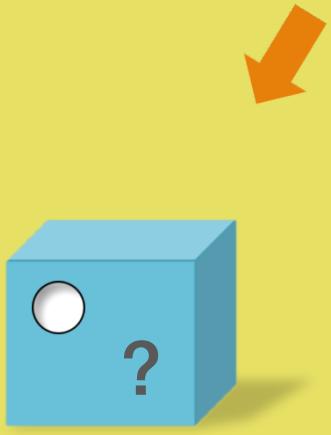
UbiComp 2012

Investigating Receptiveness to Sensing and Inference in the Home Using Sensor Proxies



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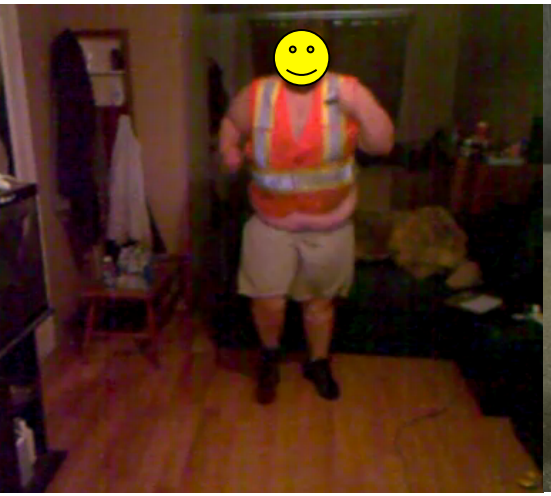
Motivation

In-home sensing and inference systems impose **privacy risks** and **social tensions**



Entertainment
(e.g., Kinect)

Energy Monitoring

Eldercare Application
(e.g., Fall Detection)

Home Security Monitor

Goal

Understand privacy concerns around sensing and inference systems in the home

- Tensions among stakeholders
- Perceived risks and benefits

Collect **contextualized feedback**

Studying end-users' perceptions

Probing

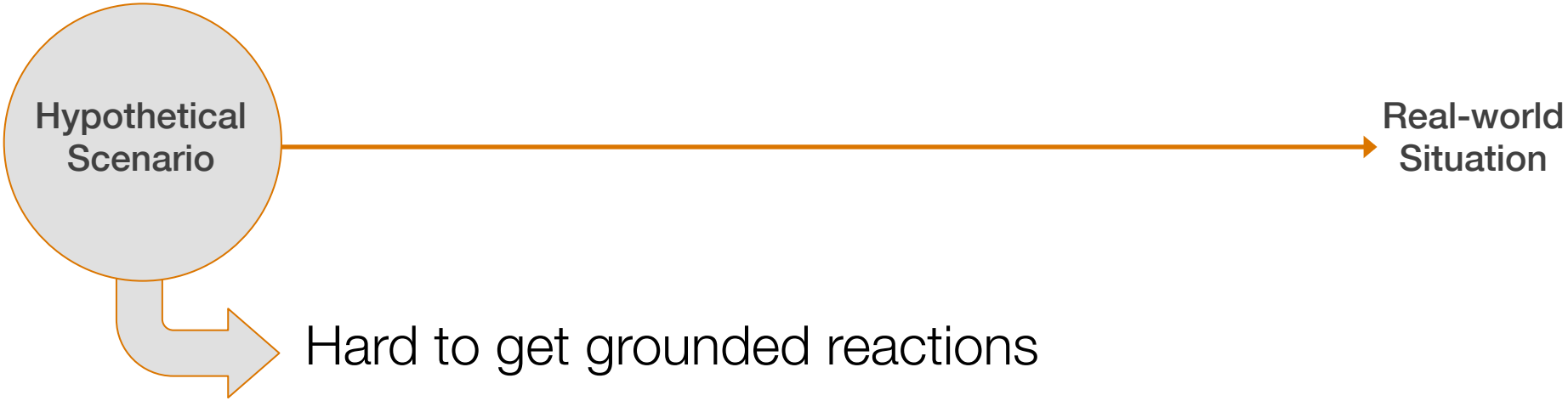
My private moment survey
(Choe et al., 2011)

Deployment of sensing / recording devices

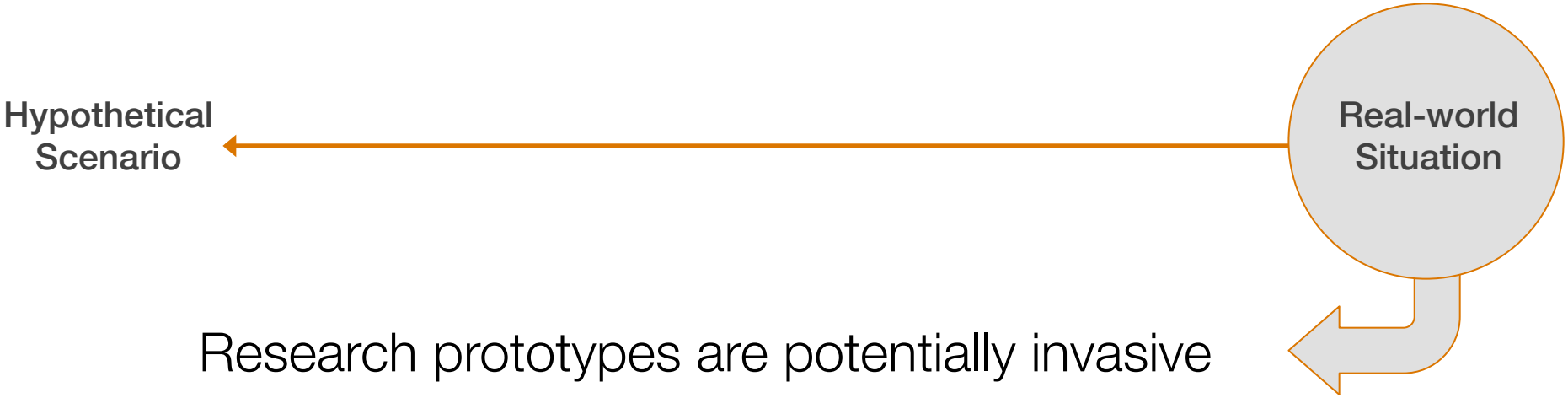
BufferWare (Hayes et al., 2007)

Lullaby (Kay et al., 2012)

Challenges


Hypothetical Scenario
Real-world Situation
Hard to get grounded reactions

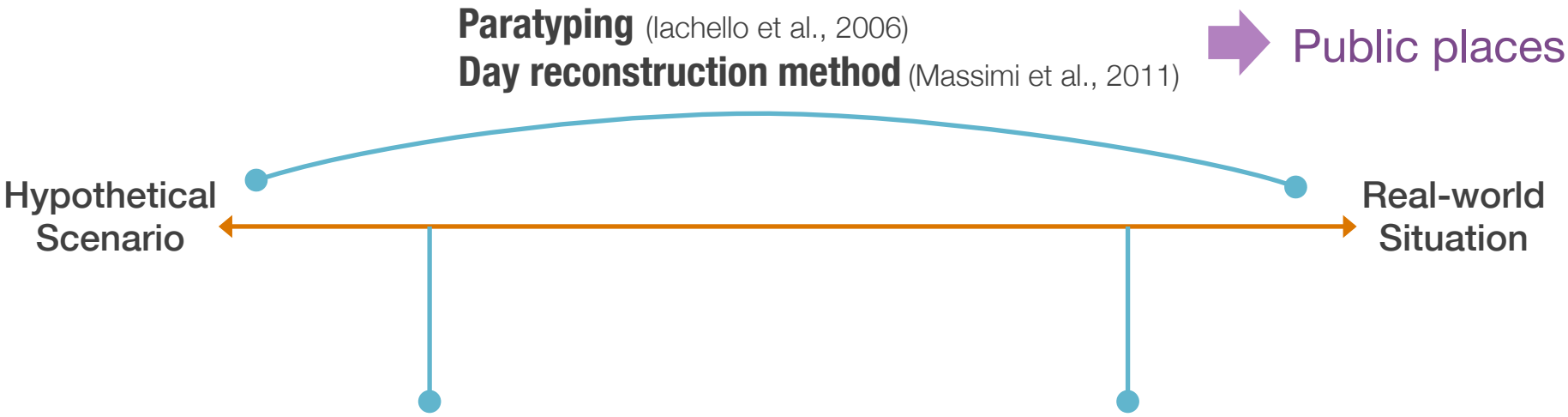
Challenges



Research prototypes are potentially invasive

The risks and social ramifications of research prototypes are unknown

Studying end users' perceptions



Probing

My private moment survey
(Choe et al., 2011)

Deployment of sensing / recording devices

BufferWare (Hayes et al., 2007)

Lullaby (Kay et al., 2012)

Study Procedure

PHASE 1

In-lab: technology education session

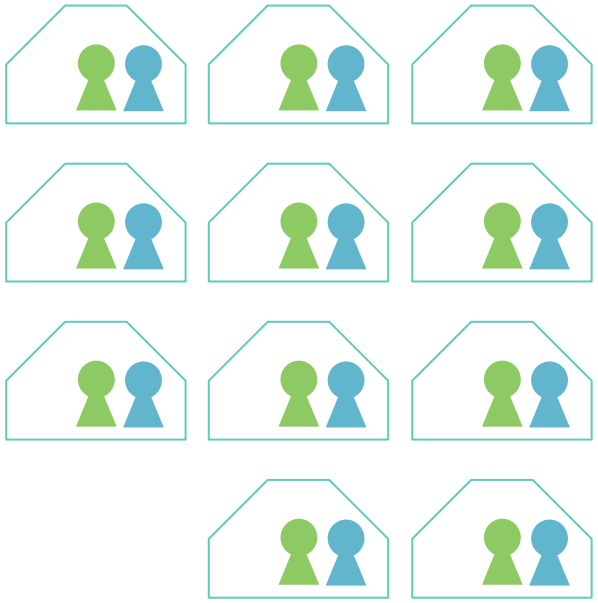
PHASE 2 (4 weeks)

In-home: cultural probes with sensor proxies + diary study

PHASE 3

In-lab: exit interview

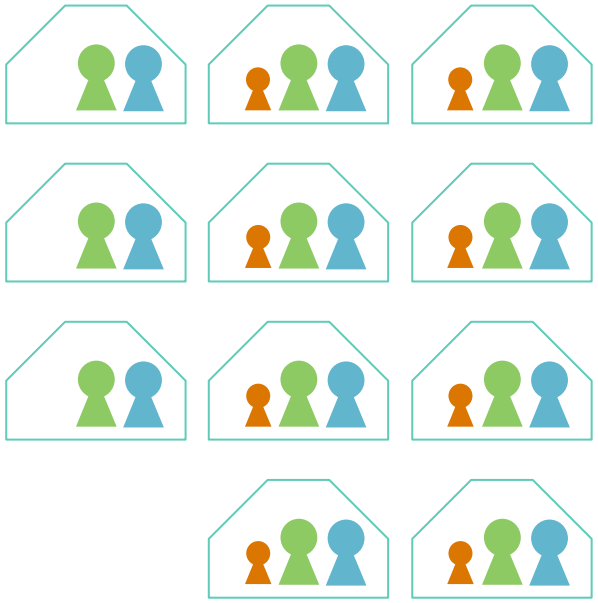
Participants



Couples living together across 11 households

Single family home

Participants

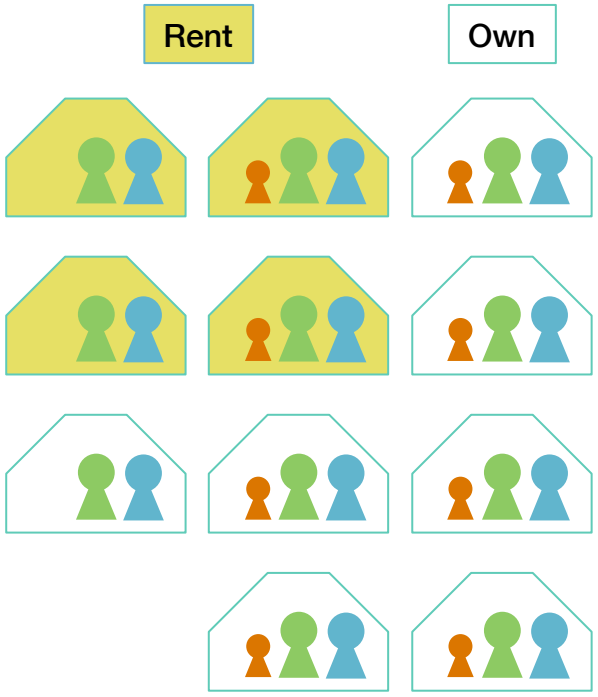


Couples living together across 11 households

Single family home

Have child(ren) – 8 households

Participants



Couples living together across 11 households

Single family home

Have child(ren) – 8 households

Rent (4 households) vs. Own (7 households)

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Four sensing data types

- Video data
- Microphone data
- Electricity use data
- Movement data

Video Data

Electricity Use Data

Frequency Bin / Time (244 ms)	0Hz	244Hz	488Hz	732Hz
1	3.534	3.792	2.784	3.316
2	3.578	3.632	2.892	3.087
3	3.517	3.203	3.212	3.162
4	3.491	3.456	2.554	2.981
5	3.240	3.876	3.481	3.245
6	3.551	3.791	3.213	2.700

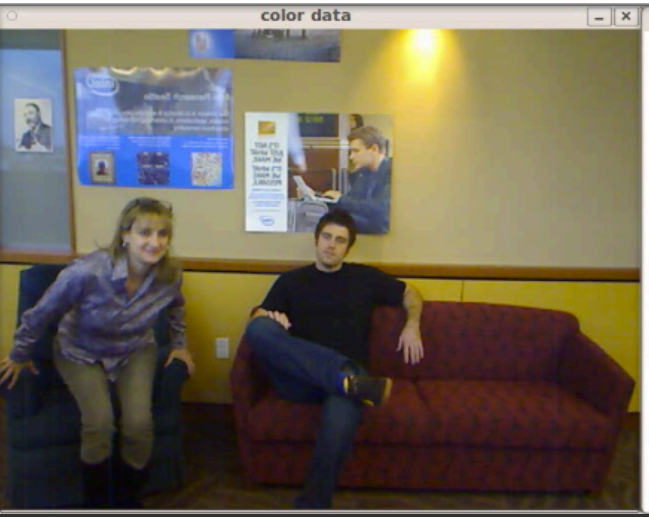
Movement Data

Time (ms)	X (m/s²)	Y (m/s²)	Z (m/s²)
294	0.04	9.08	4.18
296	-0.04	9.08	4.18
298	0.04	9.08	4.09
301	0.00	9.04	4.14
303	0.00	9.08	4.09
306	-0.04	9.04	4.05
308	0.00	9.11	4.10
310	0.00	9.08	4.10
315	0.04	9.08	4.14

Three data processing techniques

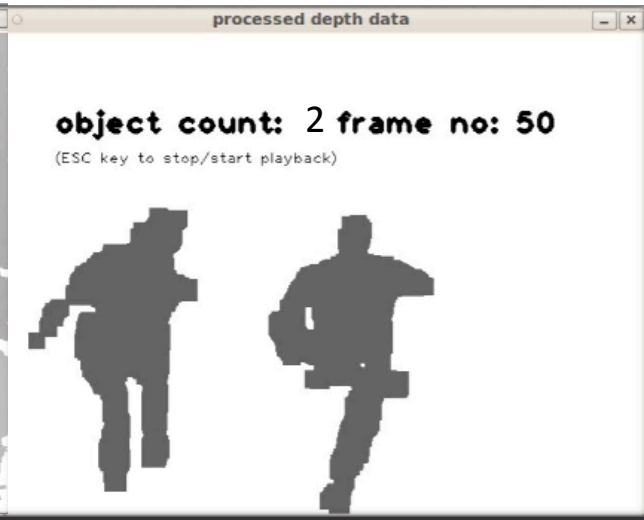
- Raw data
- Filtered data
- Inference data

Raw Video



Filtered Video (Depth only)

Inference Data (Object count)



Brainstorm possible application scenarios

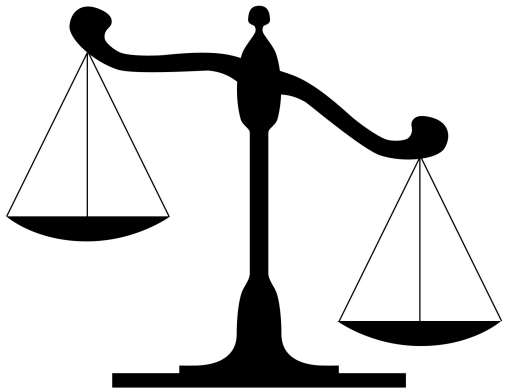
Example questions:

"In what situations do you think these technologies might be helpful to you?"

"Is there anything about this data that would make you uncomfortable if it were installed in your home?"

Consider the trade-offs (benefits / risks)

"What if a service provider has access to the data?"



Study Procedure

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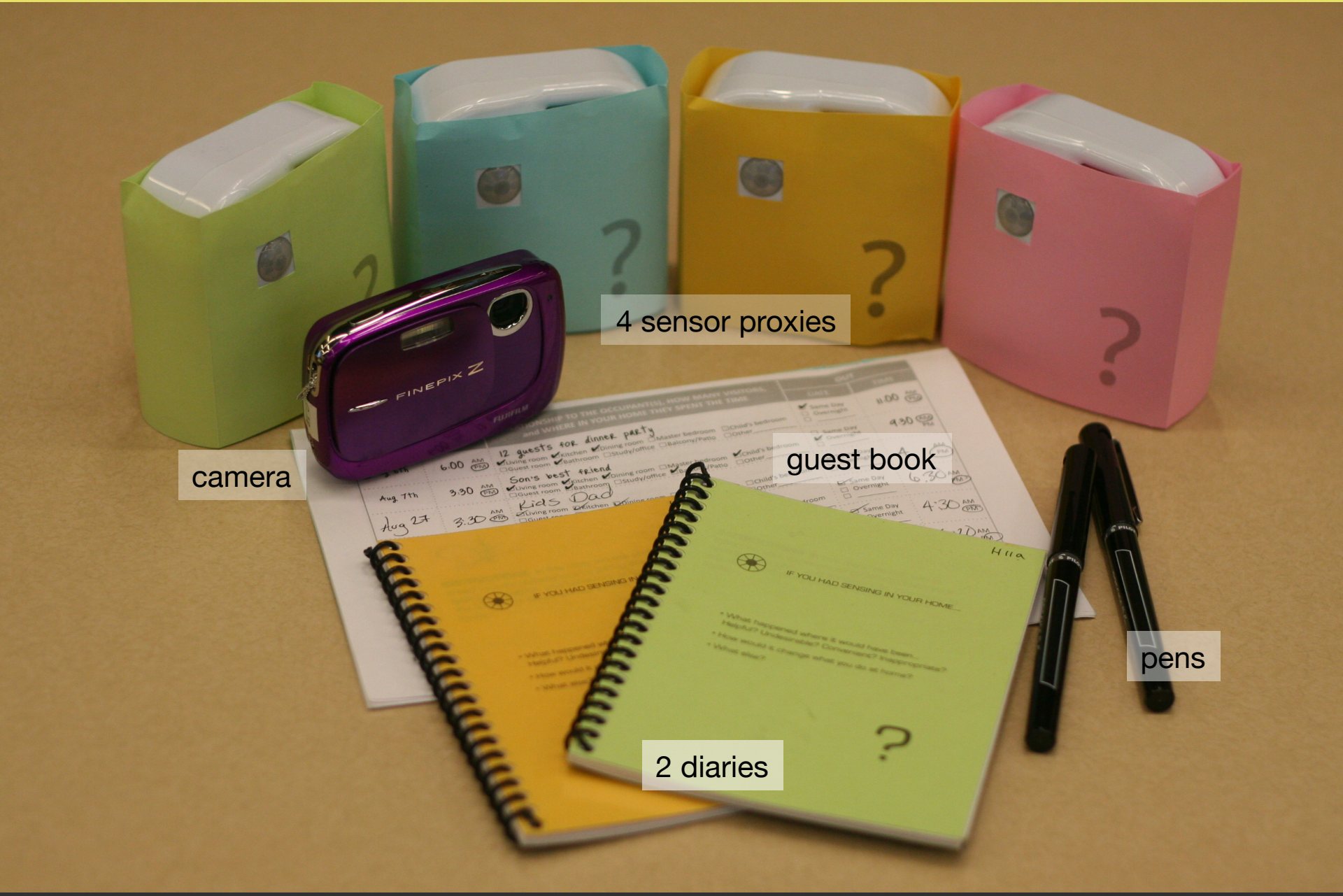
In-home: cultural probes with sensor proxies + diary study

PHASE 3

In-lab: exit interview

PHASE 2 – CULTURAL PROBES + DIARY STUDY



Sensor Proxy: off-the-shelf motion sensor light

Wireless Motion Sensor Light - 10 Super-Bright LED

by SE

(423 customer reviews) | Like (73)

List Price: ~~$15.00~~

Price: $7.45 Prime

You Save: $7.55 (50%)

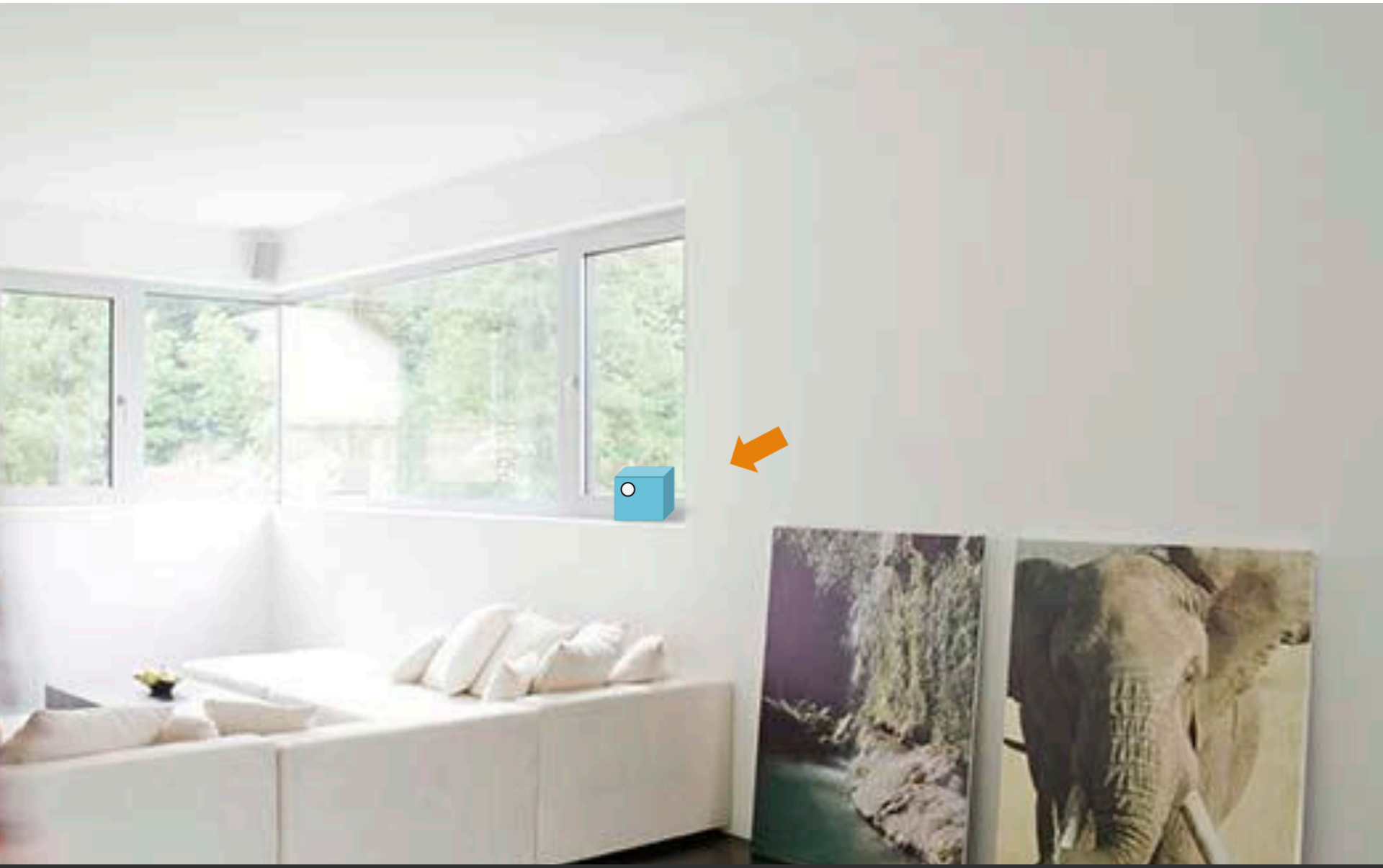
In Stock.

Sold by Gadgetscollection and Fulfilled by Amazon. Gift-wrap available.

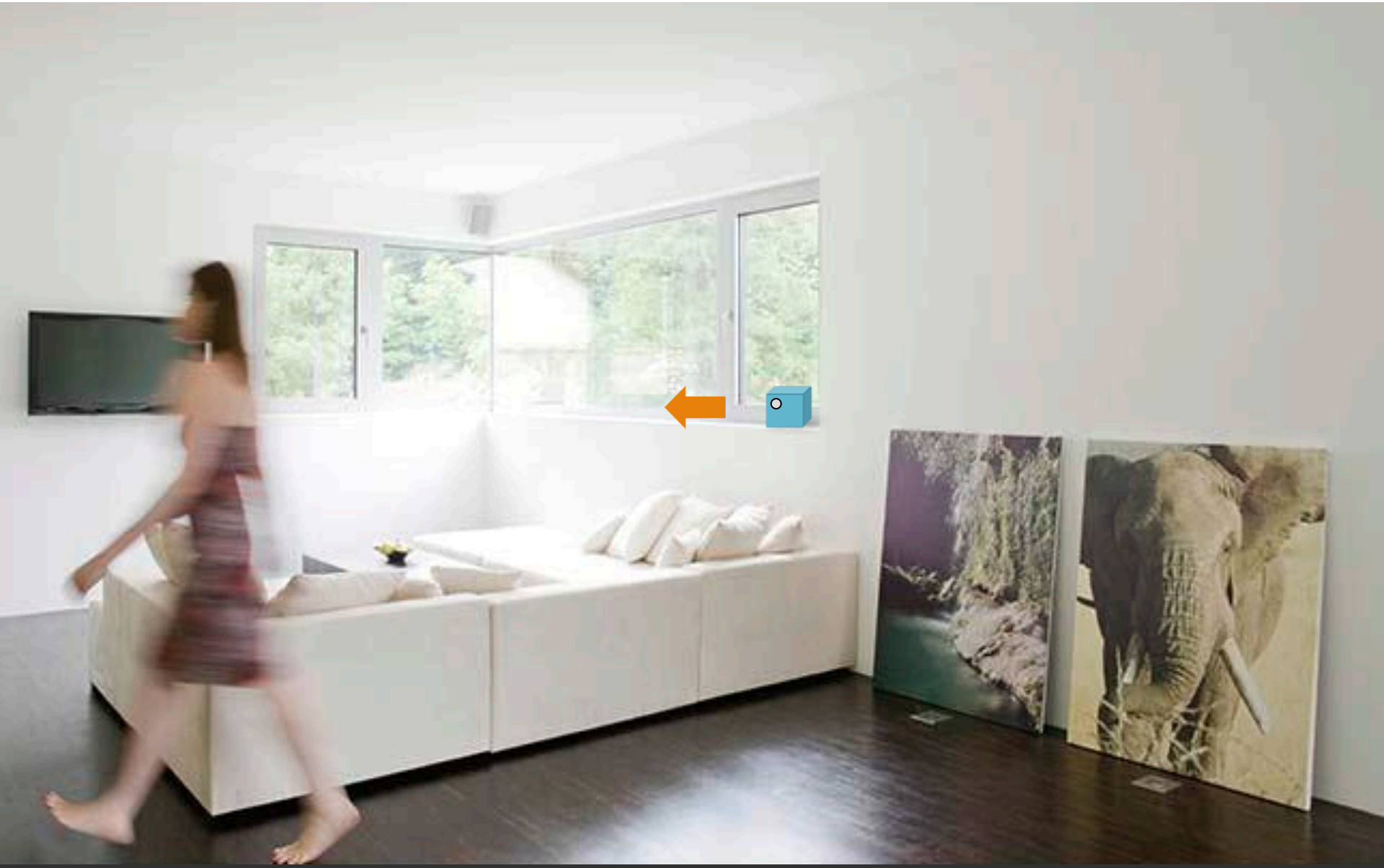
17 new from $6.57

Size/Weight	3” X 3”, 4.3 oz
Power	3 AA batteries
Effective range	10-15’ front, 15-20’ side-to-side

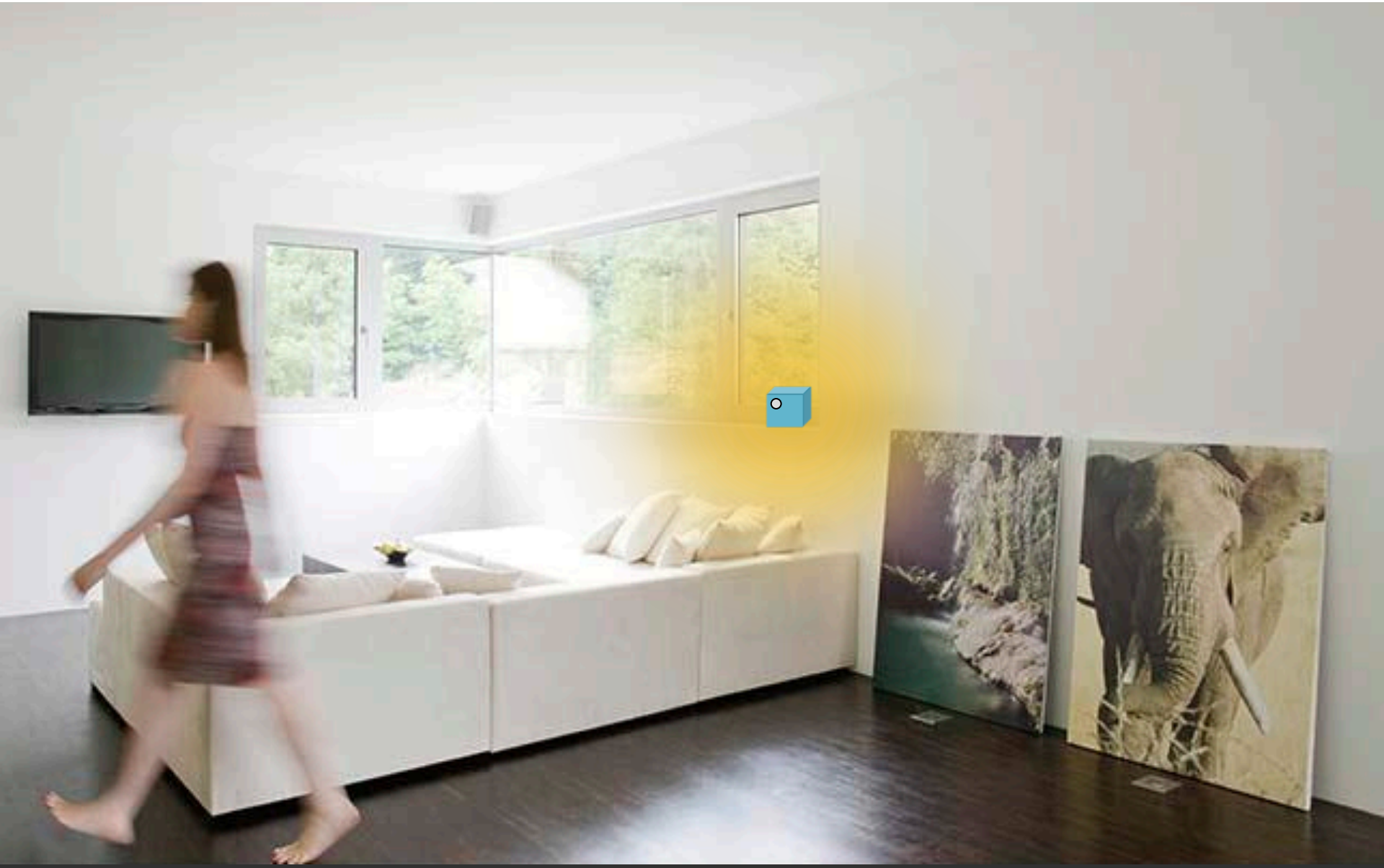
Sensor Proxy



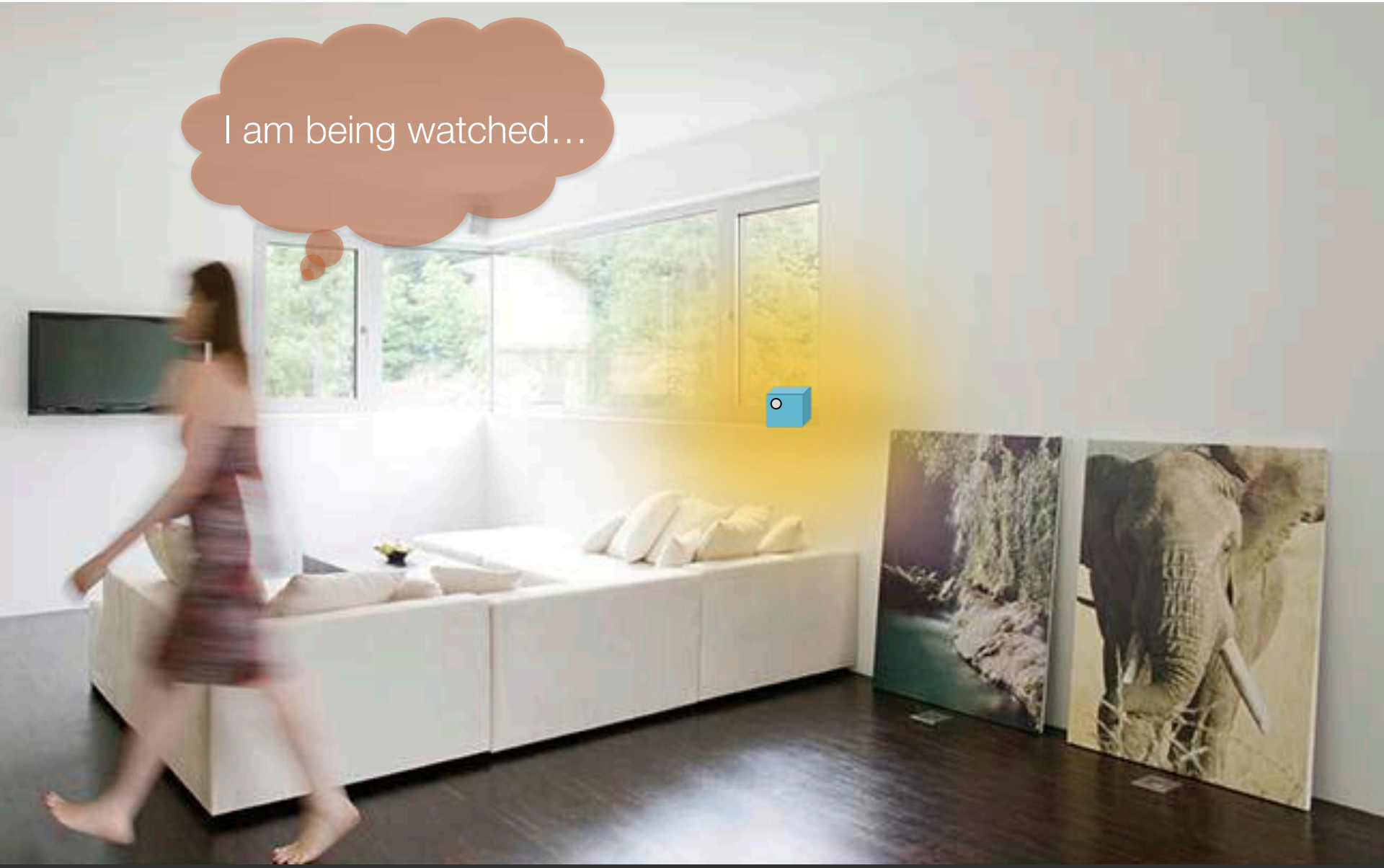
Sensor Proxy



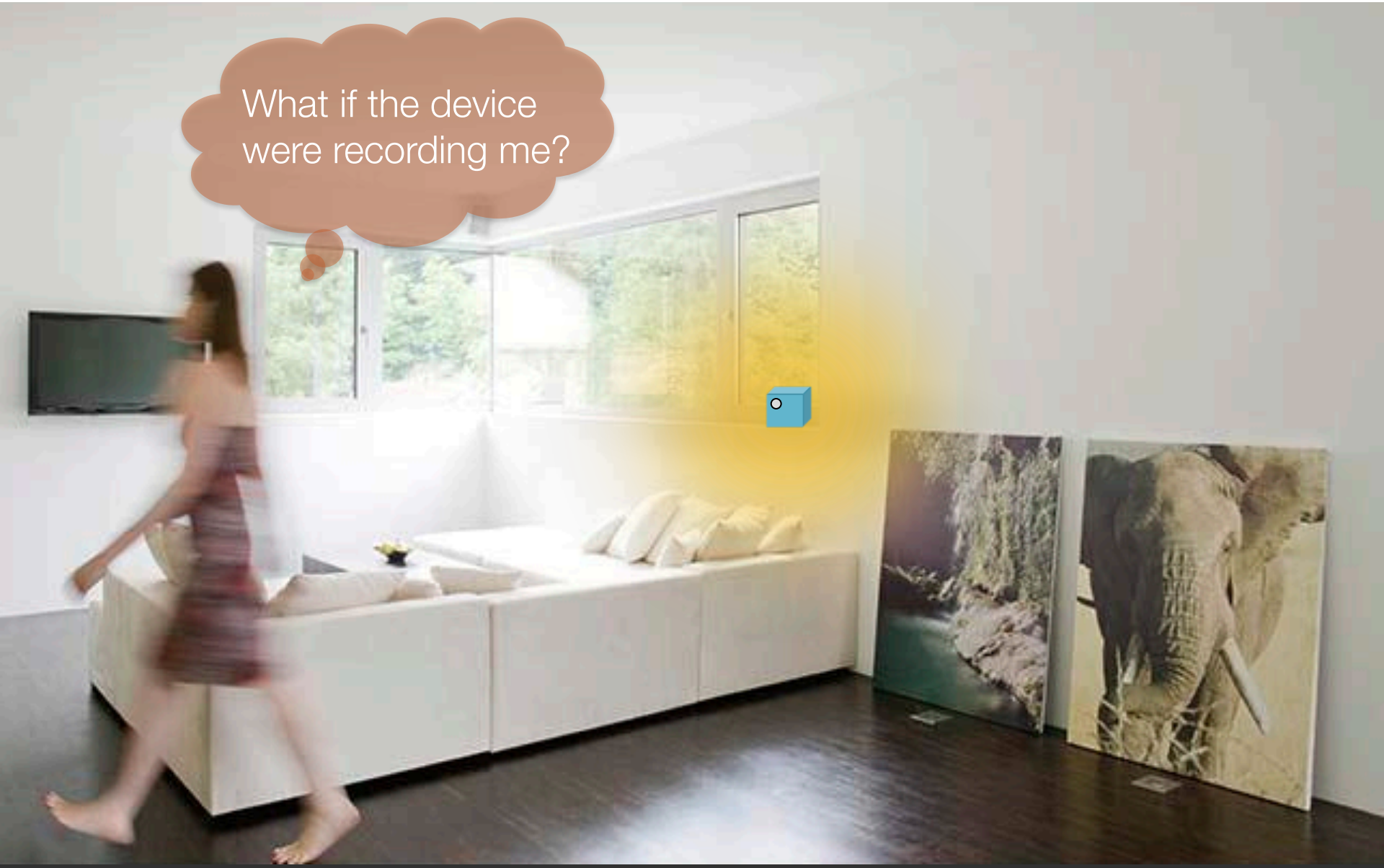
Sensor Proxy



Sensor Proxy



Sensor Proxy



Sensor Proxy


Living Room

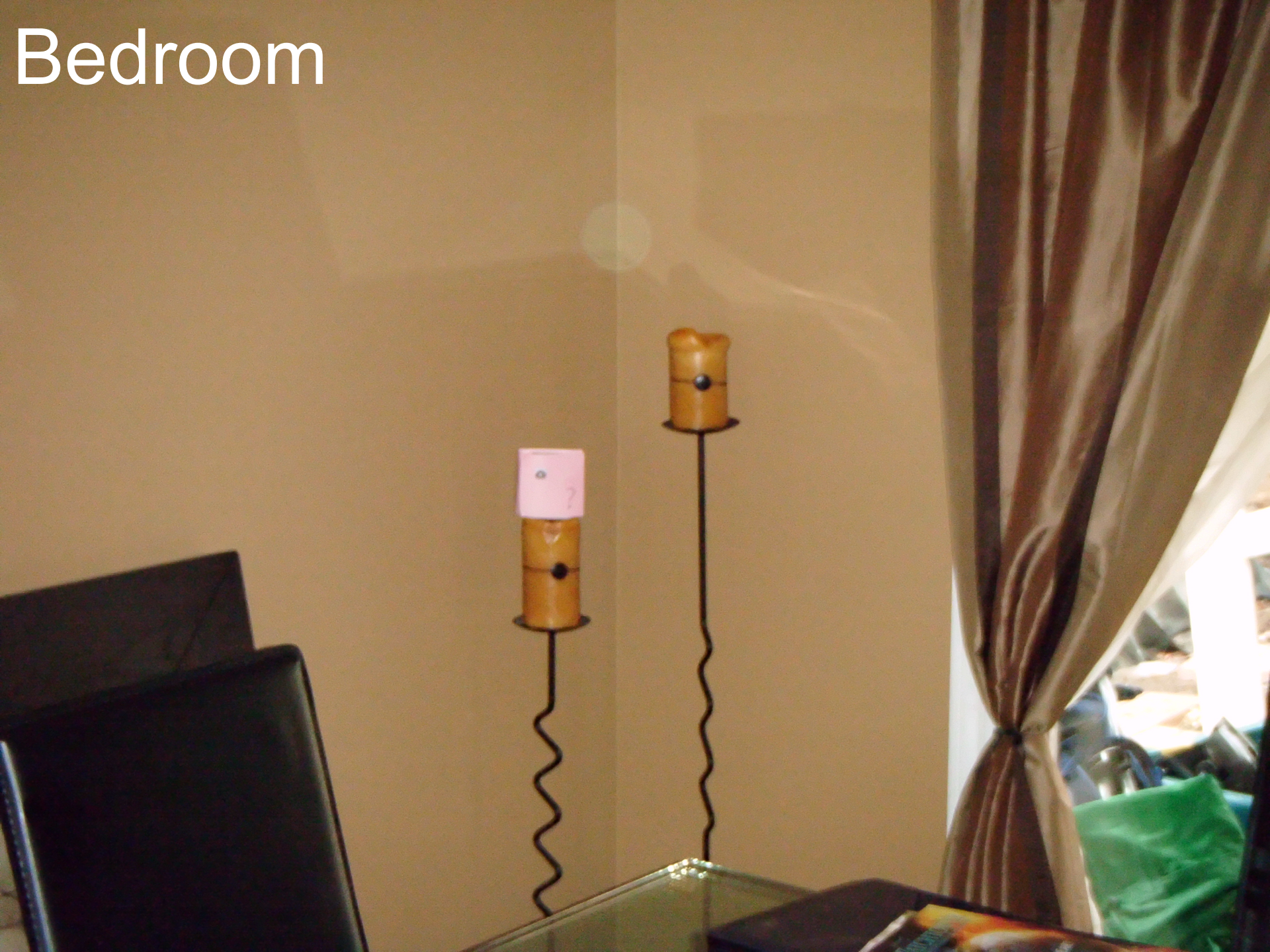
Kitchen

Sink


BRIGHT GREEN
Concentrated
Dish Washing
Liquid
Original
KRUD
KUTTE
CONCENTRATED CLEANE
DEGREASER/STAIN REMOV

Study

Bedroom

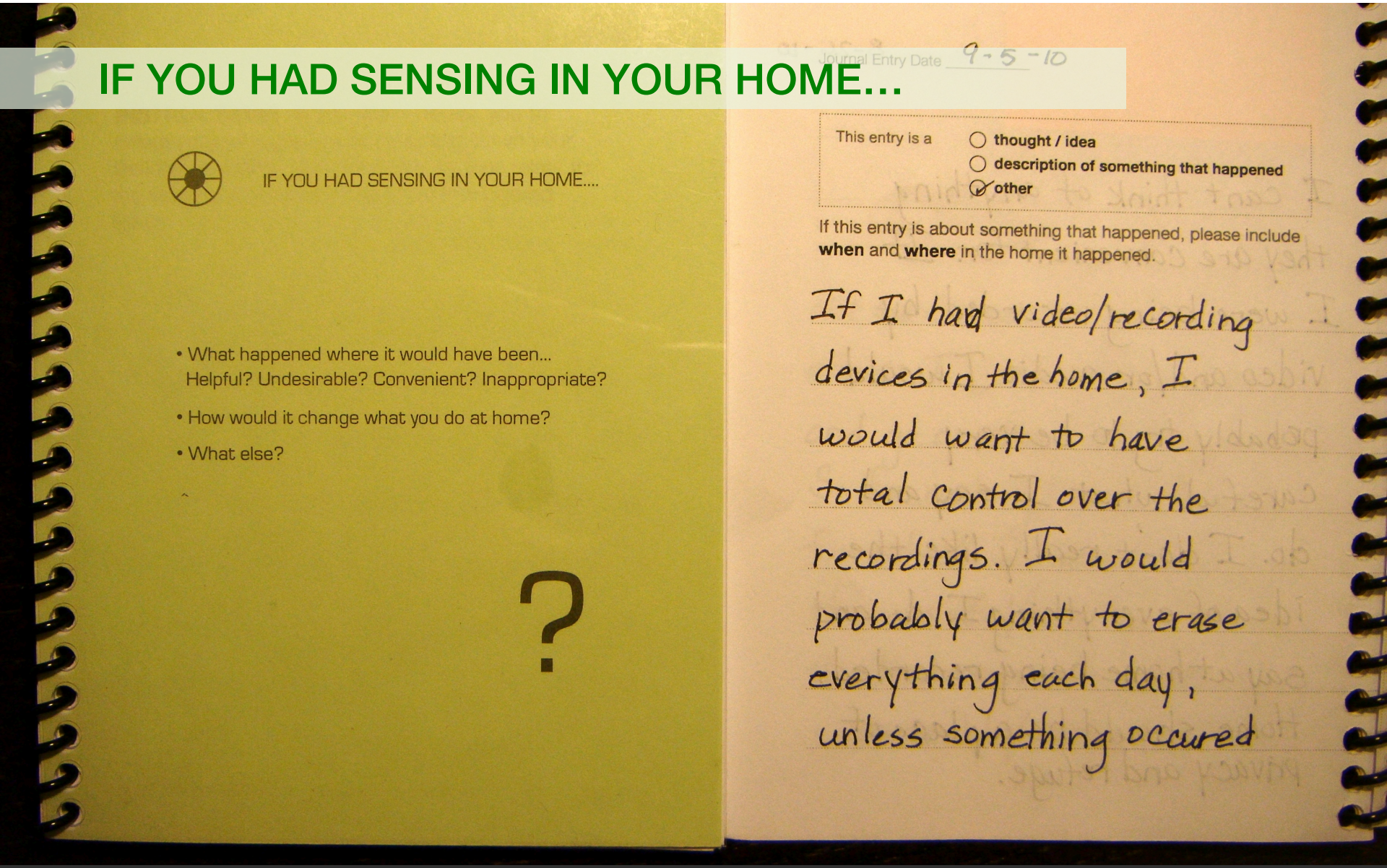


Too bright!


AUTO
OFF
INSTRUCTIONS
1st week: toggle the switch to "OFF"
2nd – 4th week: toggle the switch to "AUTO"
LONG SLEEVE
LONG SLEEVE
LONG SLEEVE
LONG SLEEVE
LONG SLEEVE

Capturing contextualized thoughts

IF YOU HAD SENSING IN YOUR HOME…



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In-lab: exit interview

Revisiting the previous questions

Changes of Opinions?

- Perceptions toward different data types and data processing techniques
- Utility of the potential applications

Talked about the study with anyone?

- Neighbors, close friends, service people, etc.

Analysis

Produced a rich dataset:

Initial and exit interview (44 interviews)

79 diary entries

A grounded theory approach

Took multiple passes of the data and created codebook

Kept a record of which participant responses stemmed from which phase of the study

Results

Tensions among stakeholders

Perceived benefits

Perceived risks and concerns

Tensions among stakeholders

"My 30-year-old brother-in-law stopped by to visit. He was watching TV in the living room when I came home and activated the sensor as I passed it. **He asked what the light was for** and I explained that we are doing a study about sensing devices in the home. We told him that potentially **video (raw/clear), glass shattering detection, and power (electricity) monitoring could be available in the future**. He said that if the device was **video recording** him that he would **feel very uncomfortable and would not want to visit.**" –Male, 37, diary entry

- A conversation starter
- The proxies prompted participants to think about how they might communicate such a system to a visitor
- Sensitive reaction toward video recording

Tensions among stakeholders

Notification strategies vary depending on

Relationship between the householder and visitor

- Close friends / relatives: **casual / explicit notification**
- Service people (e.g., babysitter, caregiver): **subtle notification**

> "I would say, "Just to let you know, we have a home monitoring system and, you know, we're not going to be like keeping tabs on you, but I want you to know that," because it would invoke fear in them, I think." –Male, 36, exit interview

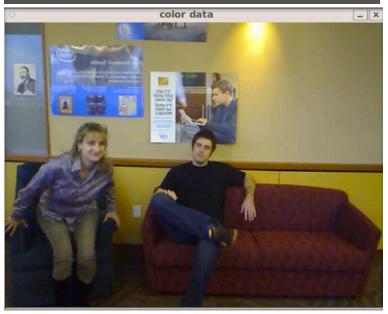
Tensions among stakeholders

Notification strategies vary depending on

Data type & processing techniques

Video and Audio:

RAW DATA



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FILTERED DATA

More obligated to tell

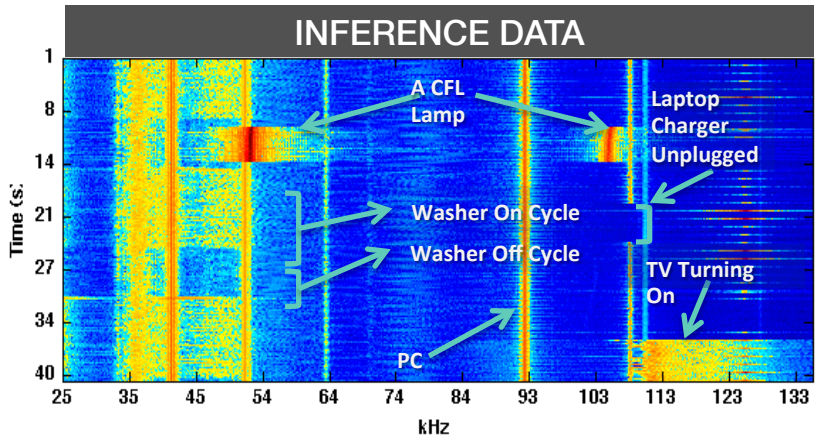
Less obligated to tell

Tensions among stakeholders

Notification strategies vary depending on

Data type & processing techniques

Electricity Use & Movement Data:



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RAW DATA

Time (244 ms) \ Frequency	0Hz	244Hz	488Hz
1	3.534	3.792	2.784
2	3.578	3.632	2.892
3	3.517	3.203	3.212
4	3.491	3.456	2.554

More obligated to tell

Less obligated to tell

Tensions among stakeholders

Reciprocity ("if I see you, you see me") was **not** always the case in the home setting

When you are at my place

When I am at your place

Perceived benefits

Participants' perceptions shifted dramatically according to different applications and contexts

- Applications of interest to participants
  - Health & Safety (**Necessity**) vs. Home automation (**Luxuries**)
- Monetary benefits and incentives

> "I would give him [landlord] the evidence to say "look, this is what, how much we could be saving (...) The appliances really aren't efficient."
> –Female, 45, initial interview

Perceived risks and concerns

Private nature of the in-home sensing and inference data

> "…he [my kid] might be sitting there without a diaper on...what if he decides to be president and then somebody gets this video and see his—you know?"–Female, 41, exit interview

Unintended consequences of recording and playback

> "I would hate to say this. Say you're in a divorce situation. And you wanted to use that as information, you know, to present your case. Then it seems like, "Well, I've got this all recorded here." But is that fair? Is that right?" –Male, 45, exit interview

Discussion

Aesthetics vs. Visible notification

Mechanisms to reduce privacy risks

Reflections on the methods

Aesthetics vs. Visible notification

Home Aesthetics

Proper status notification

Aesthetics vs. Visible notification

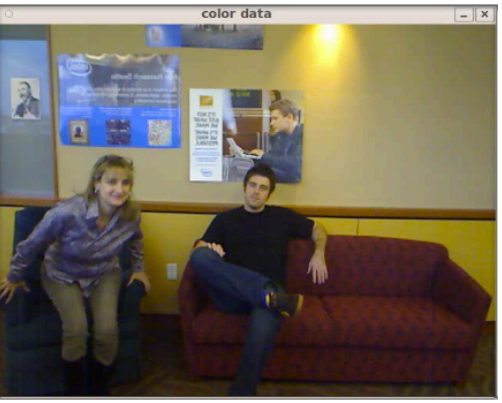
Home Aesthetics

The system sometimes needs to be hidden to fulfill its duty

Designing a gentle notification

Mechanisms to reduce privacy risks

Limited capability sensors for the home



More invasive

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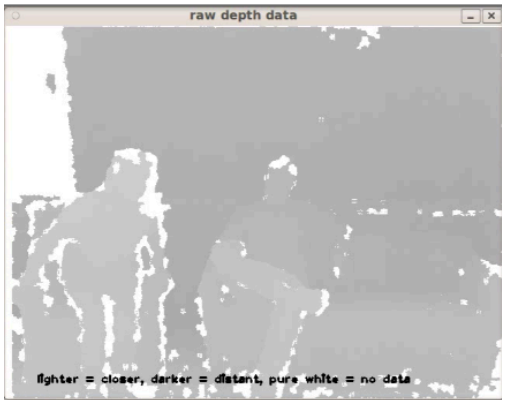

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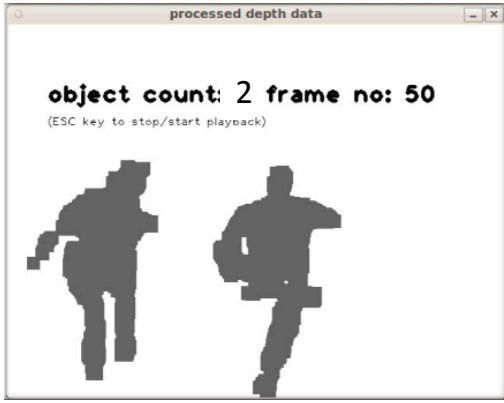
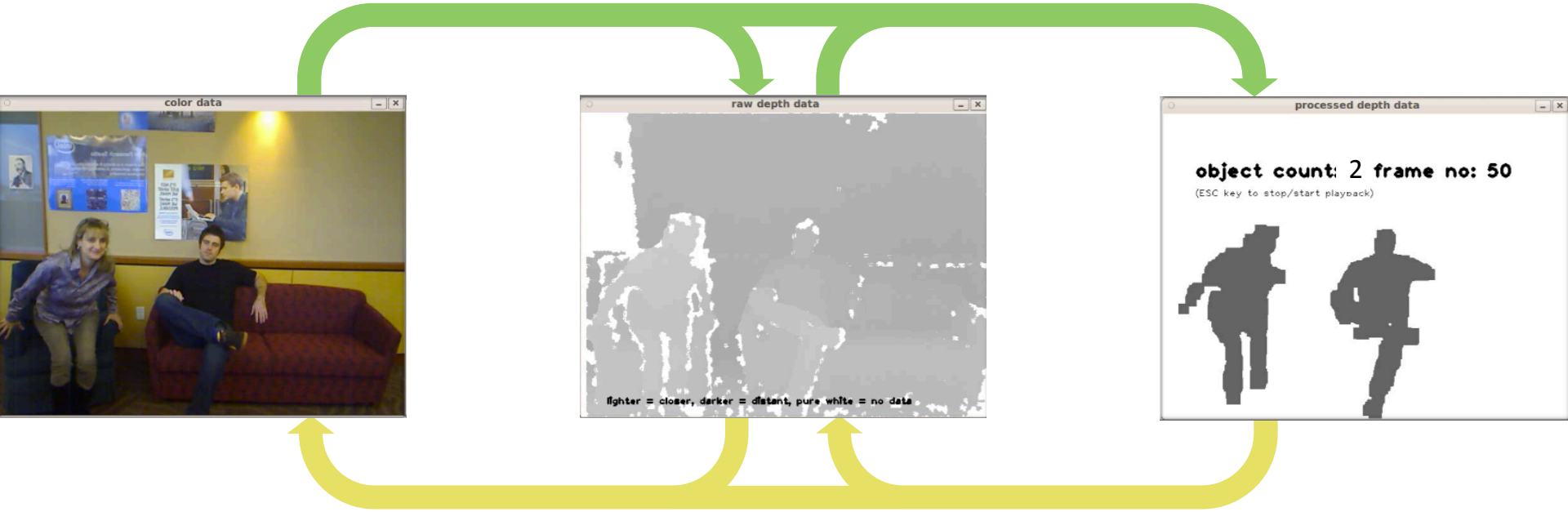


Less invasive

Mechanisms to reduce privacy risks

Context-aware sensing



Reflections on the methods

+ Effective in capturing participants' **grounded reactions**

> "I'd walk past it and I'd chuckle to myself saying, 'Oh, now just think if they were videotaping me, they'd see that I entered the house four times as I was just trying to leave.'"
> –Female, 49, exit interview

+ **Conversation starter** between householders and visitors

– Forgetting the main purpose of the Sensor Proxies and started to use them as nightlights

★ Some participants were surprised by how easily & quickly they forgot about the probes

Summary

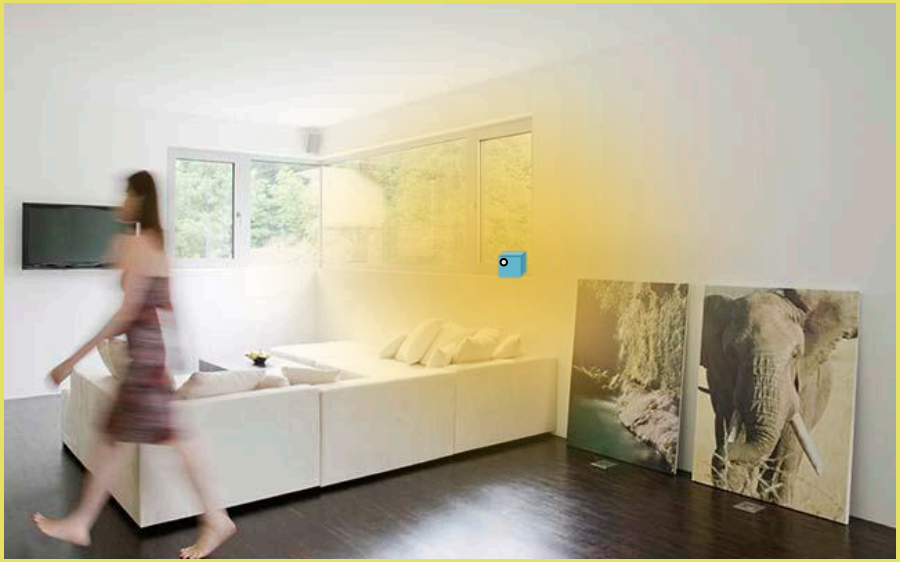
- Collect contextualized feedback

- Identify social issues that impact people's perceptions toward in-home sensing systems:

  Relationship, data types, data processing techniques

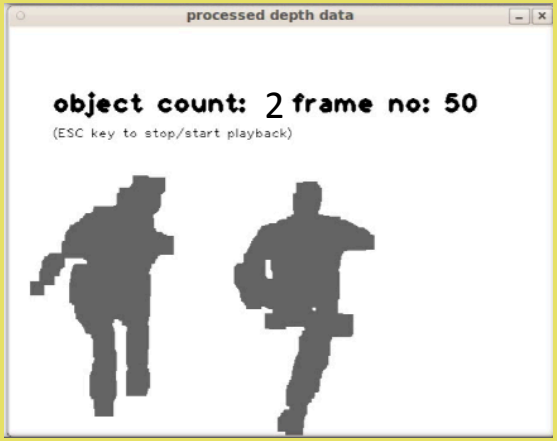
- Our study calls for careful design and implementation choices of sensing system modalities based on an understanding of privacy concerns / social tensions

The End




color data


raw depth data
fighter = closer, darker = distant, pure white = no data


processed depth data
object count: 2 frame no: 50
(ESC key to stop/start playback)