Public Displays

Understanding the Future of Digital Signage

Vorlesung „Advanced Topics in HCI”

Prof. Dr. Florian Alt, SS 2015

Motivation

Tabs

Pads

Boards

[Weiser, 1999] Ubiquitous Computing

The Lightning Man

Persepolis

Littfass-Säule

Source: Wikipedia

The Motogram

Source: IEEE Pervasive Computing

Digital City Light Posters

Source: Wall AG

State-of-the-Art Displays

Interactive Displays

Last Week in CHI 2015

BaseLase

An Interactive Focus+Context Laser Floor

Jörg Müller[1,2] Dieter Eberle[1] Constantin Schmidt[1]

[1] Quality and Usability Lab, Telekom Innovation Laboratories, TU Berlin, Germany
[2] Department of Computer Science, Aarhus University, Aarhus, Denmark

Introduction

Characteristics of Digital Signage I

- Push-based distribution
  - Advertisements
  - Information dissemination
  - Emergency announcements
- Context-specific content
  - Content related to physical context
  - In contrast to many other communication media (Exception: World Wide Web)

Source: [Davies et al., 2014]

Source: [Müller et al., 2010]

Characteristics of Digital Signage II

- Multimedia content
  - Moving images
  - Interactive applications
  - Games
- Easy to update and efficient use of physical space
  - Remote updates
  - Frequent change of content
  - Efficient use of physical space

Source: [Davies et al., 2014]

Source: 2d-code.co.uk

Advantages over Physical Signage

- Facilitating frequent, timely updates
- Increasing accuracy and provision of highly dynamic information
- Improving the aesthetics of a space (digital artwork, video, other media)
- Personalized interactive content
  - Promote viewer engagement
  - Encourage social interaction with the space

Shortcomings of Digital Displays

- Hard to understand how many people see digital signs
  - Difficulty to establish new business models
- No equivalent to click-through rate
  - Makes encouraging and tracking user actions difficult
- Encouraging passersby to see and interact with content
  - Creation and distribution of engaging content is key
  - Public engagement with public display is in general low
  - Viewers have become skilled at ignoring them (display blindness) [Müller et al., 2009]
  - Users look at displays in general for <2 seconds

Opportunities

"For advertising-based public display networks to become truly pervasive, they must provide a tangible social benefit and be engaging without being obtrusive, blending advertisements with informative content." *[Alt et al., 2012b]*


COVER FEATURE

Advertising on Public Display Networks

Florian Alt and Albrecht Schmidt, University of Stuttgart, Germany
Jörg Müller, Telekom Innovation Laboratories, Germany

For advertising-based public display networks to become truly pervasive, they must provide a tangible social benefit and be engaging without being obtrusive, blending advertisements with informative content.

Computing technologies permeate our everyday lives. The increasing affordability of powerful mobile devices, combined with cloud-based data storage and advances in wireless communications, have made it easier than ever for people to access information and obtain a wide range of products and services anytime, anywhere.[1] However, a key obstacle to the deployment of ubiquitous computing systems in public spaces is the question of who will pay for them.

Two online payment schemes prevail: Either users buy a product, such as an app or song, or they subscribe to a service, such as one that tailors content to passersby based on their preferences. While Internet access itself is typically a paid service, most Web-based services—e-mail, social networks, news, search engines, games, maps, and so on—do well as many apps are free to users and thus rely on advertising.

Just as it pays for other forms of media, including free newspapers, radio, and TV, we believe that advertising—not direct sales or service contracts—will also underwrite the future ubicomp infrastructure. We envision this infrastructure beginning as public display networks and later expanding to encompass entire interactive spaces.

However, for advertising-based public display networks to become truly pervasive, using all available communication channels,[2] they must also provide a tangible social benefit and be engaging without being obtrusive. In many ways, public display networks must parallel the World Wide Web, blending commercial with informative content.

WHY ADVERTISING?

Advertising performs a vital function in society by conveying information about products and services, which benefits both producers and consumers. It is hard to imagine a modern capitalistic economy without it.

At the same time, people often respond negatively to advertising, especially crass efforts at manipulation. Those living in large cities see up to 5,000 ads per day,[3] and many regard the proliferation of signs and billboards as a form of urban blight. São Paulo, Brazil, even went so far as to ban all public advertising in 2006.[4]

The perceived advertising glut is a product of market dynamics. Ads are intended to consume our attention, but advertisers cannot be charged for accessing this scarce resource, so the market equilibrium shifts toward consuming maximal attention.

To "price in" this negative externality, city governments forbid certain kinds of advertising or require companies to purchase a license to advertise, using the proceeds to operate public infrastructure such as bus stops and toilets. These regulations often must be amended to address challenges posed by new technologies, such as digital billboards.

50 COMPUTER Published by the IEEE Computer Society 0018-9162/12/$31.00 © 2012 IEEE

Summary

- Falling cost of hardware means that an increasing number of displays are being deployed.
- Currently these display networks are typically closed – as a viewer you have no way to get your content or applications onto the display network.
- Can we utilize the full benefit of these displays – and go beyond adverts and MTV.

http://upload.wikimedia.org/wikipedia/commons/4/4e/Shibuya_Night_(HDR).jpg

Involved Research Communities

- Graphics Communities (creating video walls, etc.)
- Ubiquitous Computing Community
- Computer Vision
- Social Sciences
- Commercial Sector

Digital Signage, Public Display, Pervasive Display:
Collections of digital displays deployed in public or semi-public space. [Davies et al., 2014]

Outline

Audience Behaviour

Interaction Techniques

How to evaluate public displays?

Audience Behavior

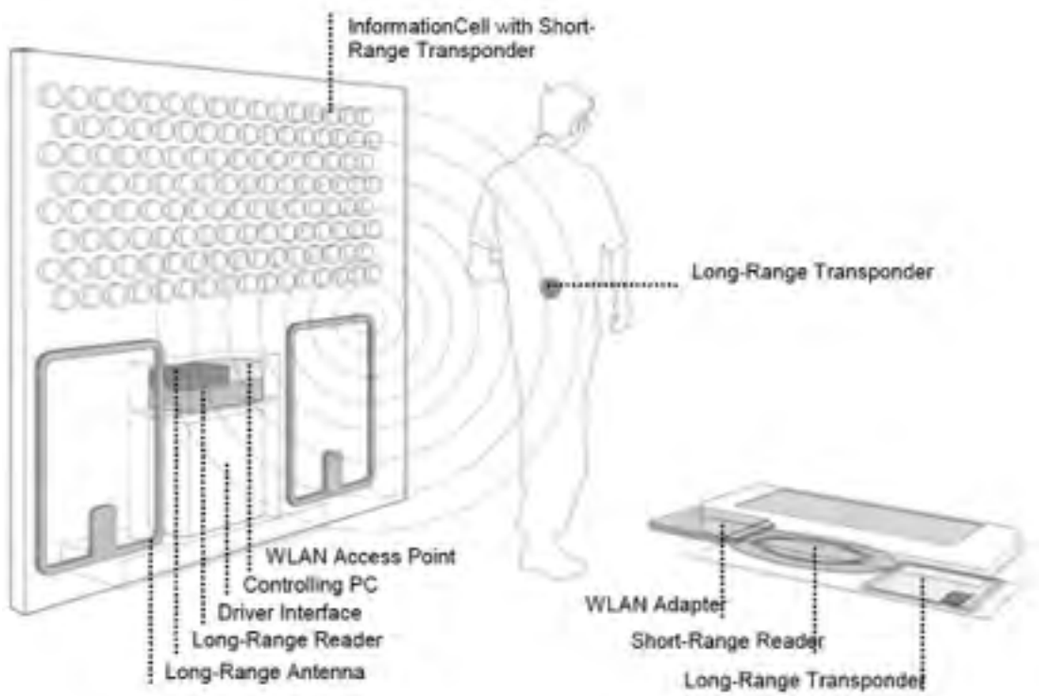
How people act in the vicinity of public displays

Spatial Models

Spatial Model of Interaction [Prante et al., 2003]

Hello.Wall

- Wall-sized ambient display employing Viewports to sense users in the vicinity
- Interaction with the display based on RFID



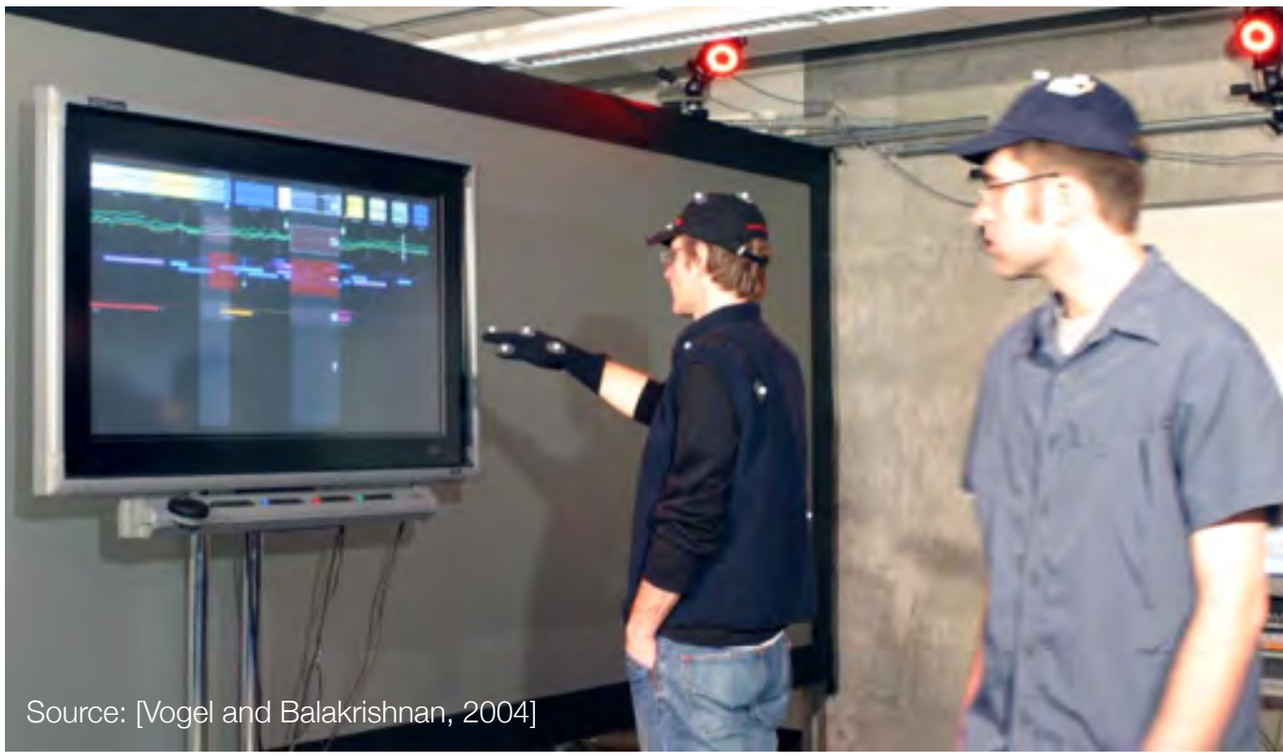
Spatial Model of Interaction [Prante et al., 2003]

Hello.Wall

Refined Spatial Model of Interaction

[Vogel & Balakrishnan, 2004]

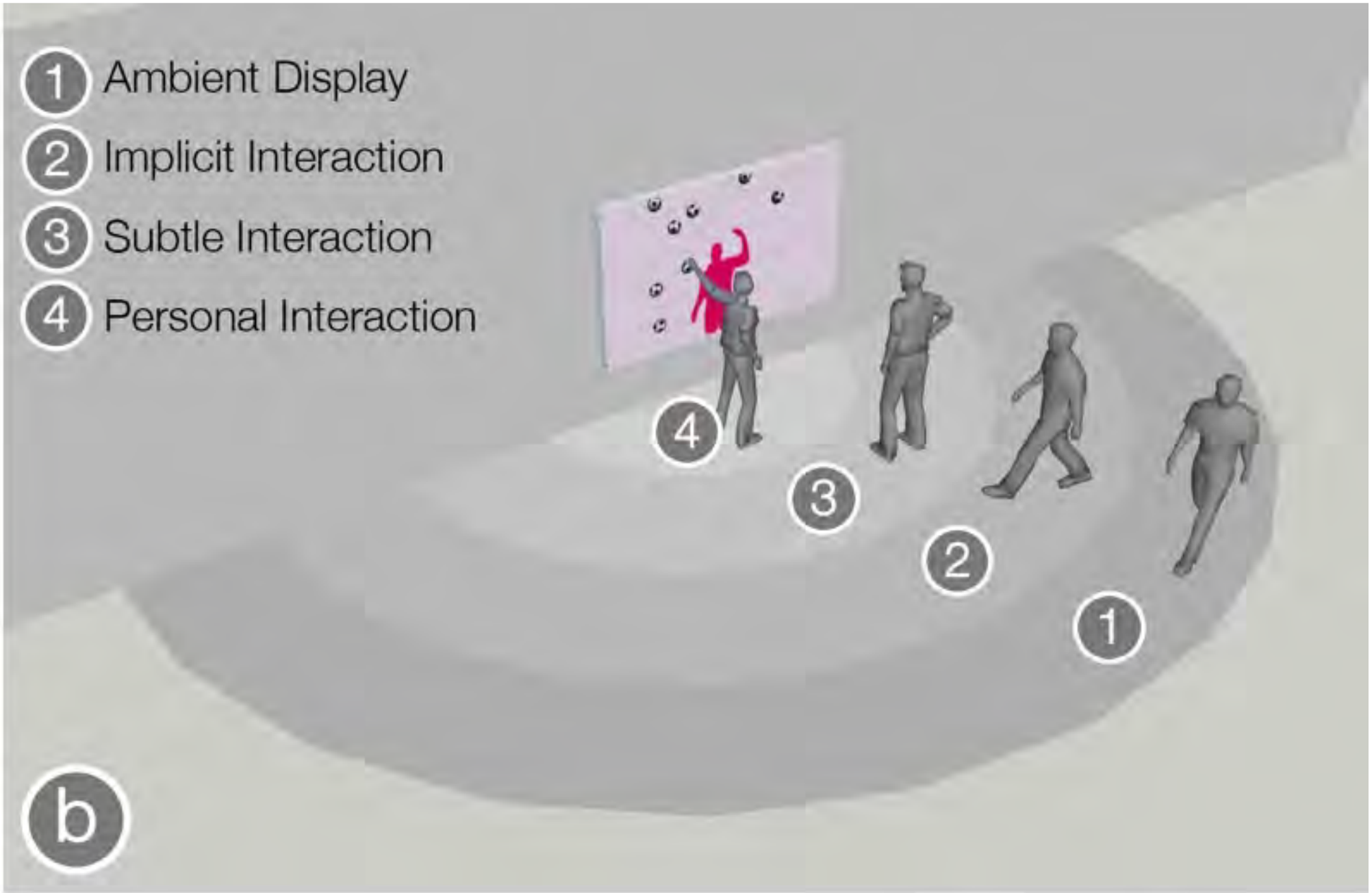
- Dividing cell interaction zone into subtle and personal interaction zone
- Generalizing idea of a notification zone into an implicit interaction zone
- Neutral state: ambient display as anchor point for subsequent interactions
- Relation to Hall's theory of proxemics



Source: [Vogel and Balakrishnan, 2004]

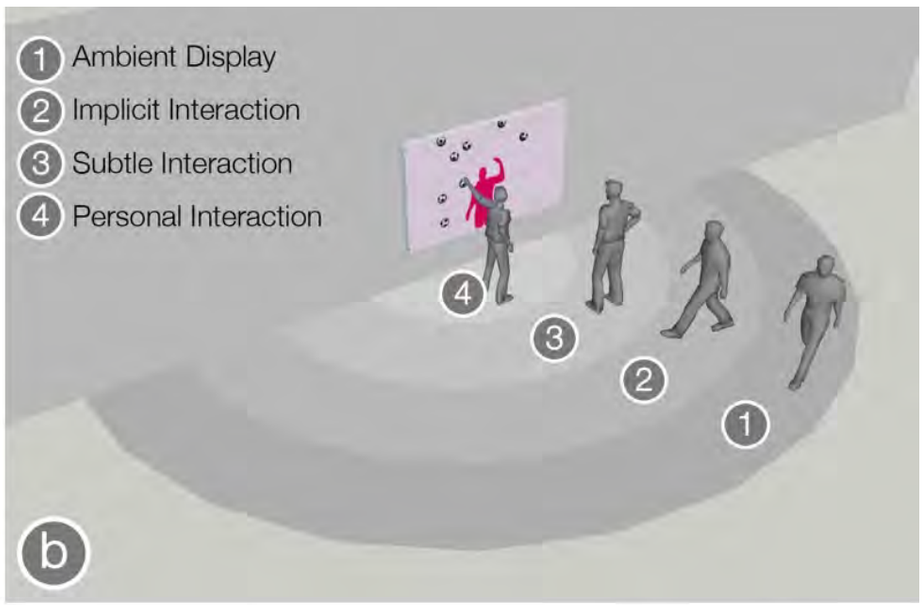
Refined Spatial Model of Interaction

[Vogel & Balakrishnan, 2004]



Discussion

- Spatial models geared towards information presentation
- Mainly suitable to model single-user interaction
- No mechanisms for modeling how users move back-and-forth between different zones

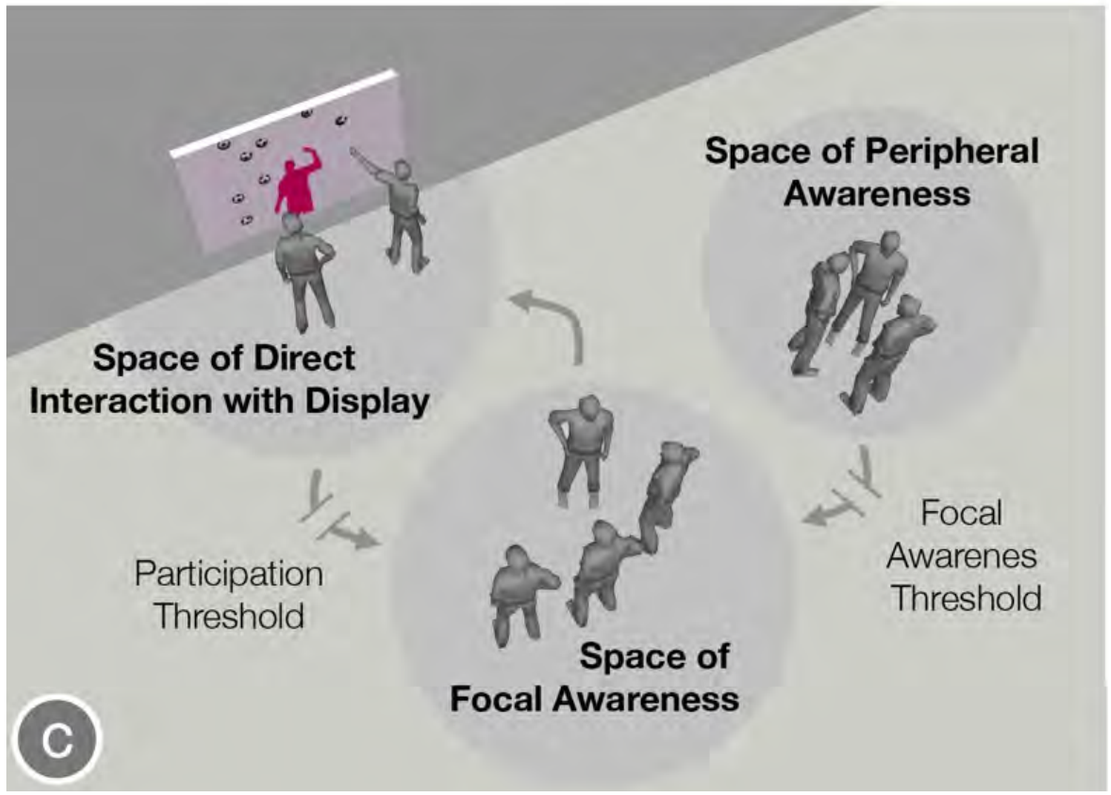


Temporal Models

The Public Interaction Flow Model

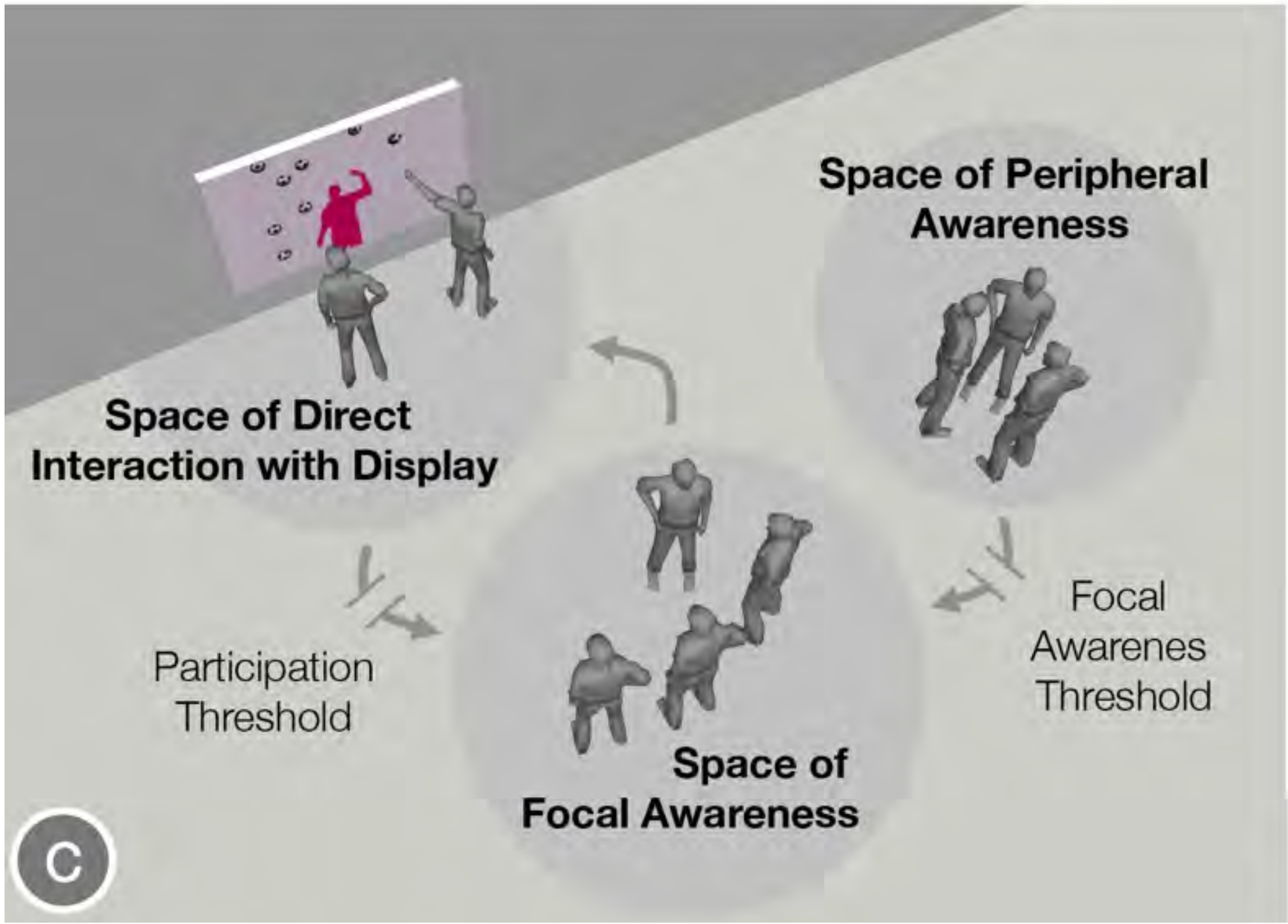
[Brignull and Rogers, 2003]

- Three activity spaces
  - **Peripheral awareness activity**: situations in which users are primarily socializing; aware of the presence of the display but not focussed yet
  - **Focal awareness activities**: user attention shifts towards display (talking about content, watching the screen)
  - **Direct interaction activities** (explicit interaction with the content)
- Thresholds lead to people switching between activity spaces
- Strengths: supports multi-user interaction; takes people moving between activities into consideration
- Weakness: disregards implicit and explicit interaction from a distance



The Public Interaction Flow Model

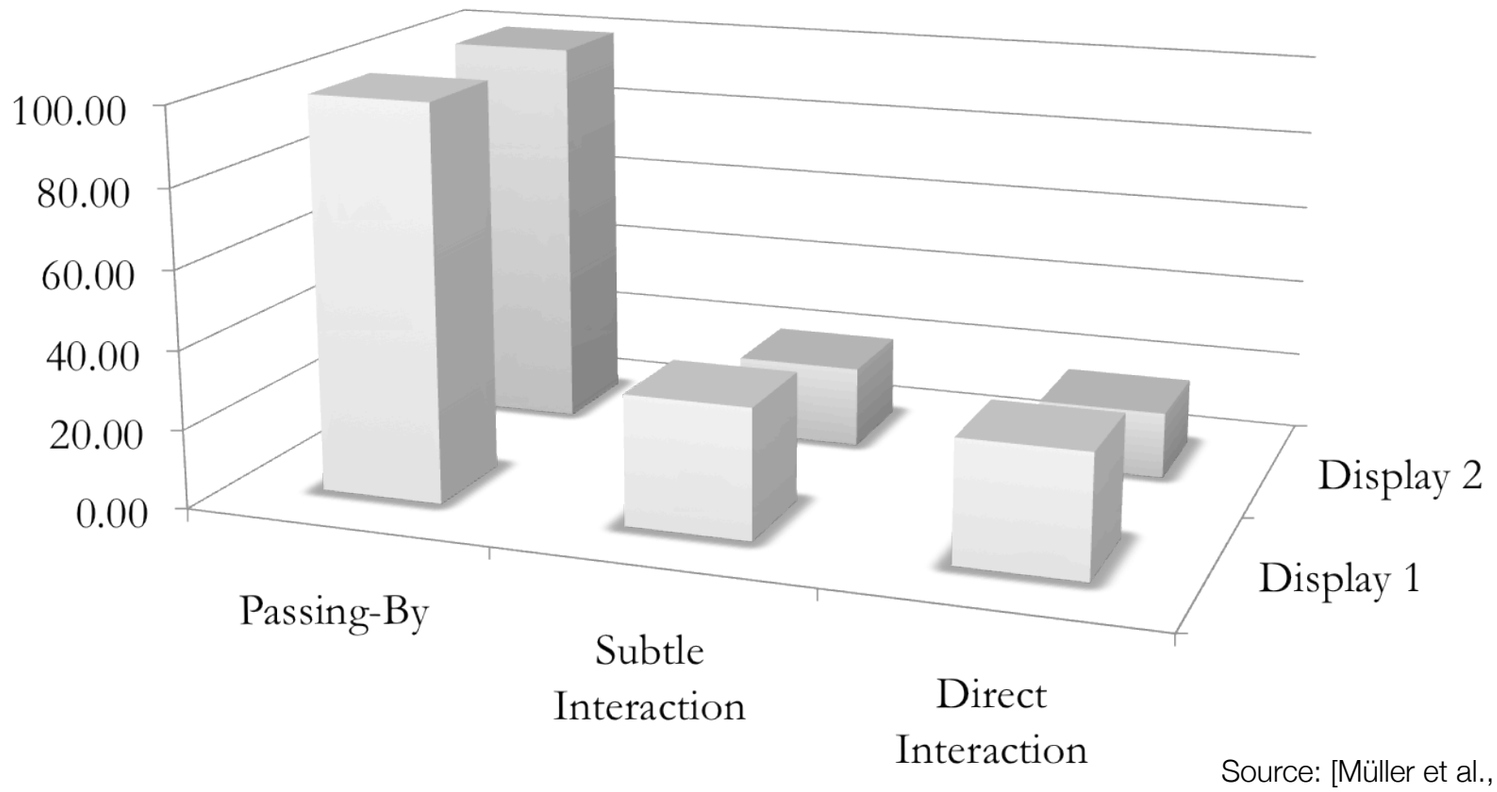
[Brignull and Rogers, 2003]



The Audience Funnel

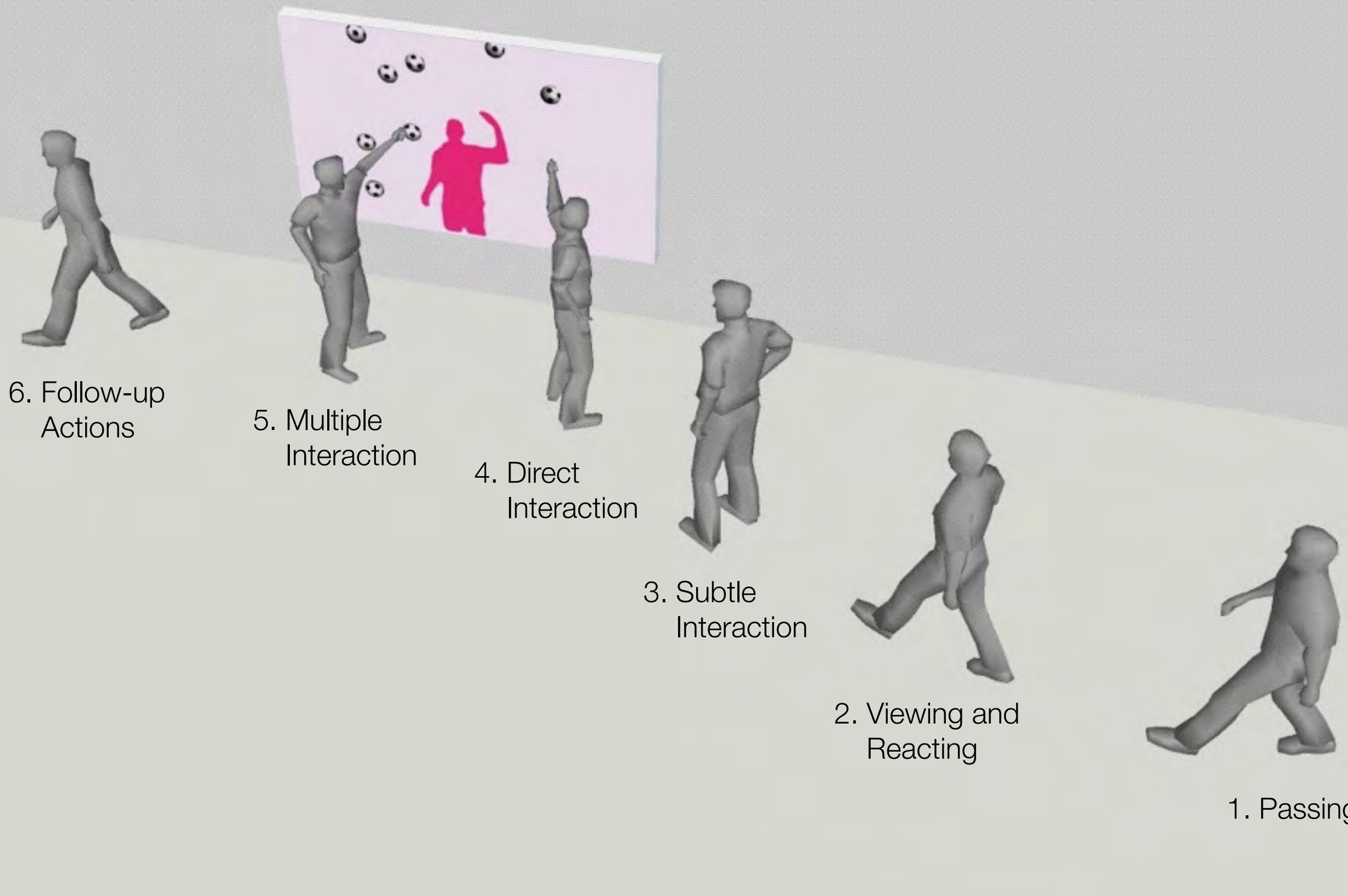
[Müller et al., 2010]

- Focuses on observable audience behavior
- Consists of several interaction phases
- Attempts to model the probability of users transitioning between phases (conversion rates)



Source: [Müller et al., 2010]

The Audience Funnel



6. Follow-up Actions

5. Multiple Interaction

4. Direct Interaction

3. Subtle Interaction

2. Viewing and Reacting

1. Passing-By

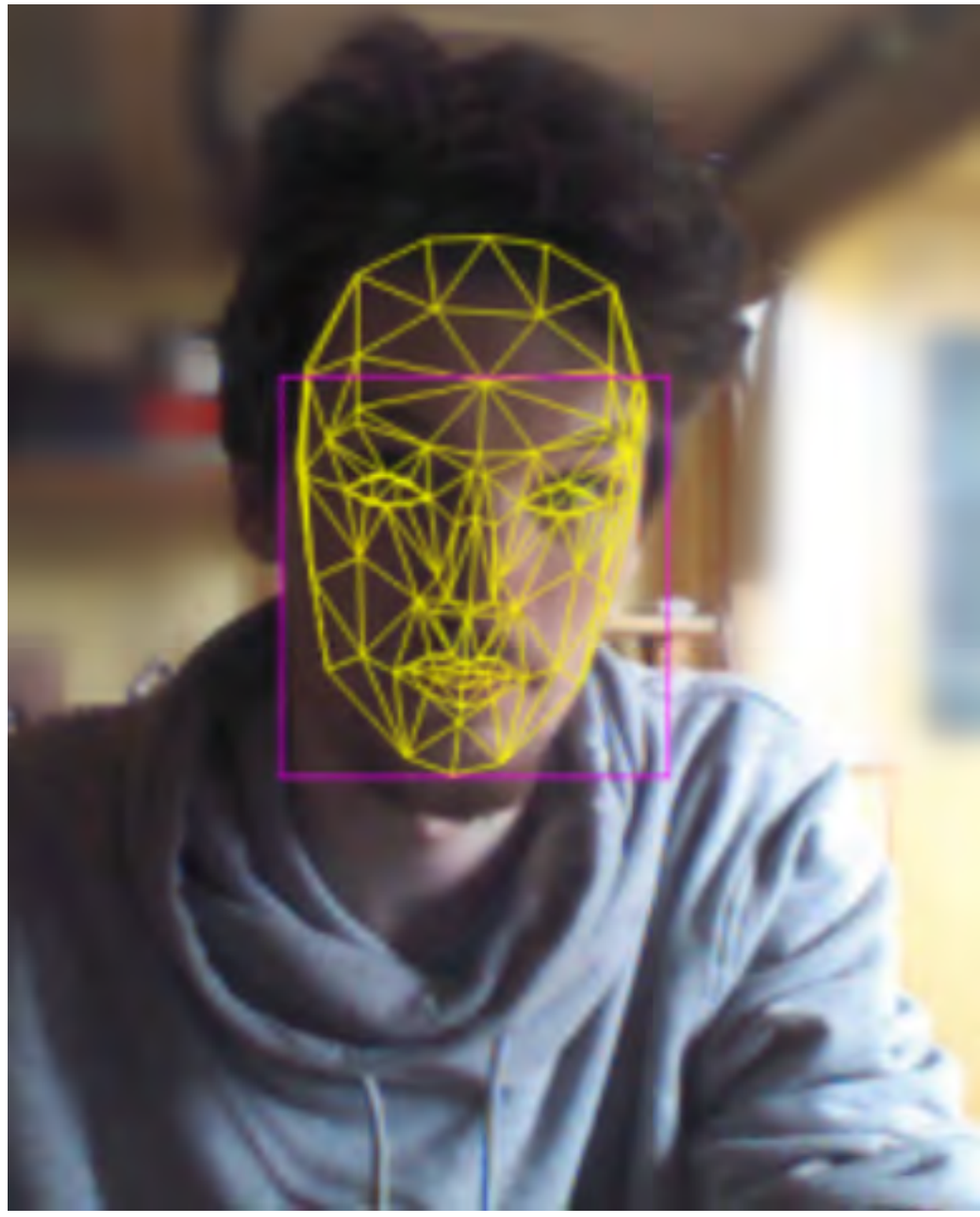
The Audience Funnel

- **Strength:**
  Can be used to describe conversion rates and hence provide a measure for success
- **Weakness:**
  No social interaction between viewers; rather linear process
- **Modeling is just the first step:**
  - How to engage users with display?
  - How to move potential viewers throughout the various phases of engagement?

Quantifying Attention

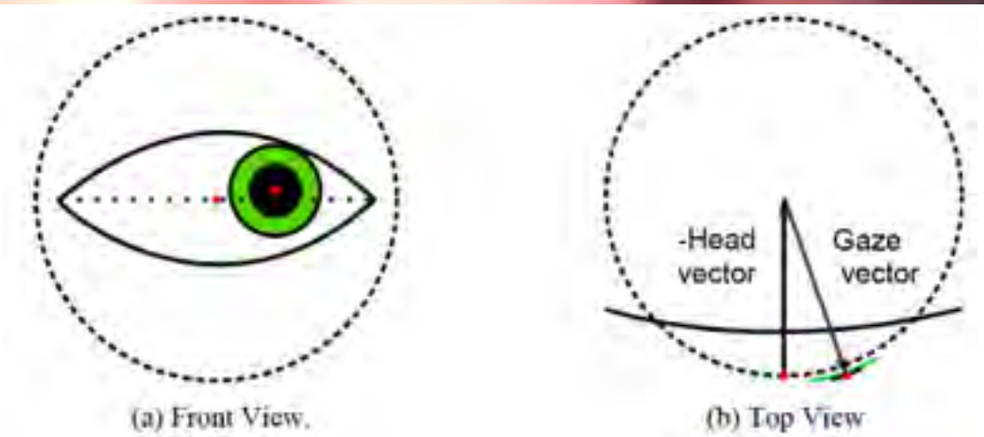
Requirements

- Presence
- Position and Orientation
- Trajectory (Velocity & Direction)
- Body Posture
- Head Orientation
- Gaze Direction



How to Determine Gaze Direction

- Obtaining head orientation
- Extracting facial features (eye corners)
- Detecting pupils
- Calculating gaze vector



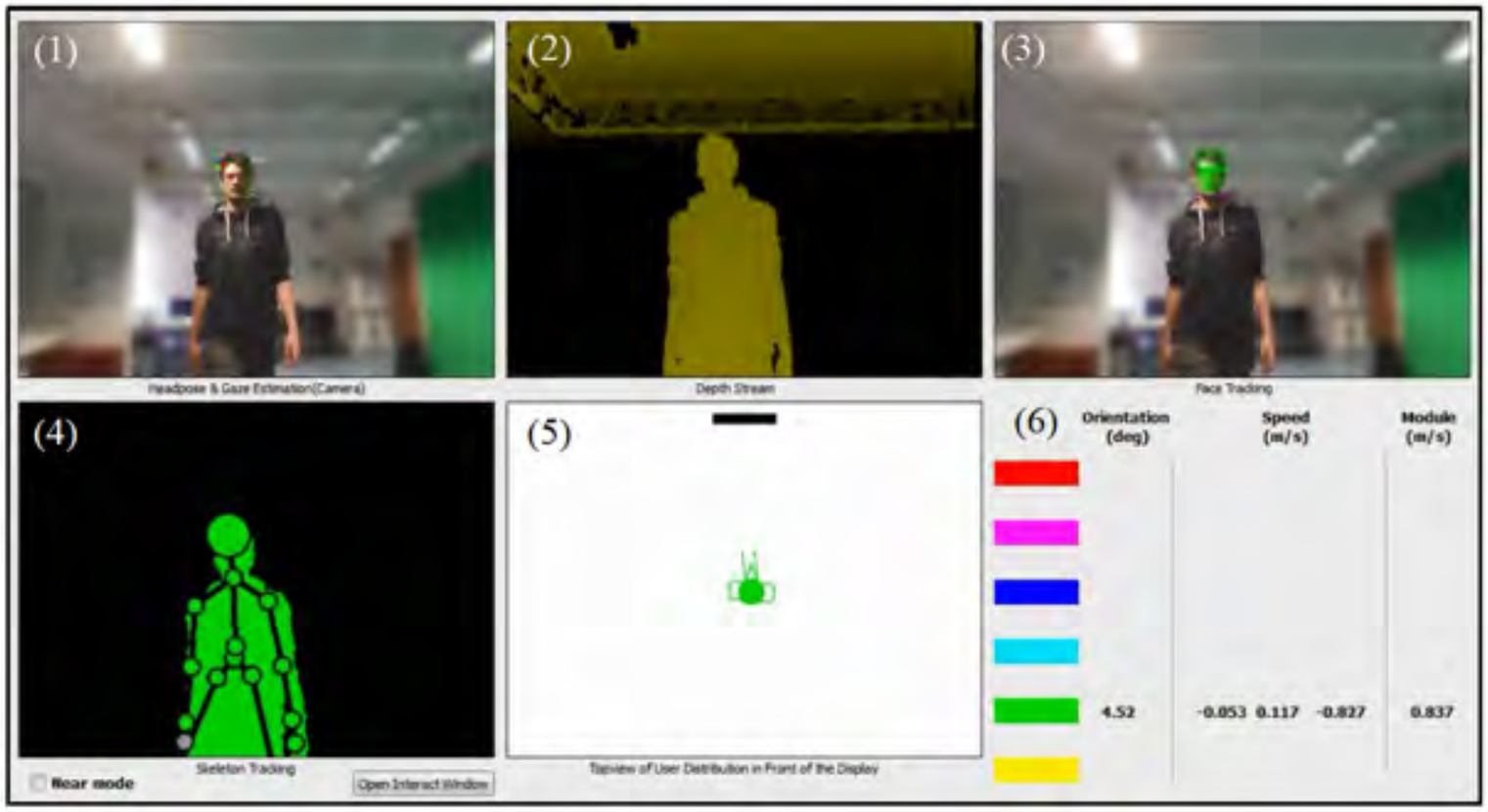
Based on:

IntraFace

Reading Recommendation:
Yanxia Zhang, Andreas Bulling, and Hans Gellersen. 2013. SideWays: a gaze interface for spontaneous interaction with situated displays. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '13). ACM, New York, NY, USA, 851-860.

Data Recording

- RGB Video
- Depth Video
- Gaze Direction
- Skeleton Data
- User Position
- Trajectory



Interaction in Public Space [Müller et al., 2010]

- **The presentation of self**
  - People want to maintain their role
  - Displays are a stage, design for introvert and extrovert people
- **Control of access to self**
  - People do not like to be unduly approached
- **Data privacy**
  - People do not like to be spied upon
- **Public Nature of Space**
  - You can not control the environment of the display
- **Social behavior**
  - People do not like to stand in the way of others

Source: smartcitiescouncil.com

Calm vs. Engagement

- **Calm Displays** [Weiser and Seely, 1997]
  - Should slide effortlessly between center
    and periphery of attention
  - Should blend into the environment
  - Should be easy to ignore
- **Engaging Displays** [Rogers, 2006]
  - Should be fun to interact with
  - Should engage, inspire and entertain the audience
  - Should attract attention

Source: [Prante et al. 2003]

Source: www.ecafe.com/getty/HIS/

Displays may not be used at all if they fail to attract attention!

Tools vs. Toys [Müller et al., 2010]

Tools

- Traditionally, public displays are viewed as tools.
- For tools, motivation for use is some external goal
- The most important criteria for tools are usefulness and utility.
- What to optimize:
  - Time (Less is better)
  - Errors

Toys

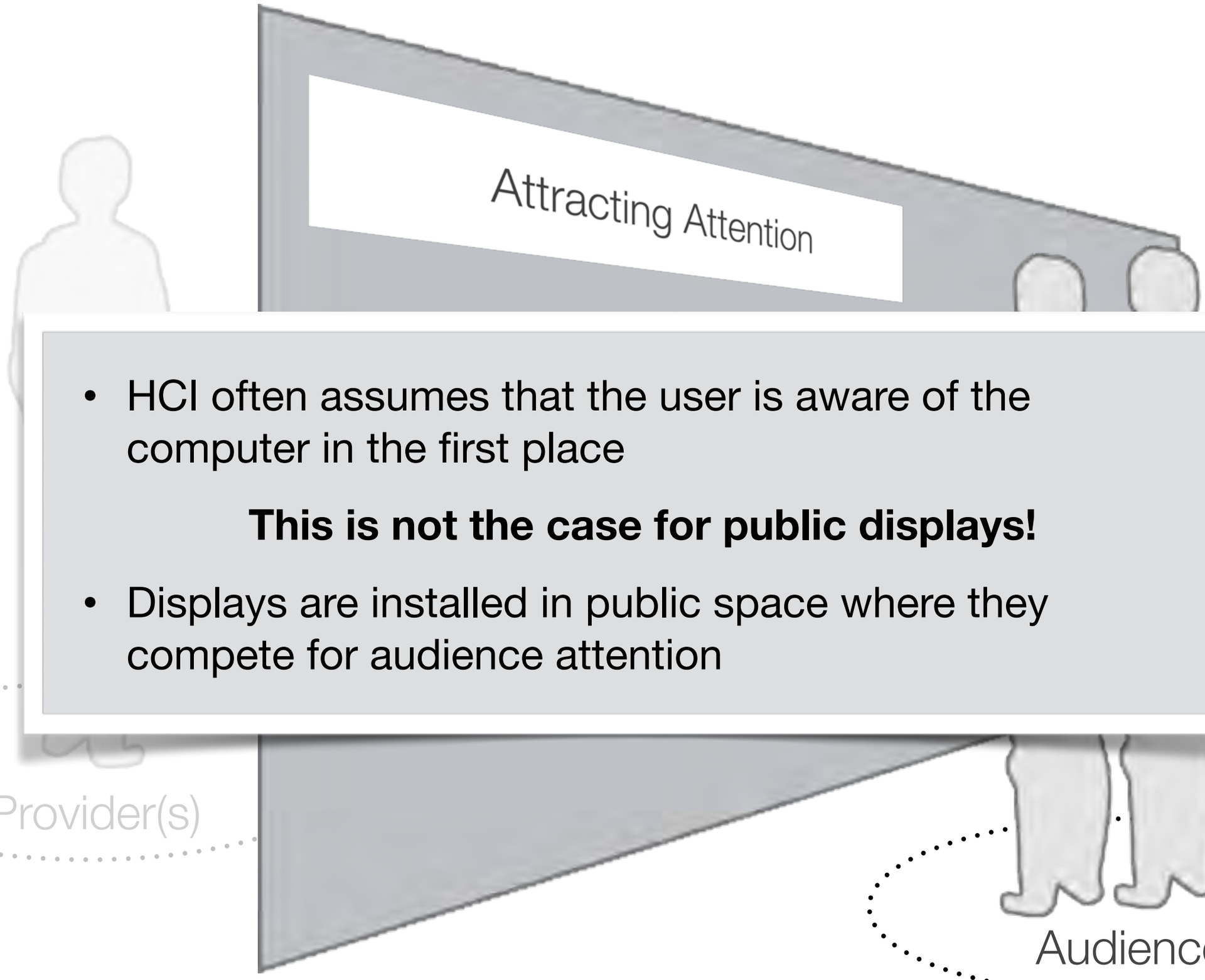
- The most important criteria for toys are motivation.
- What to optimize:
  - Conversion rates
  - Fun
  - Interaction times (More is better)

It seems more appropriate to see public displays as toys rather than tools!

Engaging Users

How to make people interact in public space

Enticing Interaction



- HCI often assumes that the user is aware of the computer in the first place

This is not the case for public displays!

- Displays are installed in public space where they compete for audience attention

Attracting Attention

Understanding Attention

[Müller et al., 2010]

- Attracting attention is difficult (first click problem)
- Most displays receive little attention
- Naive approach: use stimuli to attract attention
  - Challenging in public space
  - Does not guarantee the user looks because many objects are competing for attention
- Another approach: use physical objects
  - Animatronic hands: physical attract loop shown to be twice as effective as a virtual attract loop
  - Drawback: less flexible, difficult to update with new content

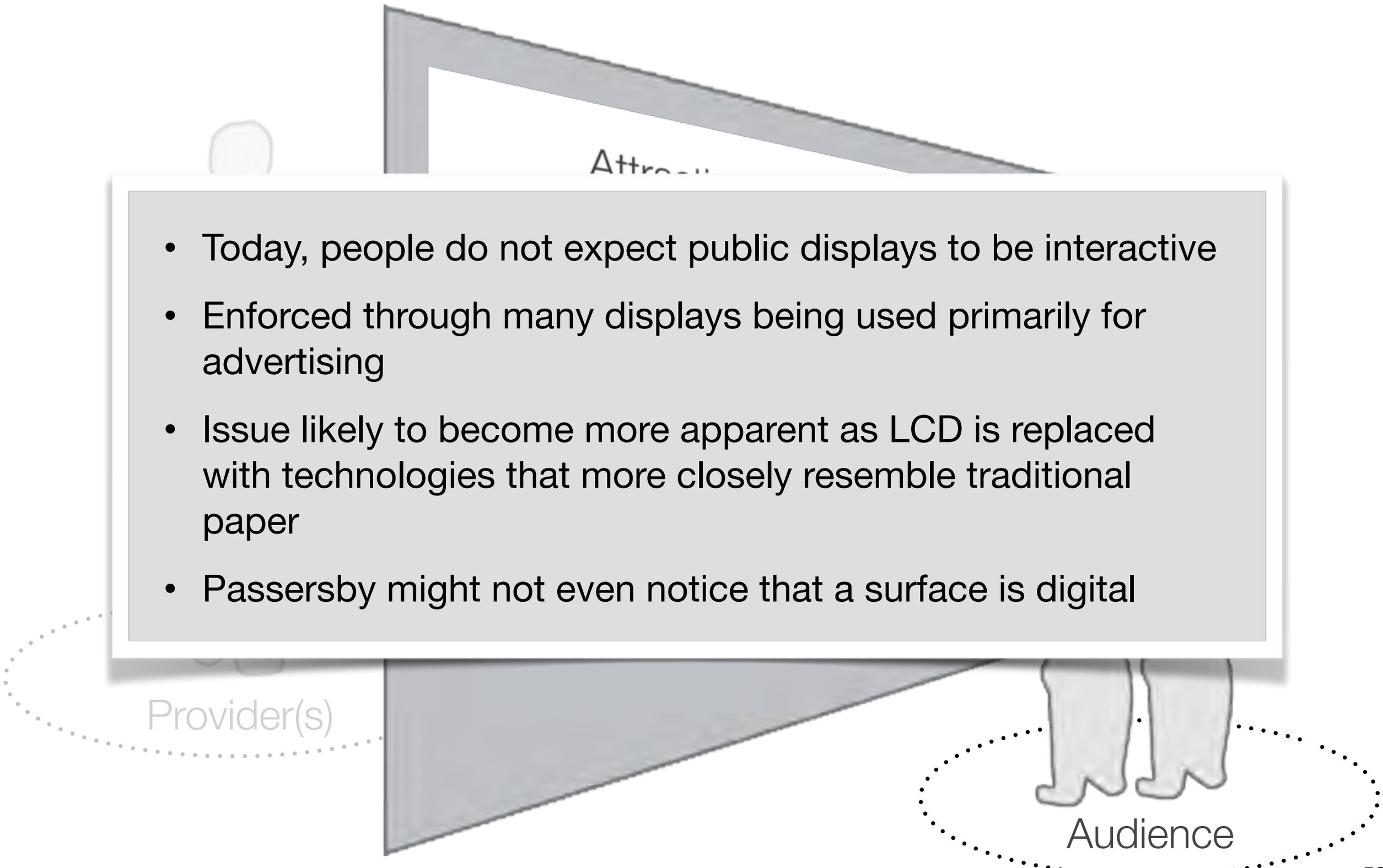
Managing Attention

- **Behavioral Urgency** [Franconeri and Simons, 2003]
  - Attention is captured by stimuli that indicate the potential need for immediate action (e.g., an animal approaching)
  - Examples: abrupt appearance of new objects, luminance contrast changes, moving and looming stimuli
- **Bayesian Surprise** [Itti et al., 1998]
  - Bottom-up visual attention: measures the difference between posterior and prior beliefs about the world
  - Model predicts attention based on high entropy, contrast, novelty of motion

Managing Attention

- **Honeypot Effect** [Brignull and Rogers, 2003]
  - A crowd gathering around a display seems to attract further attention, drawing more people to the display
- **Change Blindness**
  - Effect that describes how to reduce the attention-attracting effect of changes in display content (important when content should be changed with out the viewer noticing)
  - Examples: blanking an image, changing perspectives, displaying mud splashes, changing information slowly, changing information during eye blinks or saccades, changing information while occluded

Enticing Interaction



- Today, people do not expect public displays to be interactive
- Enforced through many displays being used primarily for advertising
- Issue likely to become more apparent as LCD is replaced with technologies that more closely resemble traditional paper
- Passersby might not even notice that a surface is digital

Communicating Interactivity [Müller et al., 2012]

Interactivity Cues

Cognitive Processing

- Call-to-action
- Attract sequence
- Analog signage

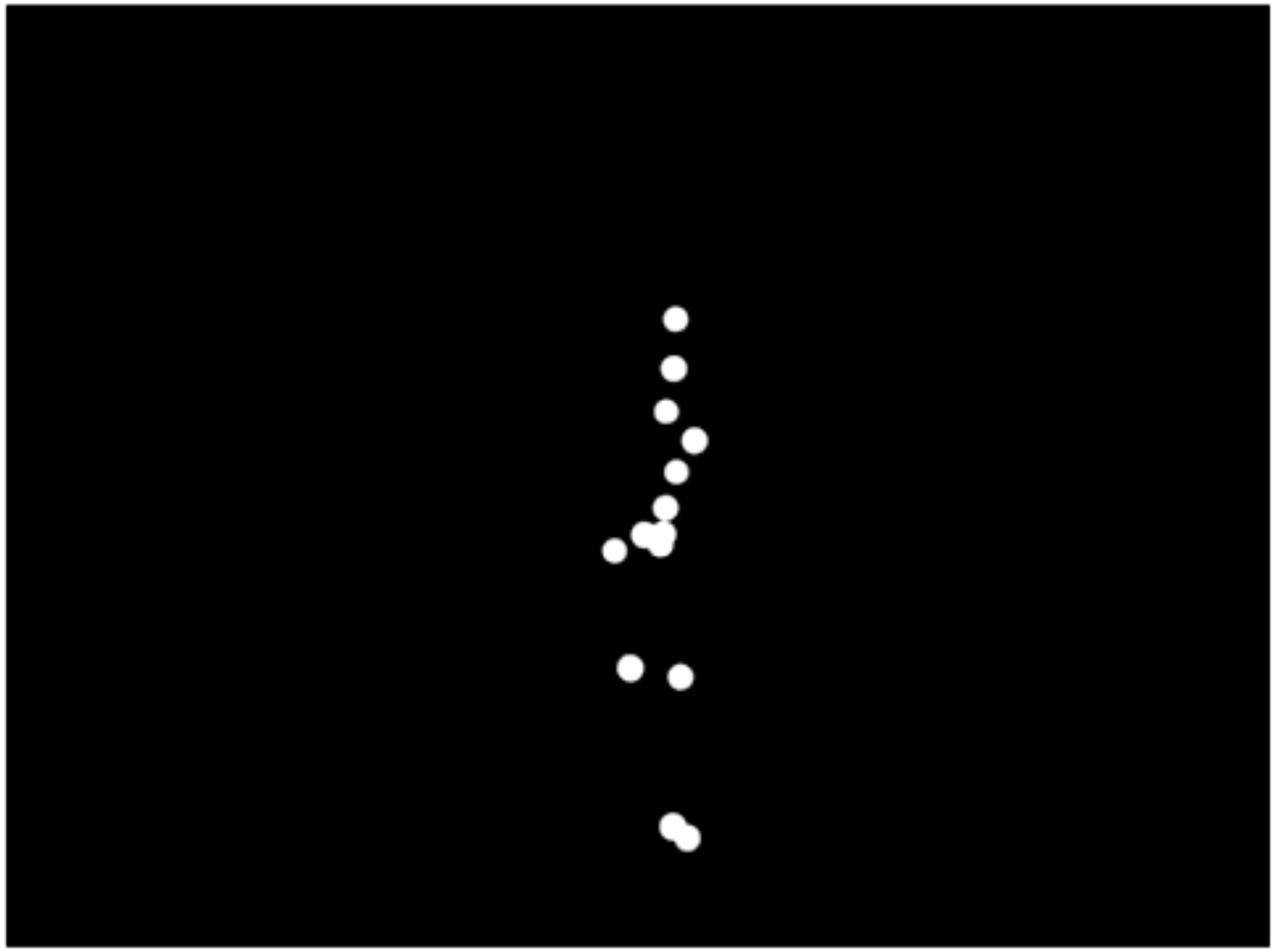
Other people

- Honeypot effect
- Persons inviting passersby

→ **User Representation**

Interactivity Cues

Image-based Matching

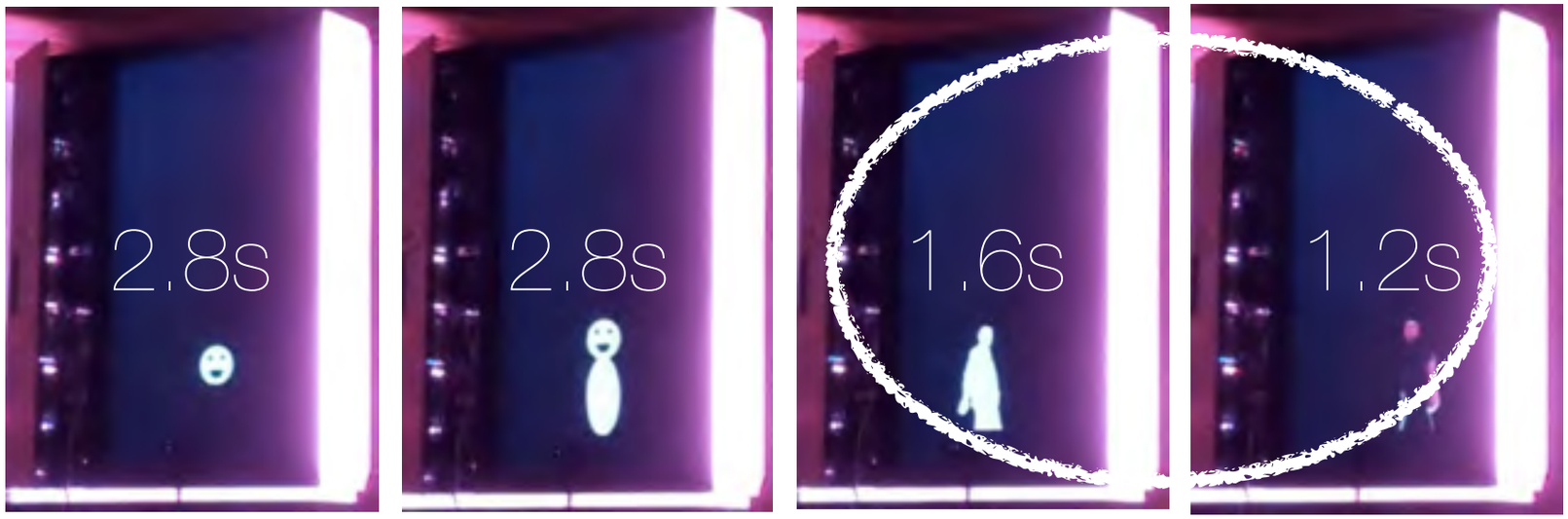


Correlation-based Matching

Lab Study: Comparing Interactivity Cues

Time to Understand Interactivity

Interactive



Non-Interactive

Significant effect for representation on

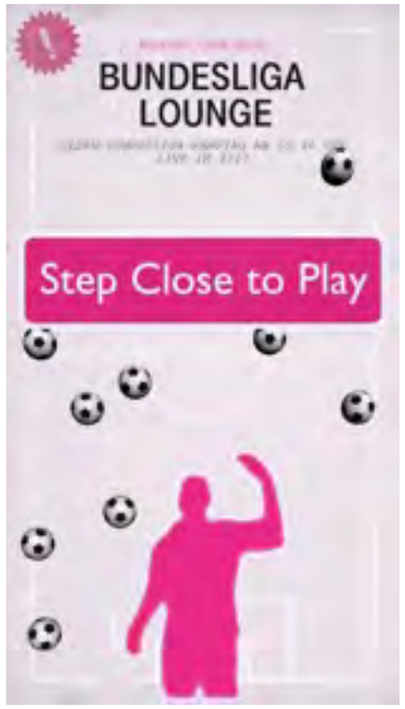
- selection time (ANOVA): $F_{3,45} = 80.76$, $p<.0001$
- accuracy (ANOVA): $F_{3,45} = 43.09$, $p<.0001$

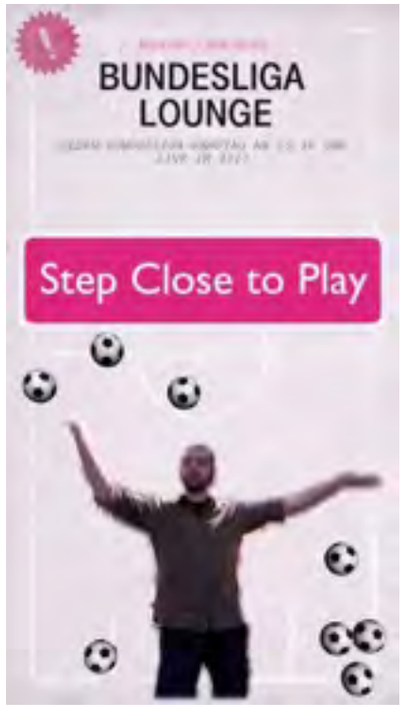
Field Study

- Measurement for 11 days
- 1500h video
- Semi-manual coding
  (cohen's kappa = .75)
- Observations and interviews

Conditions

Call-to-Action





Inadvertent Interaction

Findings: Number of Interactions

	no representation	silhouette	mirror
call-to-action	67	59	79
inadvertent	60	87	150

Significant effect for

- interactivity cue (call-to-action vs. inadvertent interaction) (ANOVA): $F_{1,11} = 12.6$, $p<.001$
- user representation (ANOVA): $F_{2,22} = 13.1$, $p<.005$
- user representation * interactivity cue (ANOVA): $F_{2,22} = 6.8$, $p<.005$

The Landing Effect

The Honeypot Effect

Looking Glass - Summary

- Image representation is a powerful cue to communicate interactivity.
- Developers of public display applications should design for the landing effect.
- Attract many people to interact (honeypot effect).
- Almost all people interact in groups.

Immediate Usability

- After people notice interactivity, **immediate usability** is important
- Recommendations [Kules et al., 2004]
  - Implement an attract sequence; clearly indicate how to end the attract sequence and begin using the system (e.g., call-to-action)
  - Support zero-trial learning: users should be able to user the interface after observing others or using it themselves for a brief period of time (15-60s)
  - Encourage users to immediately interact with the content
- Users not immediately being successful often simply abandon the device (already delay of a few seconds is problematic)
- Users think device is not interactive or broken

Motivating Further Engagement

- How to motivate people to interact?
  - People do not go out to look at a public display but tend to come across a public display (e.g., bus stop)
  - They become motivated by external factors to look
- Greater Trend:
  Spread of computer usage from the workplace into public life
  - Display to serve a range of functions (helping users achieve tasks to more speculative forms)
- Task-oriented theories:
  Regard the “how” of an interactivity, but not the “why”

Significant need to advance understanding of the motivation behind users’ activities!

Potential Motivating Factors [Michelis, 2009]

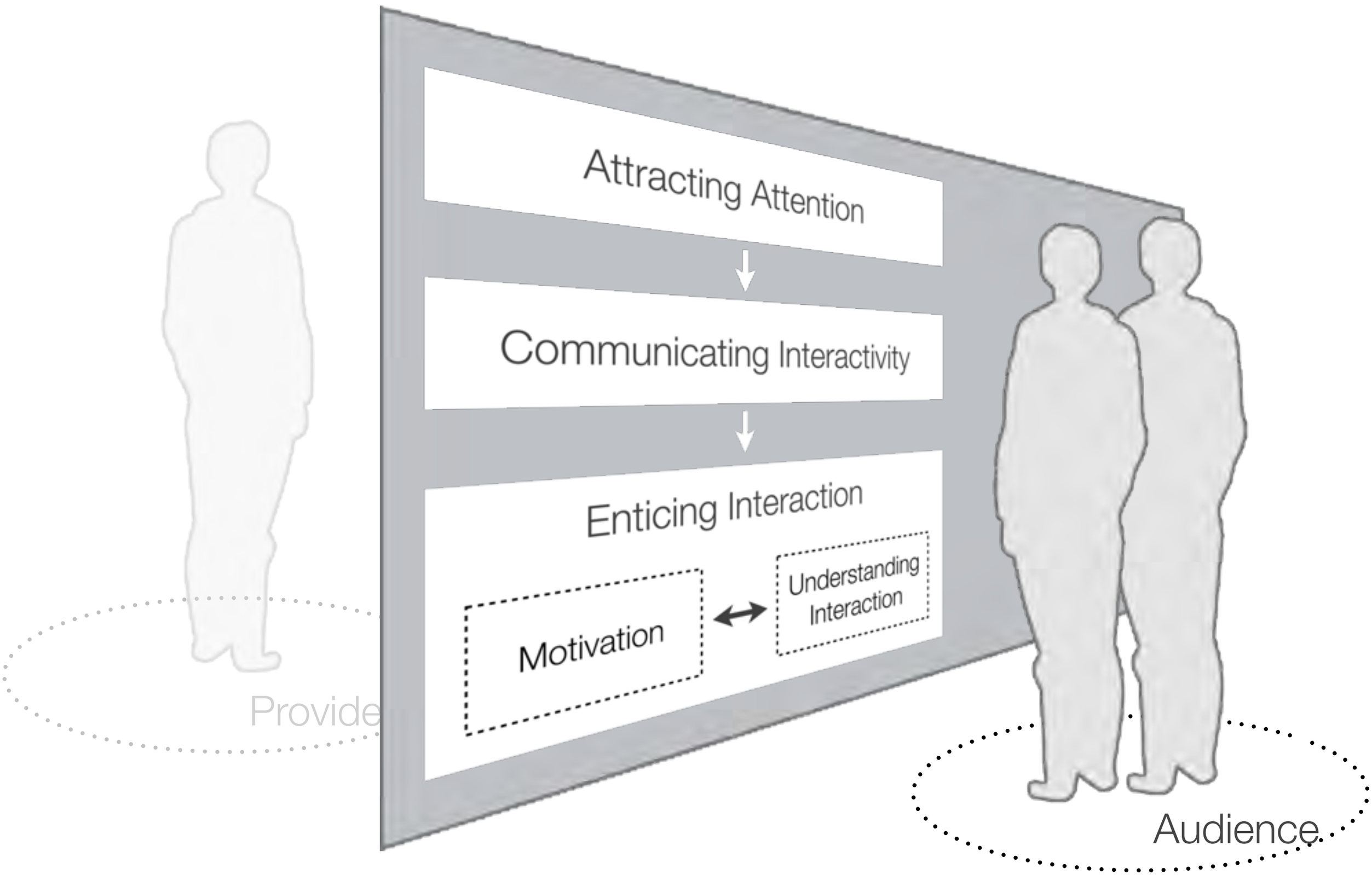
- **Challenge and Control**
  - Can help to motivate users but must be carefully balanced
  - Too little challenge leads to boredom, too much challenge leads to anxiety
  - People strive for an optimal level of competency

- **Curiosity and Exploration**
  - Curiosity as a key characteristic of intrinsically motivating environments
  - Interaction should be neither too complex nor too trivial
  - Interactive elements should be novel and surprising but not incomprehensible
  - User should have initial expectations for how the interaction proceeds but these should only be partially met

Potential Motivating Factors [Michelis, 2009]

- **Choice**
  - Motivation for particular behavior increases if people can select between alternatives
- **Fantasy and Metaphor**
  - Imaginary settings appear to have a motivating effect, particularly if constraints of reality are switched off so that one imagines possessing new abilities
  - Extent to which interactive environments inspire fantasy determines their attractiveness and generates interest
- **Collaboration**
  - Interaction with other human beings
  - Ability to influence the interaction of another person is motivating

Enticing Interaction



Interaction Techniques

Enabling Users to Interact with Public Displays

Overview [Davies et al., 2014]

- By providing support for user interaction a wide range of new features can be enabled
  - **Navigation**
    - Browse content on the display
  - **Expression of interest**
    - Tailoring the content displays show
  - **Content takeaway**
    - Retrieving content from displays using a mobile phone, email or URL
  - **Content upload**
    - Supporting user-generated content


Katso Oulun alueen
myytävät asunnot
osoitteesta Etuovi.com
Sekalaista
Koulutus
Löytötavarat
Tapahtumat
Osta ja myy
Osta ja myy
OULU

Touch

Issues in Supporting Touch

- Users need to be able to physically reach the screen
- Screen protection: prevent theft, prevent access to controls, be resistant to everyday knocks
- Screen visibility
- Screen maintenance

Audience Expectations

- Currently no commonly agreed way of communicating interactivity
- High user expectations with regard to touch due to smartphones
  - Multi-touch
  - Touch gestures (pinches and flicks)
- Support of multi-user interaction (closer to tabletop /surface computing than to phones)

Touch Technologies

- **Resistive touch**
  - Two layers of resistive material, separated by an air gap
  - Advantages: very cheap to manufacture
  - Disadvantage: not as responsive as capacitive sensing
- **Capacitive sensing**
  - Determines touch location based on change in capacitance
  - Disadvantage: relatively inaccurate, need to be touched by something conductive (gloves in winter!)
  - Advantage: does not require pressure, better user experience
- **IR touch screens / Optical touch screens**
  - Use sensors around the edge of the screen

Mid-Air Gestures

Motivation for Mid-Air Gestures

- Suitable for displays at a distance that can not be easily reached
- Many users are reluctant to use touch screens for hygienic reasons, particularly in public spaces
- Often a catalyst for performative interaction
- Selection and text entry difficult

Meaningful Gestures

- No commonly accepted gesture set for interacting with public displays
- Researchers and developers often need to create their own gesture set
- Requirements
  - Gesture set should **draw upon existing operations** that users are familiar with (pan and pinch gesture from smartphones)
  - Gestures should be **coherent**, making it easier for the viewer to understand which gestures are supported by a system
  - Gestures need to be **easy to recognize and easy to teach** (next slide)

Recognizing Gestures [Walter et al., 2013]

- Delimitation of beginning of gesture (registration), continuation, and end of gesture (termination)
- **Difficult to recognize for mid-air gestures compared to touch**
- Possible solutions
  - Multimodality
    - Combining touch and speech: “put that … there”
    - Needs to be discovered
    - May be inappropriate in certain environments (speech in a museum)
  - Reserved actions
    - Drawing a certain form in the air (e.g., a question mark)
  - Clutching
    - Users explicitly signal the system that it needs to engage the gesture recognizer

Teaching Gestures [Walter et al., 2013]

- Major challenge: informing viewers of the display of the gestures that can be used to interact with the system
- Many gestures are not intuitive! Need to help the user discover possible gestures
- Present cues using
  - Spatial division (splitting the screen into one area with content and one where the gesture is explained)
  - Temporal division (the regular content is temporally interrupted with the gesture cue)
  - Cue integrated with content
- Spatial multiplexing found to be best as it does not interrupt the content (interruptions may increase the tendency for users to leave the screen)

Teaching Gestures [Walter et al., 2013]

- Learning from mouse and touch interfaces
  - Showing videos (GestureBar)
  - Displaying hand poses for registering a gesture (ShadowGuides)
- Difficult to apply to public displays
  - Prior knowledge about modality required
  - Approaches designed for goal-driven applications (as opposed to playful display applications); users aware of available commands
  - People neither aware of interactive capabilities nor how they can interact or whether gesture-based interaction is supported

Gesture Technologies

- Device-based techniques
  - Rely upon sensor worn on the body e.g., accelerometer or positioning sensors
  - Examples: Nintendo Wii, BeeCon BlueWand, Vicon tracking system and markers
- Camera-based techniques
  - Often favored in public spaces as user does not rely upon additional gear
  - One or more cameras required to capture scene; image analysis techniques to extract information on body posture or position of the user
  - Examples: Microsoft Kinect (information on body, hands and fingers are detected and matched against skeleton model), camera and point light source to track user's hands

Mobile Device Interaction

Using Smartphones for Interaction

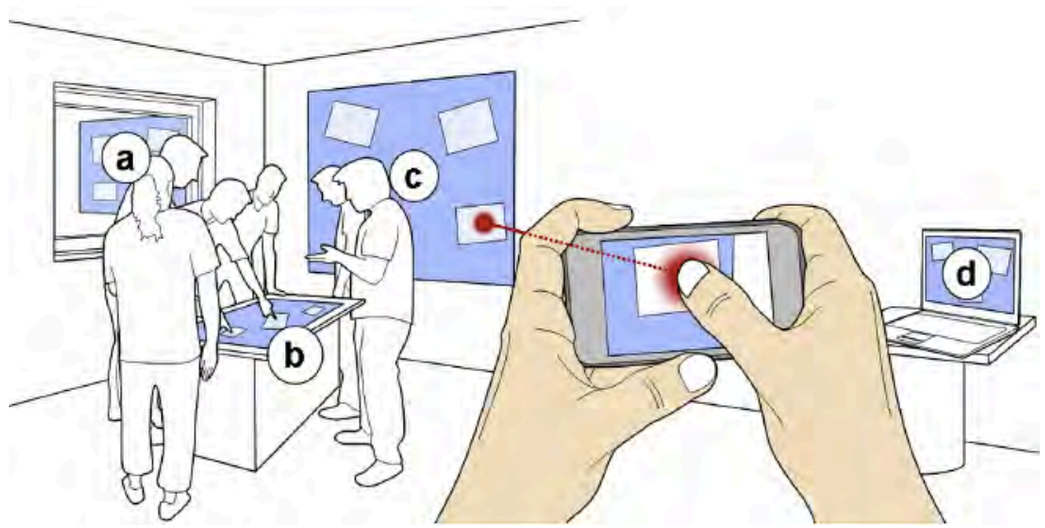
- Gateway to devices in the local physical environment
- Personalized content to reflect the interests of viewers
- Express preferences and communicate with nearby displays
- Longitudinal personalization

Examples

- InstantPlaces and eCampus (Bluetooth)
  [Jose et al., 2008], [Storz et al., 2006]
  - Altering device names to tag features of their identity and link to their flickr profile
- Tacita (WiFi fingerprints, GPS, Bluetooth)
  [Davies et al., 2014b]
  - Uses smartphone to collect user preferences that are communicated to cloud-based applications for presentation on nearby displays
  - Reverses the traditional pattern of announcements, requiting a user's mobile device to determine its proximity to a display
  - Personalization requests themselves are issues via a trusted application

Interaction

- Beyond form of identification, smartphones can be used to add interactivity to displays (e.g., as remote controls)
- Using traditional communication functionality of the device (e.g., SMS), input mechanisms (e.g., keyboard, touchscreen), or additional technologies (NFC)
- Novel forms of interaction:
  - Touch projector enables interaction with remote displays using a live video image on the device [Boring et al., 2009]
  - Using the flashlight of a phone and a display camera to create a novel pointing device
  - Using phones for gaze input?



Source: [Boring et al., 2010]

Co-Displays and Cyber-Foraging

- Smartphone user struggling with limited screen real estate of the device can forage a nearby display and transfer content for clearer personal viewing or sharing
- Individual view: Smartphone as private co-displays to augment the view provided by public displays
- Making aspects of the public display content deliberately private
  - Content can be blurred out on the public display and be made visible on the phone
- Further output techniques: rotating compass combines a public display and feedback via vibrations on the mobile phone to support pedestrian navigation

Information Takeaway

- Takeaway functionality allows viewers to collect information from the display
  - Equivalent of tear off strips found on analogue signs or click-throughs on conventional web adverts
  - Technologies: QR codes and RFID
- Examples
  - Shoot&Copy: trigger fetching content over Bluetooth or GPRS
  - Digifieds: taking away classified ads using an Android app [Alt et al., 2010]
  - She: accelerometers to detect gestures in order to indicate selection of items on a nearby public display

Analysis

- Trend towards more interaction but no agreement on what form this interaction should take
- No standard for the types of interaction and gestures that are possible
- To avoid user confusion and to drive uptake of interactive displays it is important to begin to converge on standard tools and techniques for user interaction