Resistive Objects

smart objects that become less agreeable than they can be, for a purpose

Jaroslaw Domaszewicz

Institute of Telecommunications
Warsaw University of Technology
Warsaw, Poland

Alexander Gluhak

Intel Labs Europe
London, UK

Illustrations by Simona Ciocoiu

Consider …

Consider a smart object that occasionally passes a negative judgment on the user's behavior (past, present, or imminent).
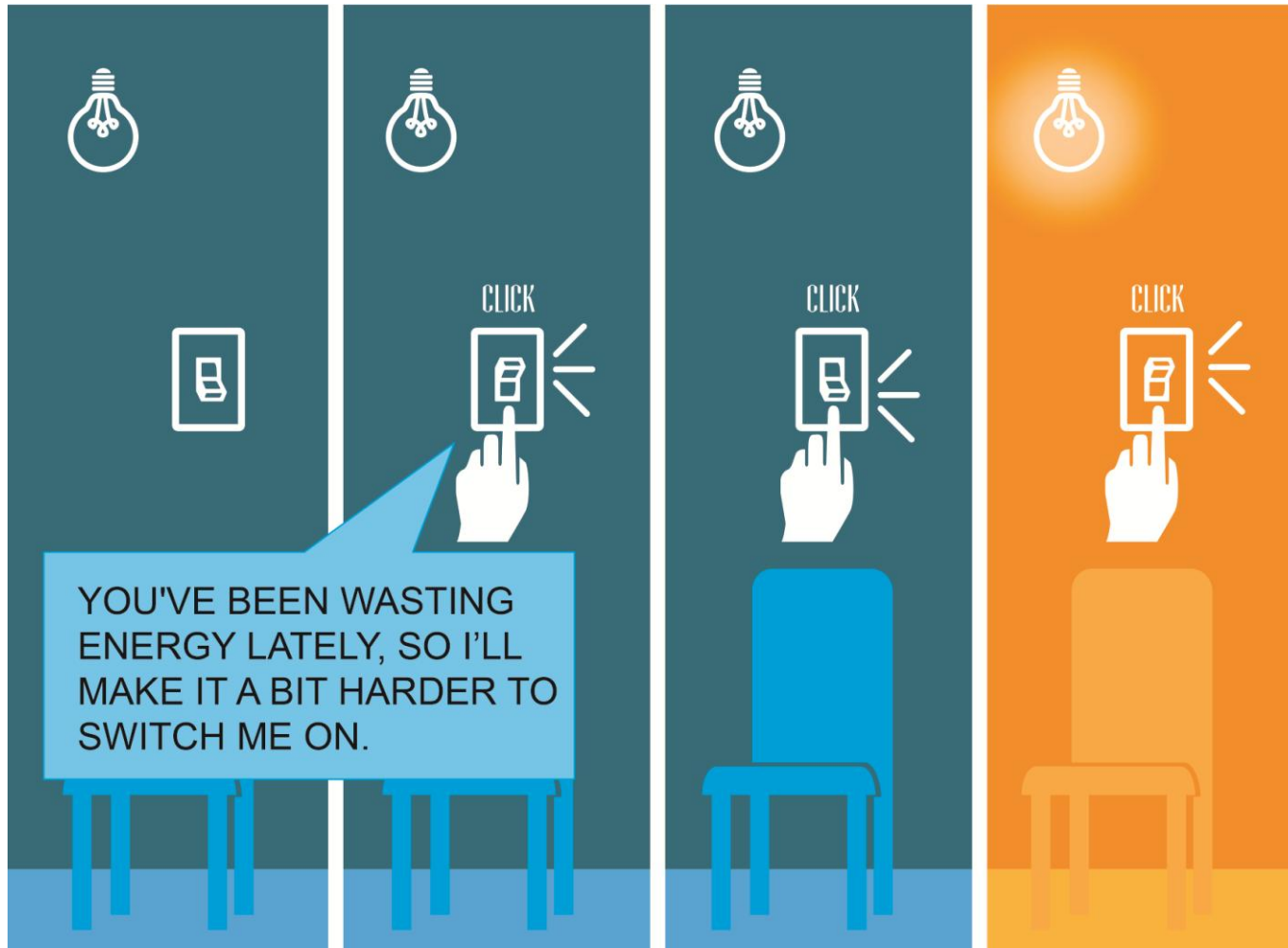
It then conveys the judgment to the user.

It does so via the way it works, without words.

For example, it may do so by …
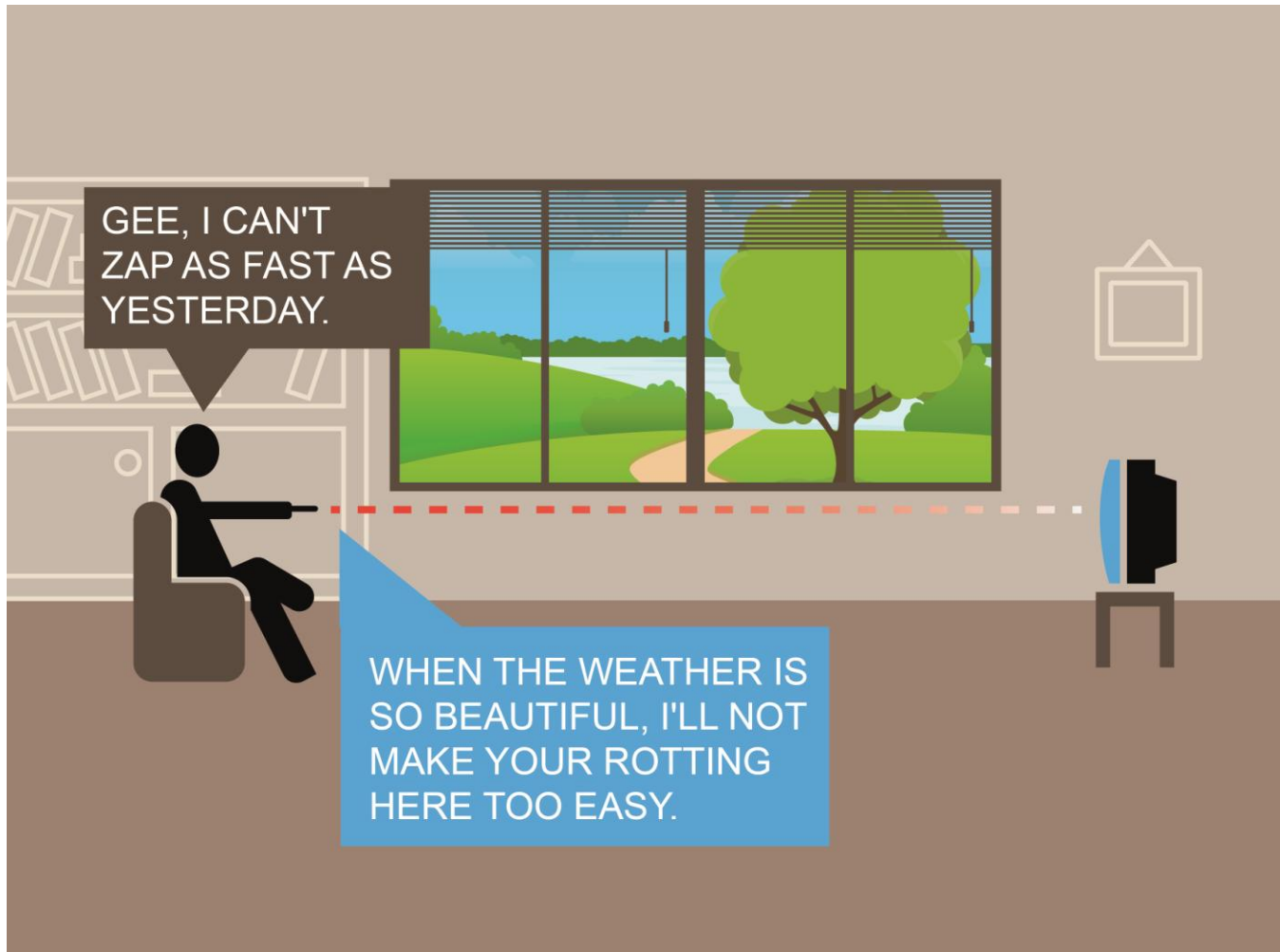
Example 1: home lighting

... requiring more effort.

Example 2: TV remote

... delaying reactions.

Example 3: smartphone

... blinking disapprovingly.
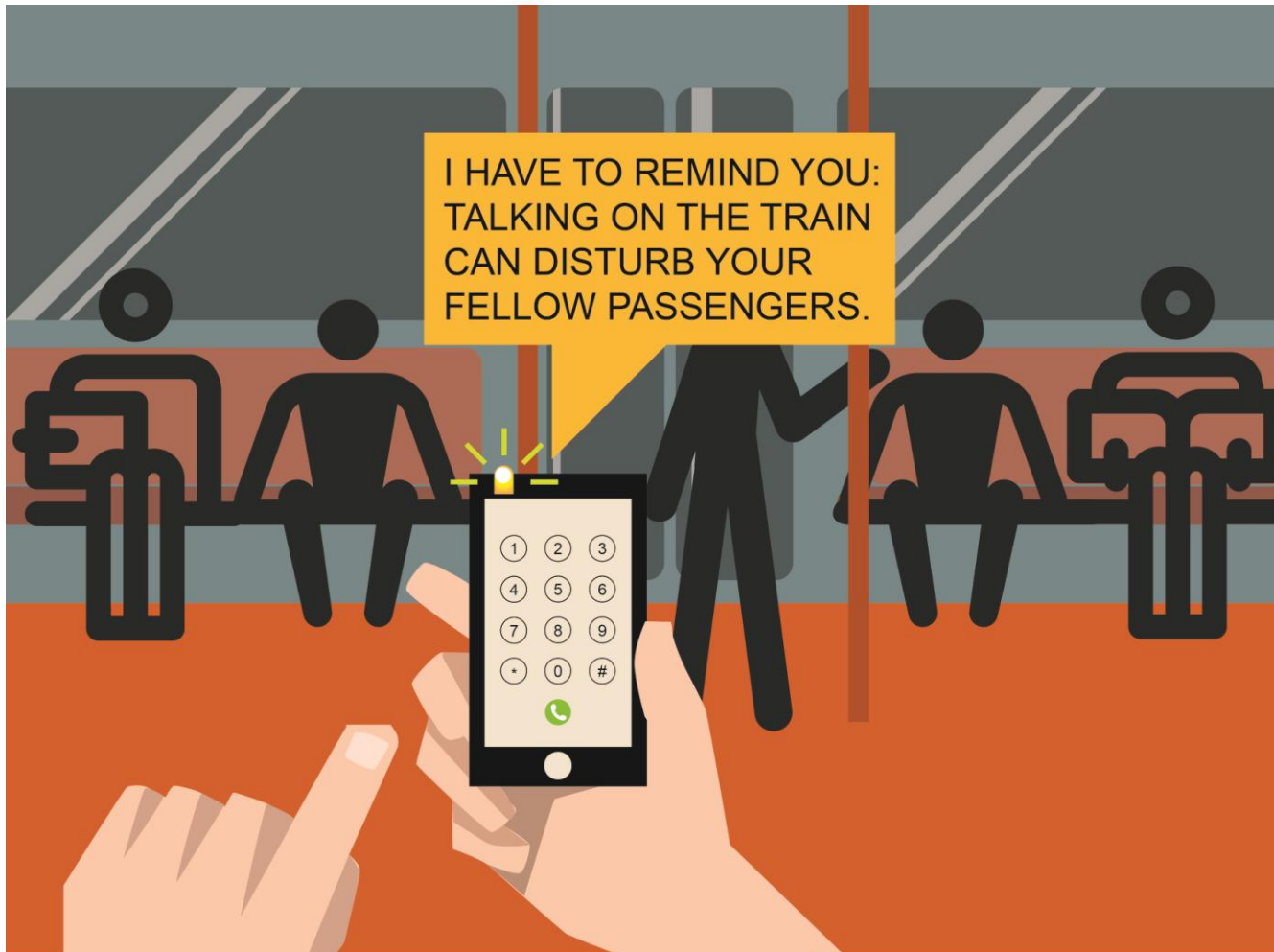
Example 4 (community–wide): escalator

… slowing down.

Resistive object: definition

- A ***resistive object*** is one that in response to some contextual conditions becomes noticeably less "agreeable" to the user.

- We use "agreeability" as a non-technical umbrella term to refer to any of three ***modalities of resistance***, which are quite different in nature.

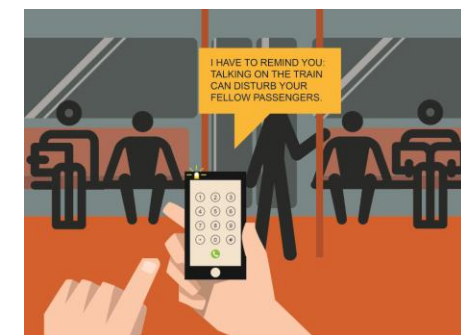# How: modalities of resistance

- The object's <u>usability</u> may drop. ➡

- The object's <u>performance</u> may drop. ➡

- The object may start delivering <u>"disapproving" stimuli</u> to the user. (We call them ***explicit resistance***.) ➡
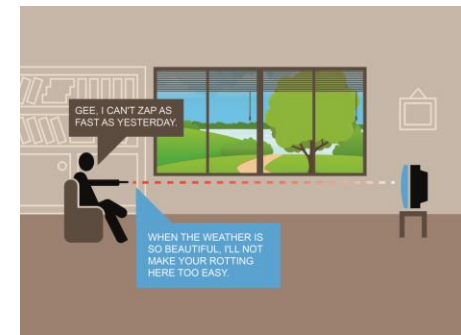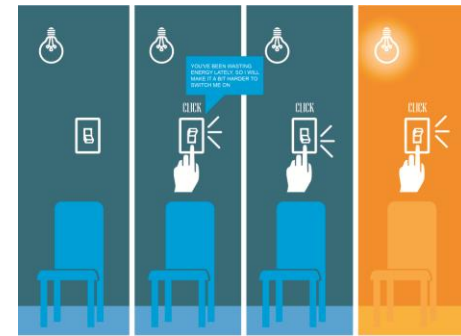
We assume that for any object only <u>one</u> modality is at work.

Why: modes of resistance

- ***Payback***
  An object may become more resistant in return for the user's improper <u>past</u> behavior.
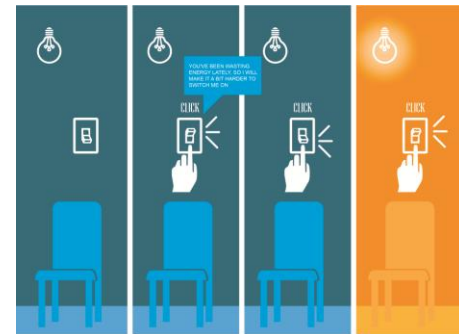
- ***Immediate feedback***
  The resistance is meant to encourage the user to change her undesirable behavior <u>at the moment</u>.

- ***Advance feedback***
  As the user handles the object, she receives an instant, discouraging evaluation of a bad action that she is likely to take in the <u>immediate future</u> (but has not yet taken).
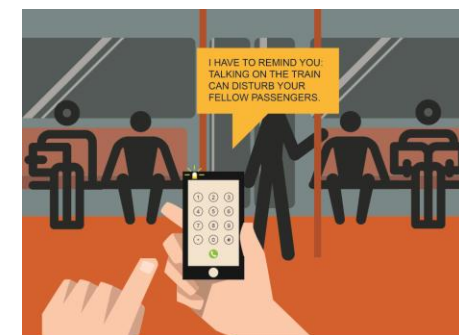
Personal and community–wide objects

- A **personal** resistive object is used by an individual or family.
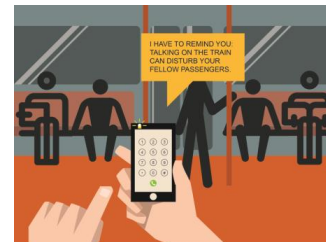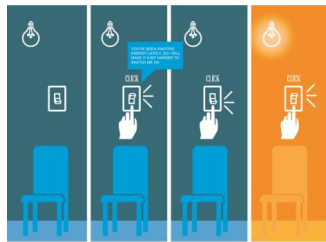
- A **community-wide** resistive object is used by a possibly large group of loosely related people. It may span a meeting room, building, neighborhood, city, nation, or even the entire globe.
The object reacts to <u>collective</u> behavior derived from individual contributions.

Resistance level

- The loss of agreeability occurs to a varying degree, as the context changes.
- We refer to the degree, to which the object has become less agreeable as its **resistance level**.

current resistance level

0.0   1.0

resistance level

minimum resistance:
- best performance
- best usability
- no explicit resistance

maximum resistance:
- performance at its lowest or …
- usability at its lowest or …
- explicit resistance most intense

(*only* <u>one</u> *of the above three holds, depending on the modality*)
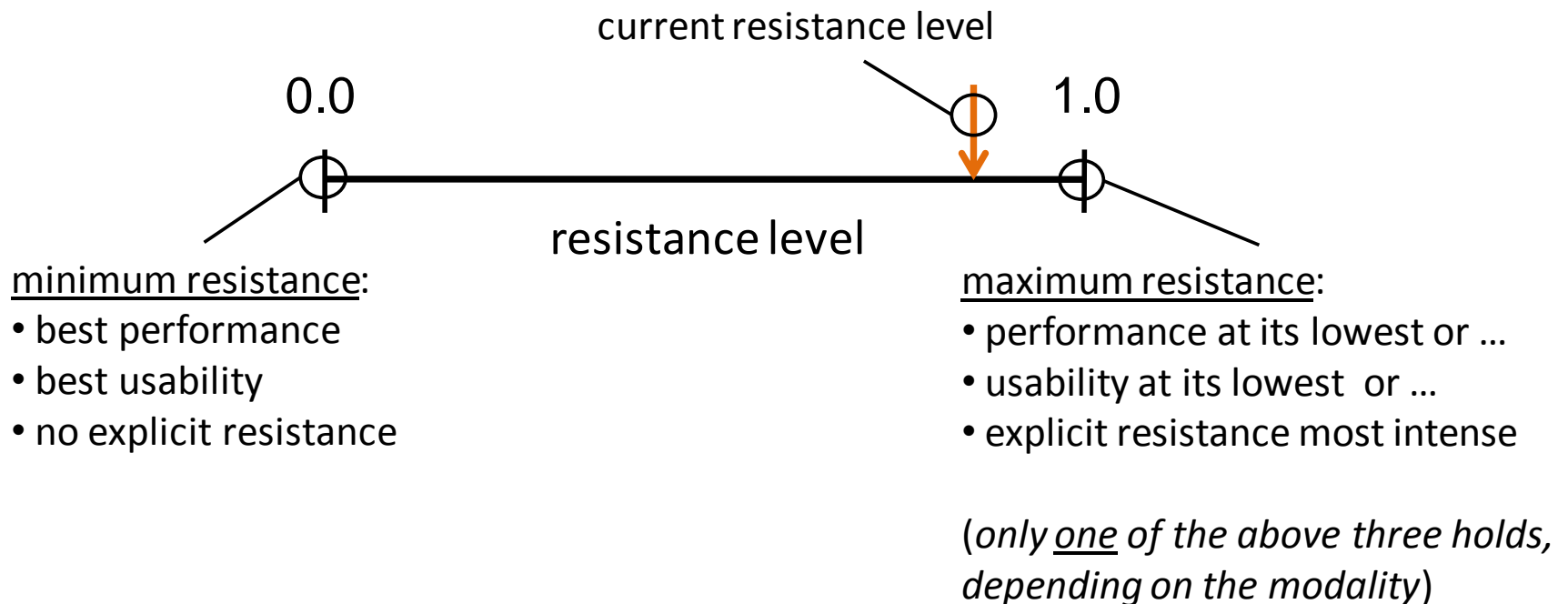
Key design principle

At any resistance level the resistive object remains fully functional and usable.

In particular, the user should be able to <u>ignore</u> the object's resistance.

Key design principle (cont.)

At the highest resistance level (only one of the following holds) …

- The object's usability is at its lowest, but it remains acceptable.
  The point is to make the user aware of changes in usability, not to render the object hard to use.

- The object's performance at its lowest, but it remains acceptable.
  In fact, it may still be better than the regular performance of a lower-end, non-resistive product. What matters is that the user can easily detect performance variations.

- The stimuli of explicit resistance are most intense and may be hard to overlook, but they are still easy to disregard.

Model of resistivity

raw context data

user-understood
resistance driver

resistance level

user-perceived
resistive parameter

context synthesizer → resistance characteristic → resistance converter →

resistance level

1.0

0.0

resistance driver

key property: **monotonicity**
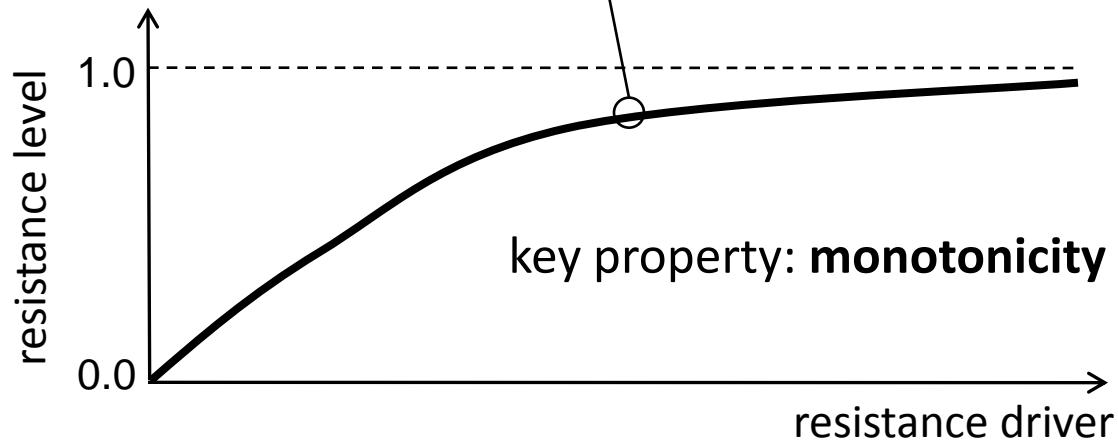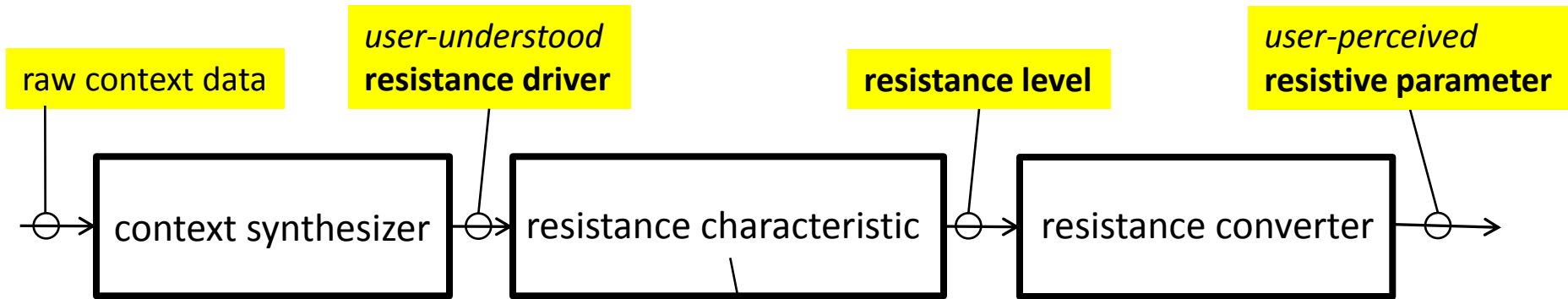
Model of resistivity: resistive TV remote

user-understood resistance driver: **how nice is the weather**

resistance level

user-perceived resistive parameter: **the extra delay**

weather detector

resistance characteristic

converter

temperature, humidity, brightness, …

values of the resistive parameter for the highest and lowest object agreeability
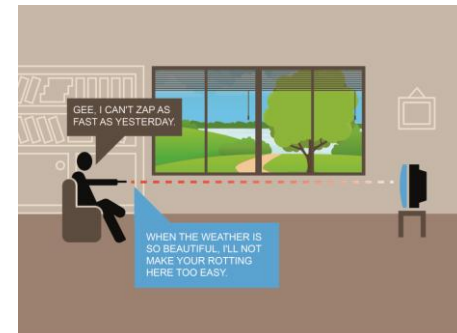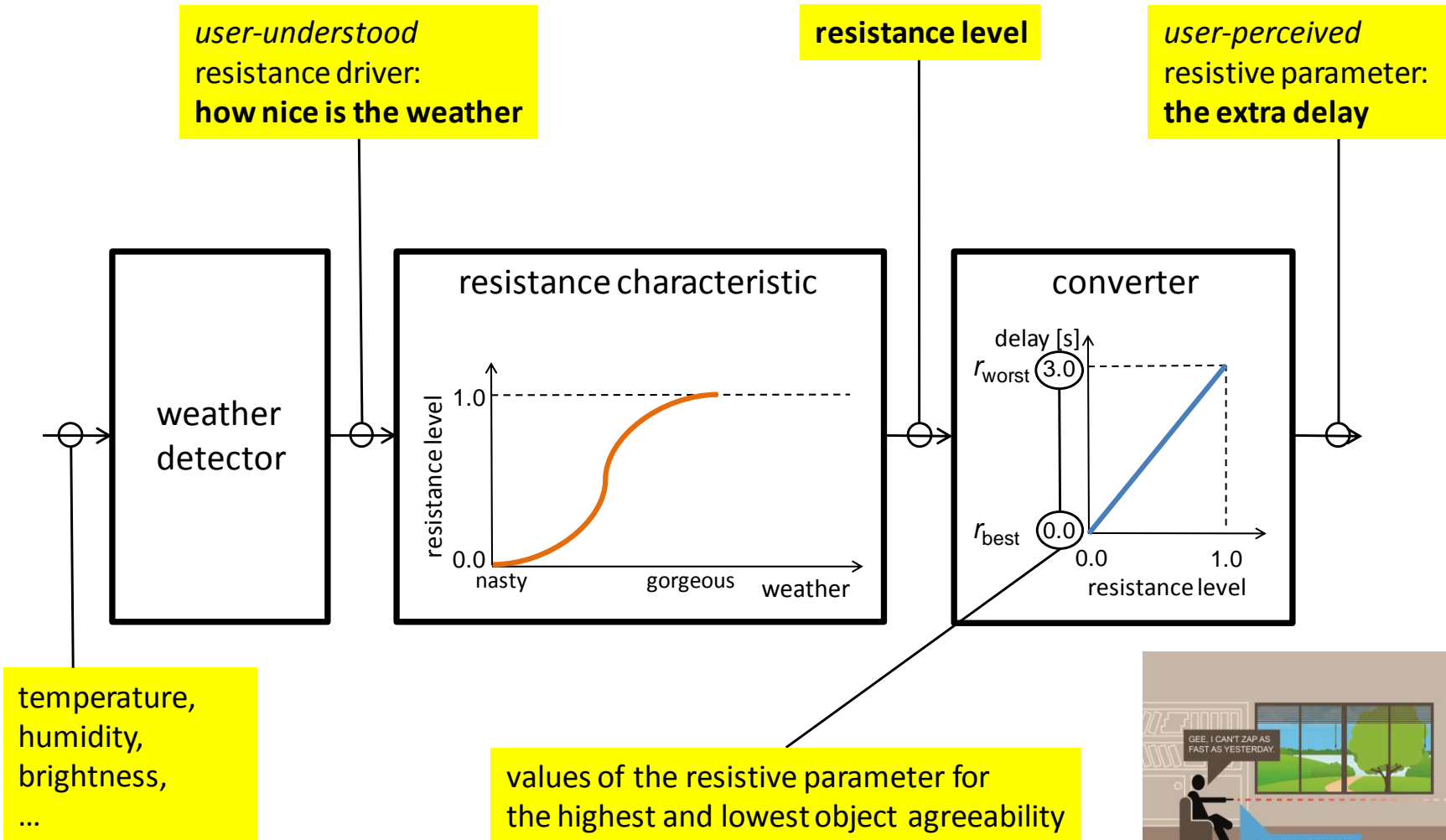
Model of resistivity: resistive lighting
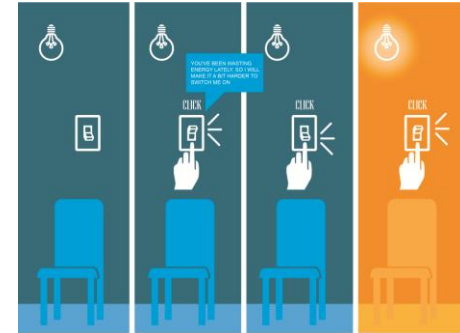
sensor data	light switching occurrences, data from human presence sensors, …
resistance driver	energy waste factor (say, for a two week moving window) in {1,2,3,4,5}
resistive parameter	the number of times one needs to toggle a switch to switch lights on
r_{best}	1
r_{worst}	5

Note: specific values are only examples.

Model of resistivity: resistive smartphone

sensor data	accelerometer data, sound, …
resistance driver	current activity in {default, on the train, driving a car}
resistive parameter	the frequency of the notification LED's blinking
r_{best}	0 Hz
r_{worst}	2 Hz

Note: specific values are only examples.

Model of resistivity: resistive escalator

sensor data	per-person escalator vs. stairs usage data
resistance driver	<u>per-community</u> escalator usage ratio (say, for a one week moving window)
resistive parameter	the speed of the escalator (when there is a rider)
r_{best}	0.6 m/s
r_{worst}	0.3 m/s

Note: specific values are only examples.

Model of resistivity: resistive escalator

sensor data	per-person escalator vs. stairs usage data
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r_{best}	0.6 m/s
r_{worst}	0.3 m/s

both speeds are acceptable for "normal" escalators

User's conceptual model (technical terms)

- For a given object the user should know its …
    - <u>resistance driver</u> (e.g., the weather outside),
    - <u>resistive parameter</u> (e.g., the delay in reaction to a key press).

- Further, the user should understand that …

<u>IF</u> the resistive parameter has changed for the worse,
<u>THEN</u> the value of the resistance driver has increased (and vice versa).

- We believe that in most cases more detailed knowledge
(say, of the resistance characteristic) is not needed,
or can be acquired by using the object for some time.

User's conceptual model (human terms)

from the user's manual:

*With your resistive lighting,
the number of times you need to toggle to switch on the lights
depends on how well you've been conserving energy lately.*

That can be any number from one to five. The fewer, the better.

If toggling once does the job, congratulations – you've been very conscientious about saving energy.

If you need to toggle five times, you've been quite negligent; please consider being more careful to improve your score.

User's conceptual model (human terms)

resistive parameter

With your resistive lighting,

the number of times you need to toggle to switch on the lights

depends on how well you've been conserving energy lately.

resistance driver

That can be any number from one to five. The fewer, the better.

If toggling once does the job, congratulations – you've been very conscientious about saving energy.

interpreting the resistive parameter in terms of the resistance driver

If you need to toggle five times, you've been quite negligent; please consider being more careful to improve your score.

Resistivity matrix

Modality (how) / Mode (why)	Performance	Usability	Explicit resistance
Payback	**Resistive remote** (watching time) **Resistive browser** (browsing time) **Resistive coffee machine** **Resistive escalator** (payback)	**Resistive lighting** **Resistive road** (speeding driven) **Resistive self-closing faucet**	**Resistive lighting** (with earcons)
Immediate feedback	**Resistive remote** (weather) **Resistive browser** (aimless browsing) **Resistive escalator** (immediate feedback)	**Resistive road** (pedestrian driven)	**HAPIfork** **SubRosa**
Advance feedback	**Resistive automatic door**		**Resistive phone** **Nest thermostat** **Window signaling systems** **Tea Light**
Fixed resistance	**Ford MyKey**	**Regular road** (with speed bumps)	**Regular road** (with warning signs)

objects that are <u>permanently</u> less agreeable than they could be

Resistivity matrix

Modality (how) / Mode (why)	Performance	Usability	Explicit resistance
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- Most existing products and prototypes rely on explicit resistance.
- Hardly any of them (none in our matrix) applies the payback mode.
- There seems to be a lot of uncharted territory !

Related research areas

- <u>Persuasive technologies</u>
    - resistivity is meant to be one of them

- <u>Embedded, implicit interaction</u>
    - resistivity is added to a <u>regular</u> object, whose function, look, and feel are preserved
    - interaction is not a goal in itself; it occurs as a byproduct of using the object the <u>usual</u> way

- <u>Ambient information systems</u>
    - the object conveys information on the resistance driver, without attention grabbing screens (and without a distinct ambient display)

Research questions

- <u>User acceptance</u>: can the user's frustration and a sense of punishment be avoided?
  - our design principle may be a necessary but not sufficient condition for good user acceptance

- Does resistance-based feedback have <u>advantages over explicit feedback</u> delivered via displays of smartphones or laptops?
  - possible advantages: more persuasive power, less distraction

- How to answer: experiments in-the-wild, insights from psychology.
- An interesting set of issues has to do with community-wide objects.
  - note the emerging community orientation in persuasive technologies

Glimpse of validation activities

- A prototype of a TV remote control middleware platform for context-aware applications (based on the CC2533 RF4CE Development Kit from TI).

Goluch Maciej, "Programmable TV remote as platform for context-aware applications," BS thesis, Warsaw University of Technology
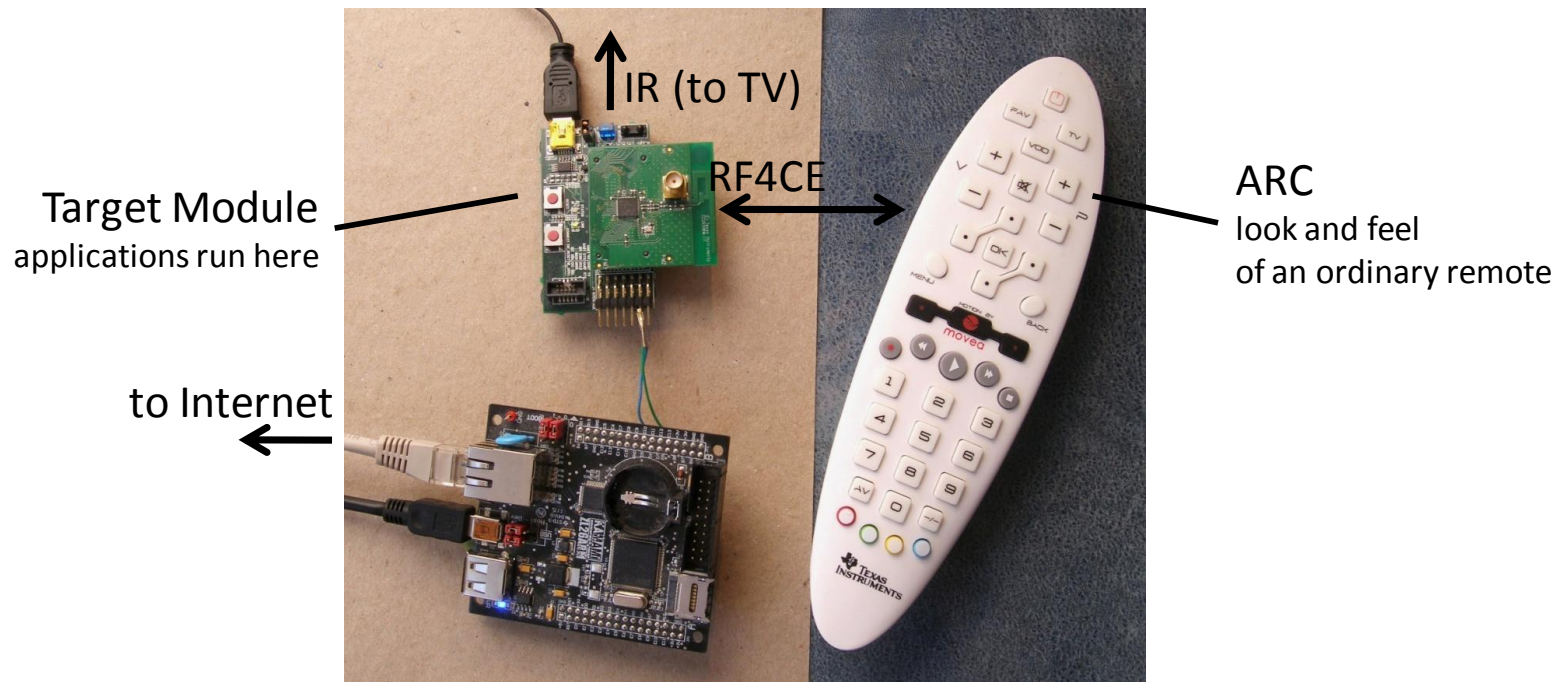
- In our validation experiment we intend to learn about user acceptance and persuasive power of different versions of the resistive remote.

Thank you!

Thanks to Simona Ciocoiu for the illustrations.