct rule, but misinterpreting result, leading to further mistakes
  - E.g., a driver unfamiliar with anti-lock brakes lifts his foot from the brake paddle, thinking the vibration he sensed is a malfunction, when it is really positive feedback
- Difficult to avoid and detect
- Help by providing clear information about system state

Slips

- Most everyday errors
- Small things going wrong
- Goal formed, but execution messed up
- Usually easy to discover
- Occur mostly in skilled behavior
- Often caused by lack of attention, busy, tired, stressed, bored, more important things to do,…
- We can only do one conscious thing at once
  - Jef Raskin, The Humane Interface: Walking and eating and solving a maths problem

Classes of Slips

- Action-based: the wrong action is performed
  - E.g., pouring a cup of coffee and milk and placing the cup in the fridge
  - Types: capture slips, description-similarity slips, mode errors
- Memory-lapse: memory fails, and the intended action is not done or its results not evaluated
  - E.g., forgetting to lock the door when leaving the house

Action-based Slips

- Capture slips
  - Two action sequences with similar initial but different later sequence
  - The sequence well practiced "captures" the unfamiliar one
  - Driving to work on a Sunday
  - Pocketing a borrowed pen

Action-based Slips

- Description-Similarity slip
  - Intention not described in enough detail, fitting 2 different action sequences
  - Often occurs if similar objects are physically close to each other (e.g., switches)
  - E.g., throwing t-shirt into toilet instead of laundry basket
  - Putting a lid onto the obviously wrong container
  - Pouring orange juice into your coffee pot

Action-based Slips

- Mode errors
  - Triggering the wrong action because the device is in a different mode than expected
  - Who has seen this in their favorite text editor: ":wq"?
  - Happens whenever devices resort to modes to cope with more functions than controls
  - The most prominent problem in many software user interfaces

Memory-Lapse Slips

- Memory lapses are common causes of errors
- Caused by interruption through other people or devices
- Forgetting to complete action sequence
  - E.g., walking into your bedroom, then wondering what you wanted to do here
- Sometimes because main part of goal is accomplished
  - E.g., ATM card in machine, originals in copier
- Minimize by
  - reducing the number of required steps
  - providing reminders of the steps
  - applying forcing functions

In-Class Exercise: Slips

- In groups of two, think of three examples of slips that happened to you. What type are they?
  - Capture (driving to work)
  - Description-similarity (shirt in toilet)
  - Mode (vi)
  - Memory-lapse (ATM)

Detecting Errors

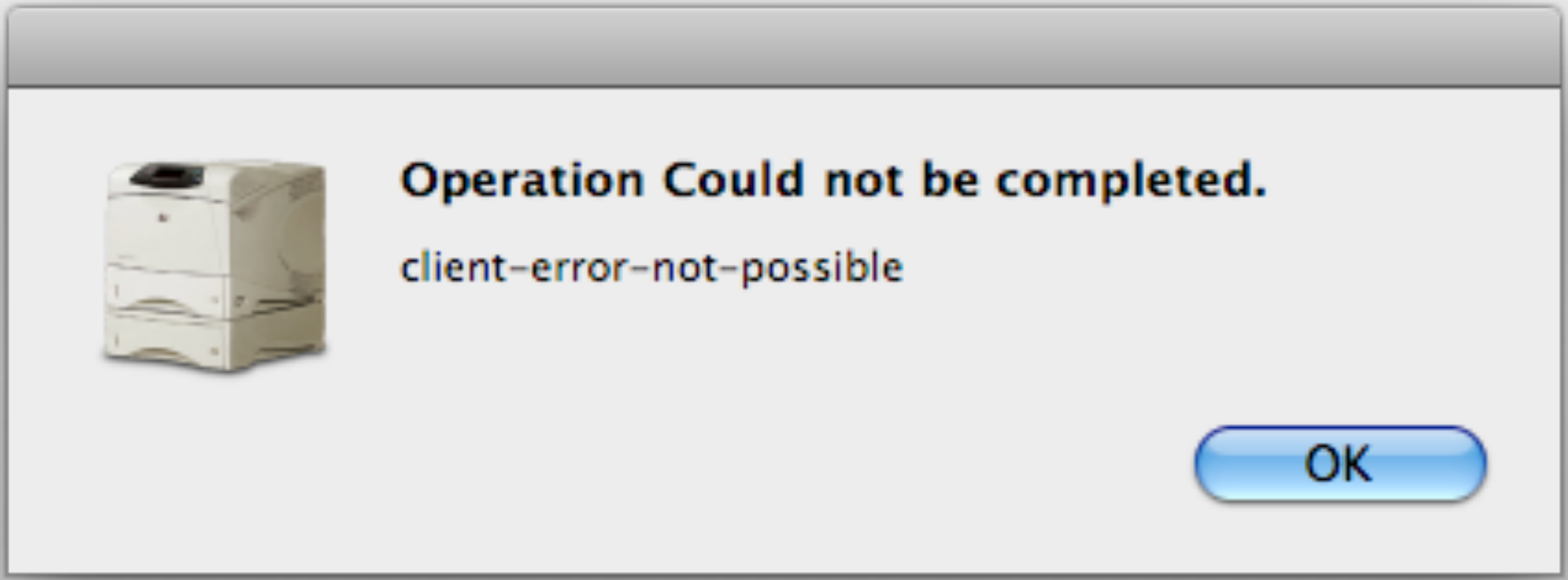
- Detecting slips is easier than mistakes, but requires visible feedback
  - Example: "Adjust the window!"
- Action-based slips are easier to detect that memory-lapses because the feedback is tangible
- Mistakes are hard to detect because nothing signals a wrong goal
- Problem: Finding the right level at which to correct
  - Are we doing this bottom-up?
  - The wrong car key
  - Confirmation is unlikely to catch errors
    - "Remove file blah.txt?"
  - Soft, reversible actions are better (e.g., trashcan), but people begin to rely on it

The Paradox of Automation

- When automation works, tasks are done as well or even better than by people
- The paradox is that automation can take over dull and simple tasks, but not complex ones
- When automation doesn't work, the results are unpredictable and could be dangerous, e.g., self-driven cars

Designing for Error

- Assume all possible errors will be made
- Minimize the chance of errors occurring
- Minimize their effect if they are made
- Make them easy to detect
- Make them easy to reverse (undo)
- Watch people using your system (and their slips and mistakes)
- Don't punish, don't ignore
- Warning signals are ignored, warning features bypassed if inconvenient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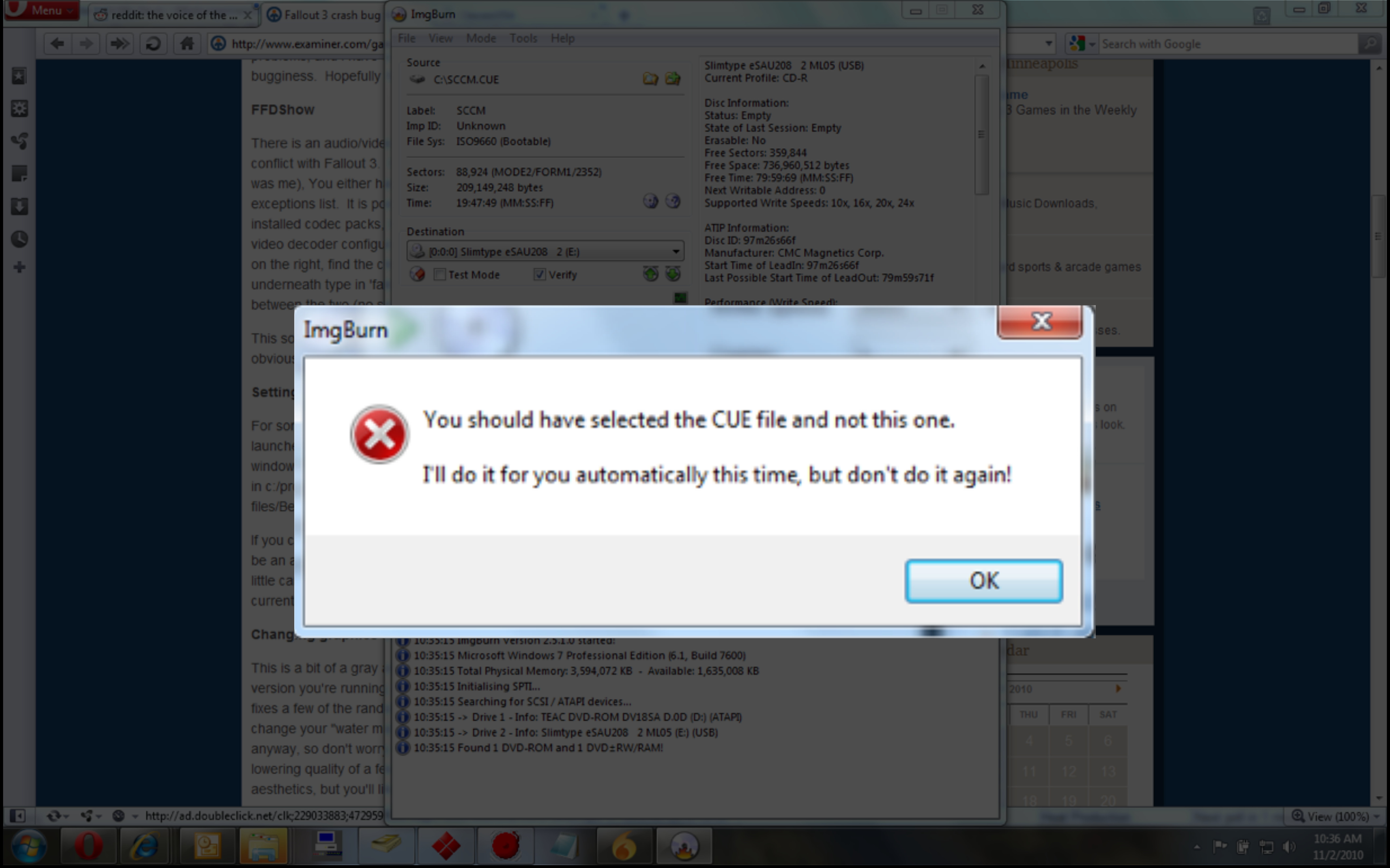

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