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Passing-by Interaction in Public

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Aachen/Berlin, May 2011
Tongyan Ning

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Abstract

Public displays are increasingly prevalent in urban environments, like airports, train stations and shop windows, however most of them are not interactive. The current approach to immerse users with public displays is through touch screen. This technique is unsuitable for many public displays, because users merely pass by and rarely stop by. Another solution to engage passersby with public displays is to avoid broadcasting superfluous information by applying menu techniques, which can enable users to select what is interesting to them.

This thesis investigates command selection in this new context of passing-by interaction in public, in which users only have a few seconds to interact. After a series of concept and gesture studies, this thesis proposes five hands-free gestural menu techniques, compare and evaluate them with traditional touch technique in a Wizard-of-Oz experiment. Based on the results of this study, design recommendations are provided for menu selection in passing-by situations.

Überblick

Bildschirme in der Öffentlichkeit gewinnen zunehmend an Allgegenwärtigkeit in Kontexten wie Flughäfen, Bahnhöfen und Einkaufsstraßen. Sie sind jedoch bisher zumeist nicht interaktiv. Aktuell wird versucht die Interaktion mit den Benutzern mittels berührungsempfindlichen Bildschirmen zu ermöglichen. Diese Interaktionstechnik ist jedoch nicht passend für viele öffentliche Anwendungen, da Nutzer nur an den Bildschirmen vorbeigehen und selten anhalten. Eine andere Lösung ist daher das Interesse der Passanten dadurch zu wecken, dass man anstelle eines kontinuierlichen Informationsfluss die Nutzer dazu befähigt auch ohne Berührung die Informationen auszuwählen, die sie interessieren.

Diese Masterarbeit studiert Menü-Interaktionstechniken für die Interaktion mit öffentlichen Bildschirmen im Vorbeigehen, bei der Nutzer nur wenige Sekunde für die Interaktion zur Verfügung haben. Ausgehend von einer Reihe von Konzept- und Gestenstudien, schlägt diese Arbeit fünf Gesten-Interaktionstechniken vor und testet diese im Vergleich mit traditionellen, berührungsempfindlichen Bildschirmen in einer Wizard-of-Oz Nutzerstudie. Auf Basis dieser Ergebnisse werden Designvorschläge abgeleitet für Menü-Interaktionstechniken mit öffentlichen Bildschirmen im Vorbeigehen.

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Chapter 1

Introduction

""Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence." "

—Weiser [1991]

Touch technique is widely used for interactive public displays.

As envisioned by Weiser [1991] public displays are informed by Ubicom . With the development of new display technology, large displays are increasingly present in public places as digital media feature. Not only passive displays are common in urban life, but also interactive displays are gradually coming to museums, train station, public plazas, and architectural facades. Currently touch technique is widely investigated for interactive presentation on large displays in both industry and research.

Public displays enable passersby a possibility of selection and immediate usability.

Different from using stationary computers, many people pass by public displays opportunistically, spend a short time on interaction, and are interested in various information. Therefore, public displays need to enable passersby a possibility of selection and provide an alternative interaction approach which achieves immediate usability. In this thesis, I start from observing the real walking-by scenarios in public place, and then derive a new context of use for public displays, *passing-by interaction*: Users do not need to stop to interact, but can interact while they keep on walking. This context of use is especially relevant to the case of frequent passersby, who pass by the same interactive public display every day (e.g., in the subway station) on their way to work. They know the system well, therefore require high efficient interaction. Base on the context, I design five gestural menu selection techniques and evaluate them with touch technique in a Wizard of Oz experiment.

Context, menu techniques, design recommendation.

The main contributions of this thesis are: (1) It identifies an innovative and important context of use for public displays: passing-by interaction. (2) it proposes and evaluates six hands-free gestural menu interaction techniques in this context. (3) it provides design recommendations for passing-by public displays.

Chapter 2

Related work

This thesis presents a design research work for gestural menu techniques on public displays. Therefore, not only existing public display and menu systems, but also gesture studies and design methodologies are related.

2.1 Public Display

A lot of interactive display research work are proposed.

Since late last century amount of interactive displays have been proposed. Bly et al. [1993]. Wellner [1993] propose DigitalDesk, which is a computer with a mounted video camera built on a physical desk, makes users interactive with it like using ordinary desk and paper. This system can also project electronic objects onto the real paper documents, where users could point with fingers or pens. Interaction approaches develop also variously from touch screen and trackball, such as Churchill et al. [2004] to operation through mobile device, such as Finke et al. [2008]. Churchill et al. [2004] design a public interface, PlasmasPlace, for presenting variety of sources related to online community of conferences. PlasmasPlace is used at CHI2002, where participants can quickly navigate conference programs by spinning a large trackball and pressing two buttons on it. Finke et al. [2008] present Polar Defence, a multi-user computer game on a public display, which passersby could access through sending SMS. In recent years, computer vision technique is widely applied to public displays, which enables interaction from a distance. Möller et al. [2009] present ReflectiveSigns, a network of displays, which reacts implicitly to the audience's viewing behavior. An early example of interaction between an Avatar on public displays and passersby is Intelligent Kiosk designed and studied by Christian and Avery [2000]. In Malik et al. [2005], a vision-tracked gestural interaction with distant displays is proposed. This system supports fast targeting and navigating to all parts of a large display by tracking full 2D multi-fingers and whole-hand gestures input on a tabletop.

City Wall project studies social effect in public.

City Wall is a collaborative playful multi-touch screen for public use. Multiple users can browse through media collections and manipulate the photos in particular with hand gestures, such as scaling, moving and rotating. Peltonen et al. [2008] put City Wall in a full outdoors environment and study how the users interact with a multi-touch display in public in different scenarios, such as in workdays, on weekends or with a public events. They apply video records to analyze users' behaviors after the experiment. Like City Wall, my work also considers social effect on users' behaviors.

ICLD presents every application on turn and is accessed through the small touchscreen.

Interactive Citylight Display (ICLD) Deutsche Telekom present their multimedia large display(Telekom [2011]) at Digital Signage Expo 2011, which is 1.68 metres wide and 2.50 metres high, comprises a 82-inch full HD display and a 17-inch touch screen (see Figure2.1). The side sections of ICLD are decorated with colorful RGB LEDs to draw passersby's attention. A sound system is embedded as an extended feature. Users are allowed to navigate the system through that small touch screen and interact with different applications through the equipped camera and integrated WLAN, bluetooth functions. The user interface is animated with interactive Flash, but does not support multiple users. Out-of-Home Media group of Deutsche Telekom designed this large display for interior public spaces, especially high-traffic locations where long waiting time is expected. Each of applications involving news, entertainment and market-

Figure 2.1: interactive city light display designed by Deutsche Telekom

ing opportunities is accessed on turn. With commercial incentive, ICLD is tested at the Stuttgart airport and presented in trade fairs in Germany. The design work in this thesis maintains the style and partial features of ICLD, but puts it into a more specific use of context.

Audience funnel framework comes from the observation of Magical Mirrors.

Magical Mirrors are a group of four large public displays installed on the shop windows, which passersby could interact with distantly. When nobody stands in front of Magical Mirrors , they are in ambient mode, which show mirror images of the environment. When people pass them by, Magical Mirrors do not only track the motions of passersby, but also react optical effects according to motions. For instance, displays release bubbles in random directions when people wave their hands. Michelis and Müller [2011] obverse interaction behaviors of 660 passersby on two weekend evenings. The observation shows people tend to walk by the displays very fast, and some of them already start to interact, though they stand relatively far from displays. Based on study result, they derive the audience funnel framework (see Figure 2.2) with six phases, passing by, viewing & reacting, subtle interaction, direct interaction,

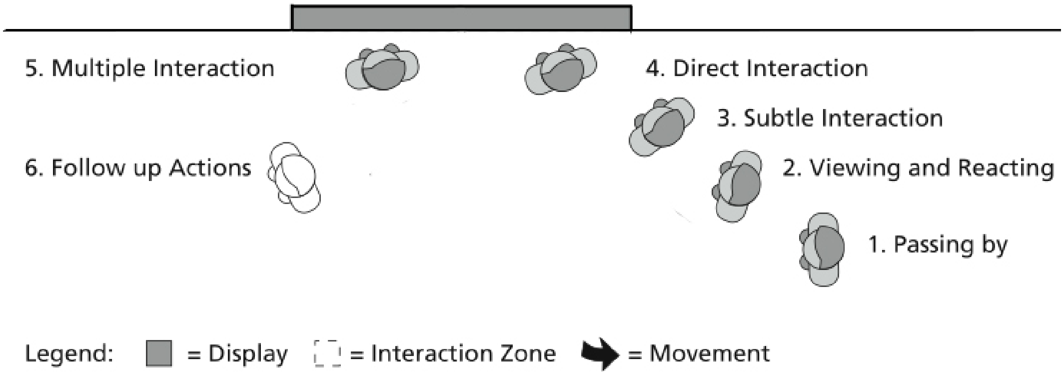


Figure 2.2: audience funnel framework

multiple interactions, and follow-up interactions. Authors believe that the audience funnel is useful to improve public display systems. Because designer can either increase the number of passersby by relocating public displays or let more users pass the audience funnel by overcoming the thresholds between phrases. For instance, the specific threshold for Magical Mirror is the one between passing by and subtle interaction. Meanwhile, they propose design suggestions for public displays in general: The lower thresholds in the funnel, such as reacting and subtle interaction, should be improved at first. Otherwise the audiences (potential users) may be dropped out before they touch higher thresholds. My work simplify this audience funnel in terms of the concrete context.

2.2 Menu Technique

Linear menus and alternatives are used on desktops, mobile devices and interactive surfaces.

Linear Menus are widely used for exploring and selecting commands in interactive applications. Ahlstroem et al. [2006] compare standard pull-down and jumping linear menu system reacting to the usage of mouse click action. The result shows that a force enhanced menu can facilitate menu interaction. Several alternatives have been proposed for desktops Bailly et al. [2007], mobile devices Roudaut et al. [2009] and interactive surfaces Bailly et al. [2010], Lepinski et al. [2010]. Bailly et al. [2007] present Wave desktop menus, which is a variant of multi-stroke marking menu, and compare it with a four hierarchical multi-stroke menu in a user experiment. Results prove that Wave menus offers better performance for both novice and expert users than multi-level marking menu. Roudaut et al. [2009] present a contextual linear menu, Leaf menu, which supports curved gestural shortcuts for commands selection on small hand-held touchscreen. In Bailly et al. [2010], Radial-Stroke and Finger-Count menu techniques are proposed to augment multi-finger and two-handed interaction approaches on multi-touch surfaces. In Lepinski et al. [2010], they investigate human capabilities of performing directional chording gestures and thereby design multitouch marking menu system on table interface. A following evaluation experiment shows that multitouch marking menu is significantly efficient than traditional marking menu for both novice and expert users.

Half-pie menu has a high usability of touchable.

Stacked Half-Pie menus Hesselmann et al. [2009] point out three problems of touch interfaces, screen occlusion by the user, menu item size and the usage of intuitive navigation paradigms. To address these problems, authors propose a Stacked Half-Pie menus working on touch screen, which facilitates an interactive navigation with a visualization of an unlimited number items on a hierarchical menu. They evaluate this approach and the result shows that half-pie menus has a high usability of touchable and makes interaction more interesting other types of menus on interactive tabletops.

Visual Touchpad enables the cooperation between the thumb and the index finger.

Visual Touchpad Malik [2007] designs a low-cost computer vision-based input device, Visual Touchpad. It detects multiple hands and fingertips over a constrained planar surface. In that paper, the author explores how multiple fingers could be used in real-world interface scenarios through Visual Touchpad. Furthermore, he proposes an interaction technique that users can control biiiidigit widgets with the thumb and index finger of a single hand in an asymmetric-dependent manner. This approach allows the index finger to perform primary tasks and the thumb to perform secondary and less frequent tasks to support the manipulations of the index finger. He also investigates the impact of visual feedback on the perception of finger span and direct manipulation. Results show that users are able to select up to 4 discrete commands using the thumb without any visual feedback. The hand gesture study in my work is inspired by Visual Touchpad work.

2.3 Gestures Study

Gestural interaction systems, gesture theories and methodologies of gesture study

Saffer [2008] provides essential information about all gestural interaction approaches for kinesiology, sensors, ergonomics, physical computing, touchscreen technology. As a guideline for gestures design, he well summarizes gestures space and patterns. Poggi [2001] presents a typology of four dimensions to identify gestures: relationship to speech, spontaneity, mapping to meaning, and semantic content. Partly similar to the work in this thesis, Xbox360 Kinect (Bleiweiss et al. [2010]) allows players to interact by meaningful whole body movement. Kendon [1988] proves that gestures have meanings and direct manipulation interfaces need language-like gestures. The book of Hand and Mind: What Gestures Reveal about Thought (McNeill [1996]) explains how symbolic and metaphoric gestures reflect human's mental models. Except gesture theories, many interesting approaches are used to make users define gestures, such as to design EdgeWrite unistroke in Wobbrock et al. [2005]. They prompt users with referents of an action and let them perform signs of those actions. Moreover, Liu et al. [2006] present how people manipulate physical paper and then design TNT gestures to match the behavior. Wizard of Oz approach is often used for gesture study. Mignot et al. [1993] study a speech and gestures application which can layout furniture. Voida et al. [2005] study gestures for accessing multiple projected displays.

Users define the gesture space, rather than designers.

User-Defined Gestures Study In Wobbrock et al. [2009], it is the first time to employ none-technical people to develop gesture sets for table surface, rather than designers organize the gesture space. Wobbrock et al. [2009] think human's gestures cannot be performed as systematically as logical principle, but idiosyncratically different. Hence, they applied an experiment by using think-aloud protocol and video analysis to elicit user behaviors for designing gestures. During the study, users without experience of touch screens are asked to execute 27 commands on a 27″ * 18″ Miscrosoft Table Surface by following the verbal description and animation. Participants' behaviors are recorded by the camera beneath the table surface and these contact information are logged to measure quantitive data. Furthermore, two experimenters observe the whole experiment particularly concerning think-alond data. Through this study, they develop the user-defined gestures space for tabletop, summarize qualitative and quantitive properties of these gestures by proposing a taxonomy (see Table 2.1), gain the users' mental model while performing gestures, and translate them into implication for interface design and technical implementation.The gesture taxnomy and methodologies proposed in 6—"Menu Techniques Evaluation" are inspired by this work and Kray et al. [2010].

Form	static pose	Hand pose is held in one location.
	dynamic pose	Hand pose changes in one location.
	static pose and path	Hand pose is held as hand moves
	dynamic pose and path	Hand pose changes as hand moves
	one point touch	Static pose with one finger.
	one point path	Static pose and path with one finger.
Nature	symbolic	Gesture visually depicts a symbol.
	physical	Gesture acts physically on objects.
	metaphorical	Gesture indicates a metaphor
	abstract	Gesture-referent mapping is arbitrary.
Binding	object-centric	Location defined w.r.t. object features.
	world-dependent	Location defined w.r.t. world features.
	world-independent	Location can ignore world features.
	mixed dependencies	World-independent plus another.
Flow	discrete	Response occurs after the user acts.
	continuous	Response occurs while the user acts.

Table 2.1: taxonomy of surface gestures

2.4 Design Principle

Users always choose easy solutions.

Lazy User Theory Tetard and Collan [2009] review many technology adoption models and propose lazy user theory that explains how users select the solution. They define user need as a specific want which can be fulfilled and user state as the explicit circumstance, such as location, available devices or resources. To fulfill in user need will cause a set of possible solutions, and user state limits the solutions to one (sometimes multiple) with lowest level of effort. Users estimate the demanded effort for each possible solution, which is compared against a solution has been used. In that paper, effort is described in different forms, like time, physical demand or mental demand. Each individual has their own transformation functions between the forms, which may also change according to user state. lazy user theory is one of primary design principles for all interaction techniques in my work.

Chapter 3

Context Study

At the beginning of the project, I organized a user study at Tegel airport aiming for identifying use cases of public interactive displays and understanding the context focusing on the following three questions.

Where to install ICLD? Passengers are generally in hurry at airport. They do different things in different areas, thereby they have various needs and spend different to fulfill needs. For instance, passengers who have completed security check may have more relaxed moods and more time, in contrast to the people who just arrive at the airport and rush to the check-in counter. Hence, where to install ICLD closely relates to the use case, and it is important to find a location where passengers possibly need and would like to interact with ICLD.

Passengers do different things in different area.

What to display on ICLD? To avoid redundant broadcasting, it is necessary to customize the information showing on the display. Passengers who pass or stay in different areas are interested in different kinds of information. It is, for instance, hard to image that a passenger who is struggling to search her departure gate intends to play a game with ICLD. Hence I should investigat passengers' preferences and the useful information for them in respective areas.

Passengers are interested in different information in different area.

How to design the interaction with ICLD? Interaction techniques and input modalities are influenced directly

Passengers prefer different interaction approaches in different area.

by users' tasks and indirectly by the environment where the interaction happens. For instance, the keyboard is more efficient than gestural input to search departure time. However interaction techniques with multi-modalities are more joyful for passengers to play a simple game with a public display. So I should investigate interaction content and approaches for different user groups.

3.1 Set Up

I conducted the user study in places before and after security check.

I conducted this user study in cooperation with Berlin Tegel airport. I applied the methods described in the following section in various spaces before and after security check of Terminal A (international), B (domestic), C (international) (see Figure 3.1).

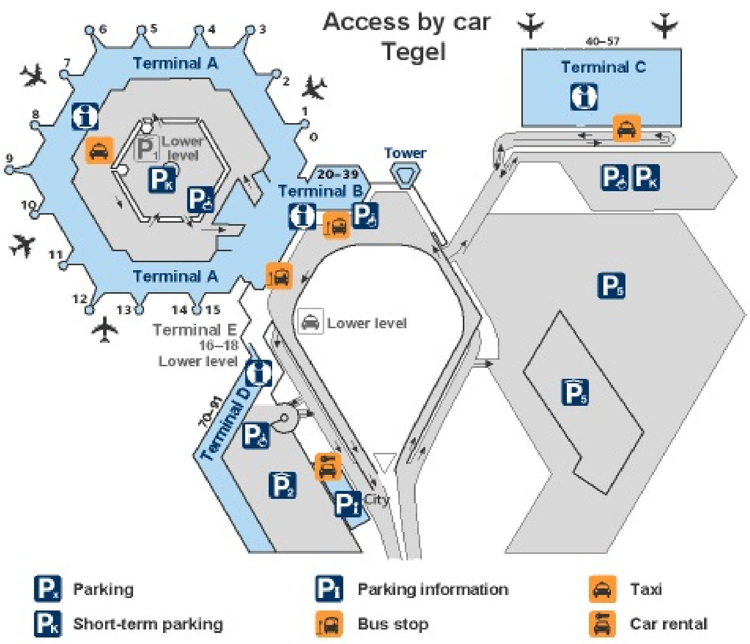


Figure 3.1: map of Berlin Tegel airport

3.2 Methodology

Ethnography. I observed the people passing by certain places during a certain period (such as 1 hour) and how long they stayed in these areas, such as the entrance hall and the shopps. I also observed people's statuses while staying in different areas, especially how frequently they watched public displays and used private digital devices. I categorized users' behaviors into four groups: idle, talking with companies, doing individual things (such as using cell phone or reading a a newspaper), and using public devices. I carried out observations at the lobby, check-in counter, and shops. Accompanied by a security guard, I also went to waiting rooms in front of on boarding gates after the security check points. I observed the passengers with particular attention to differing the domestic gates, where more business travelers departed, from the international gates, where more tourists can be found. and interviewed three persons in the waiting queue.

I observed passengers' behaviors in different places at Berlin Tegel airport.

Questionnaire. I created a likert-scale questionnaire to investigate the passengers' general background, travel habit and their satisfaction of Berlin Tegel airport, particularly of the public digital devices.

Questionnaires to investigate travel habit.

Semi-structured Interview. I interviewed the passengers with further questions after the questionnaire session and recorded the conversation as the qualitative data. I designed a brochure (See Figure 3.2) to present the hardware (ICLD) and the background of this passing by interaction project. A space left on the brochure allowed the interviewees to express their imagination of interacting with ICLD in the airport by sketching the visual manner. This approach motivated the passengers to open their minds for my interview and make users participate in the study actively.

Interview with showing a brochure

Storyboard. Distilling all the finds, I designed storyboard to interpret the scenarios and thereby generalize the use cases Lindlof and Taylor [2010].

Storyboards to present scenarios

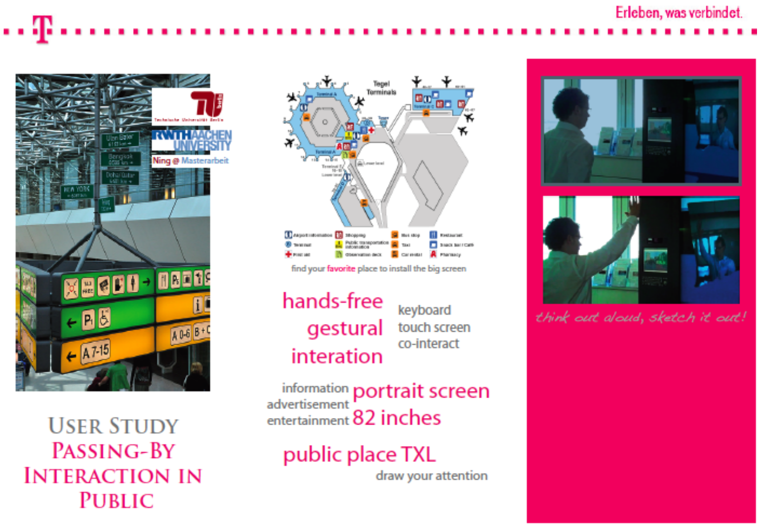


Figure 3.2: flyer used for interview

3.3 Result

3.3.1 Observation

Quantitative observation generalizes workflow model of passengers.

By the quantitative observation, I proposed a general model of passengers' statues at airport. Figure 3.3 presents the workflow of passengers, Figure 3.4 captures passengers' major tasks and behaviors in different places, and Table 3.1 shows the quantitative result of observations. Except this model, there were some interesting findings: (1) over 95% people went to check-in directly after arrived at airport. Only a few people went to cafe or sat in the corner of the lobby to kill time. (2) In some areas people had to keep moving forward every minute, though they stayed there for a relative long time, such as at check-in counter. (3) More people preferred to stay in the lobby to take farewell with friends between check-in and security check, rather than go shopping. (4) There were obviously more male than female passengers waiting in front of domestic gates and 80% of them were busy with personal thing. In contrast to this situation, there was no distinct difference of numbers between female and male passengers at international gates. They are more in group and more relaxed.

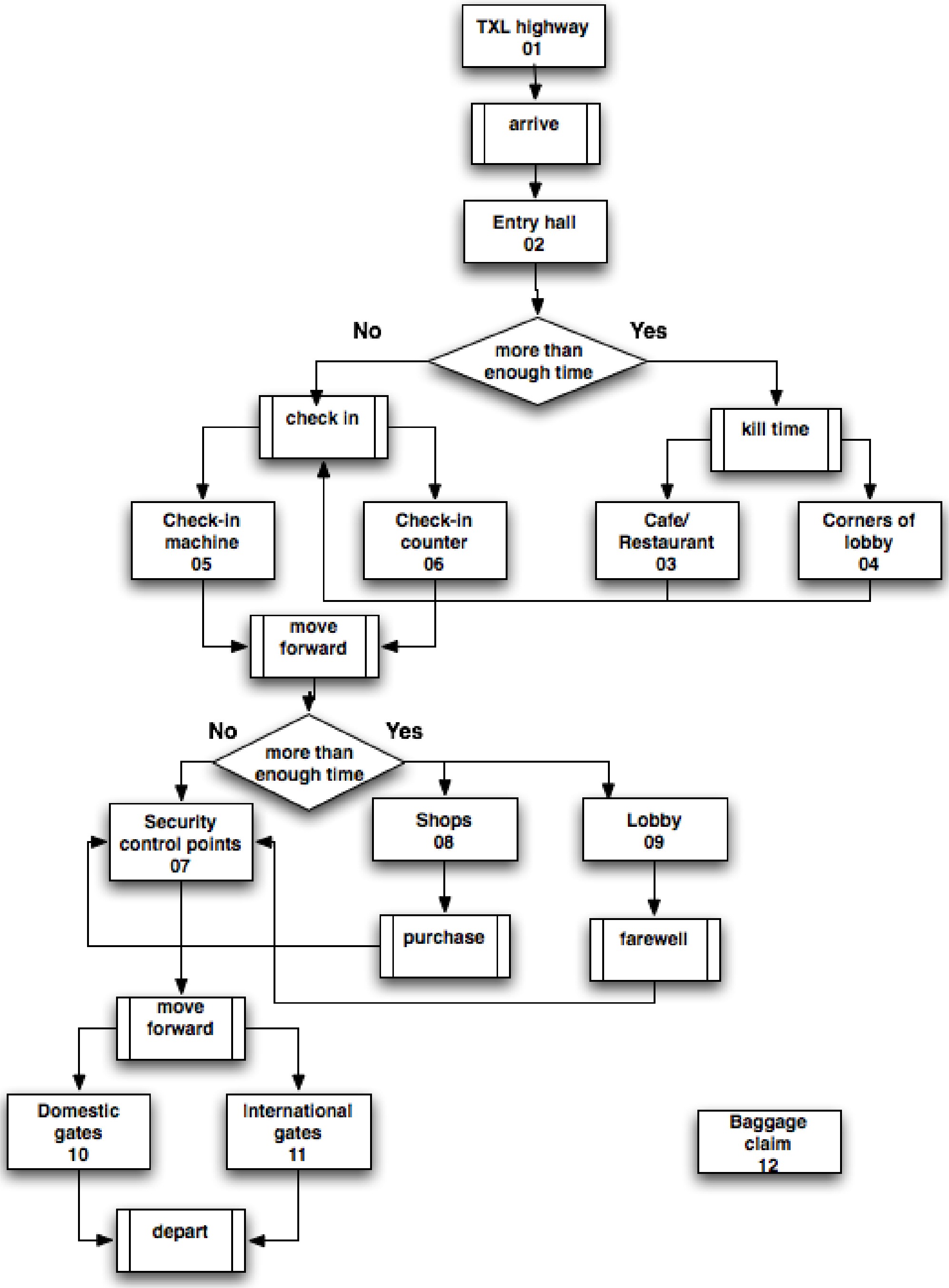


Figure 3.3: passengers workflow model at airport

Figure 3.4: situations in different places at Berlin Tegel airport

ID	place	numbers of passengers	time to stay (min)
01	TXL airport high way	10-30	2-10
02	entry hall	5-10	1-3
03	cafe/ restaurant	many	3-30
04	lobby corner	1-5	20-30
05	check-in machine	2-3	3-5
06	check-in counter	20-25	10-15
07	security check point	8-12	10-15
08	shops	many	5-15
09	lobby	many	10-20
10	domestic gate	25-30	10-30
11	international gate	25-40	20-40
12	baggage claim	50-100	15-20

Table 3.1: quantitative result of observation for each place

3.3.2 Questionnaire & Interview

Interviews show the social issues of the public display.

From the questionnaires, I found that around 15% passengers were new comers to this airport and majority of them have been there before but not very familiar with every place. Most people were aware of public displays at TXL airport, which they used to find travel information and watched news. Moreover from qualitative analysis of interview records, I found half people travel with company and they would like to do something together while waiting for departure. Though personal mobile handset like iPhone and iPad can be found anywhere at airport, some passengers thought public internet access was in need. Over 90% interviewees expressed that they did not care noise or nearby people behaving surprisingly. However, passengers, especially female, would not like to perform 'strange' gestures in the airport, after I presented them the concept of gestural interaction with the public display. One interviewee said: " I can wave my hand in the air, because I am reasonable. Other people will understand I am saying 'hallo' to that big display." " If I see someone does some strange movements in front of it (ICLD), I may laugh out, or talk about it with my family."

3.4 Three Scenarios in the Airport

Base on findings of passengers' behaviors at TXL airport, I derived three typical scenarios and represented them in storyboards.

3.4.1 Use Case 1: Check-in

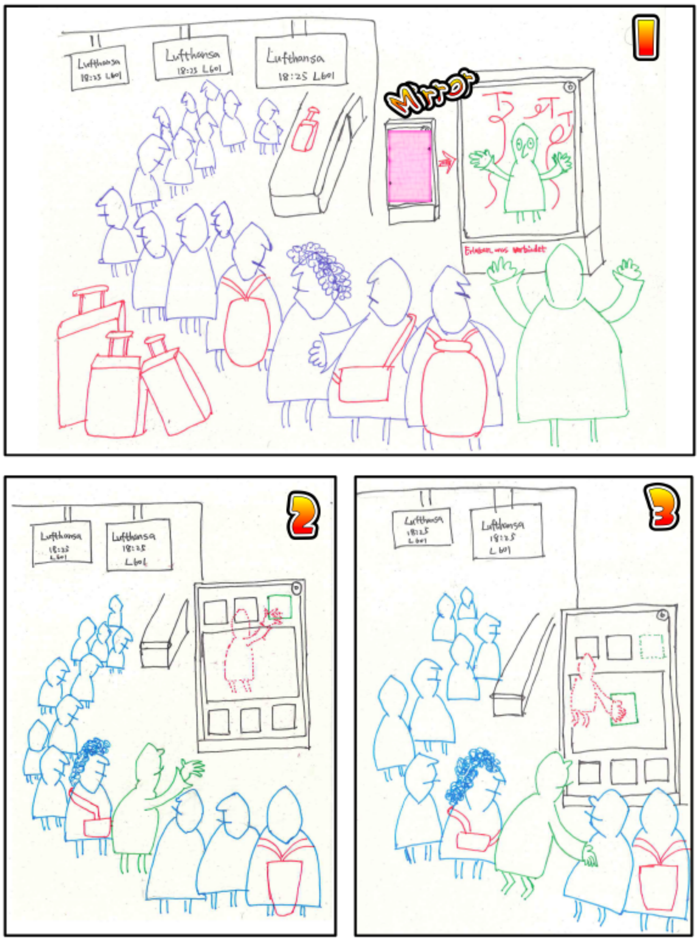


Figure 3.5: long queue in front of check-in counter

ICLD shows animations by tracking Tom's motion.

In Figure 3.5, Tom is standing in a queue exceeding 10m and waiting for check-in. He is bored by waiting. The average time of waiting is 5-15 minutes, and people in the queue have to keep moving forward every 1-2 minutes. ICLD installed in the corner of the queue shows the mirror image of Tom and animated objects around him, such as bubbles, which move by tracking Tom's motion. The screen just looks like a normal mirror when no person stands in front of it. This animation changes into a menu in 5 seconds, in which Tom can select an item by pointing and dragging it to the middle of the screen. Tom performs gestures in the air without touching ICLD and gets feedbacks from his contour rendered on the interface.

A short and interesting interaction is required by check-in counter

Analysis: waiting for check-in causes a very contradictory mood of the passengers. In one side, they have to concentrate on following the queue, in another side they are bored by waiting merely. Hence the interaction technique needs to be simple and interesting enough. It takes users only a couple of seconds, but needs to arouse the positive mood of the waiting people. Since people are maintained in a queue inside the security fences, a distant interaction technique is necessary and multi-user application is worth considering.

3.4.2 Use Case 2: Farewell

People would like to take a farewell photo between check-in and security check.

In Figure 3.6, Nancy and Ajding are saying goodbye to each other. Nancy is leaving Berlin, she has checked in and still has some time before security check. Ajding suggests to take a farewell photo, but nobody in the surrounding area is available to help take a photo. At that time, they find the photo booth application on the public display which is currently showing how to use it. Nancy and Ajding take a photo together and email it to themselves through ICLD.

ICLD can work as a landmark.

Analysis: In the airport, some passengers would like to shoot a photo for themselves to memorize the nice tour or a group photo to say goodbye. However, not all passengers have a camera in hand, sometimes they are reluctant to ask someone else 's help. Therefore, ICLD can offer the feature of photo shooting and sharing. This function can also be extended to a social network game. I asked the passenger in the interview whether they can

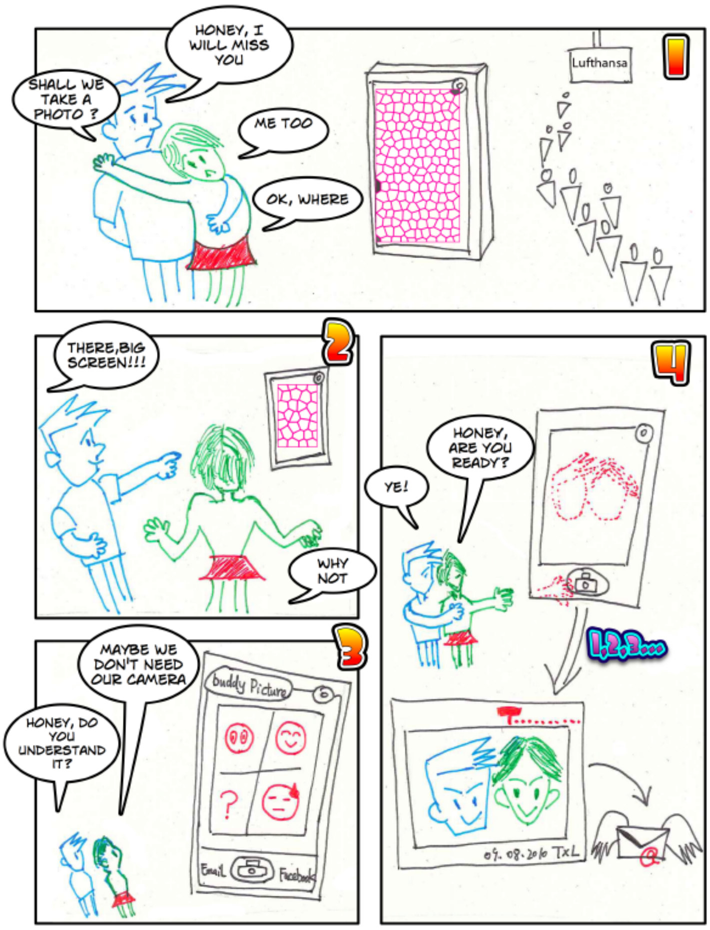


Figure 3.6: farewell in the lobby

find a landmark inside Tegel airport. If not, whether they needed one in case they got lost. One participant said," No, I haven't seen any obvious sign which tells me where to go. It is my first time here, it is hard to find everything." ICLD has potential to become new landmark of Tegel airport. Its 'huge' size not only draws attentions but also leaves a deep impression to the passengers. To emphasize this property, the outlook of ICLD needs to been designed as an icon, unique and simple to describe.

3.4.3 Use Case 3: Waiting for Boarding

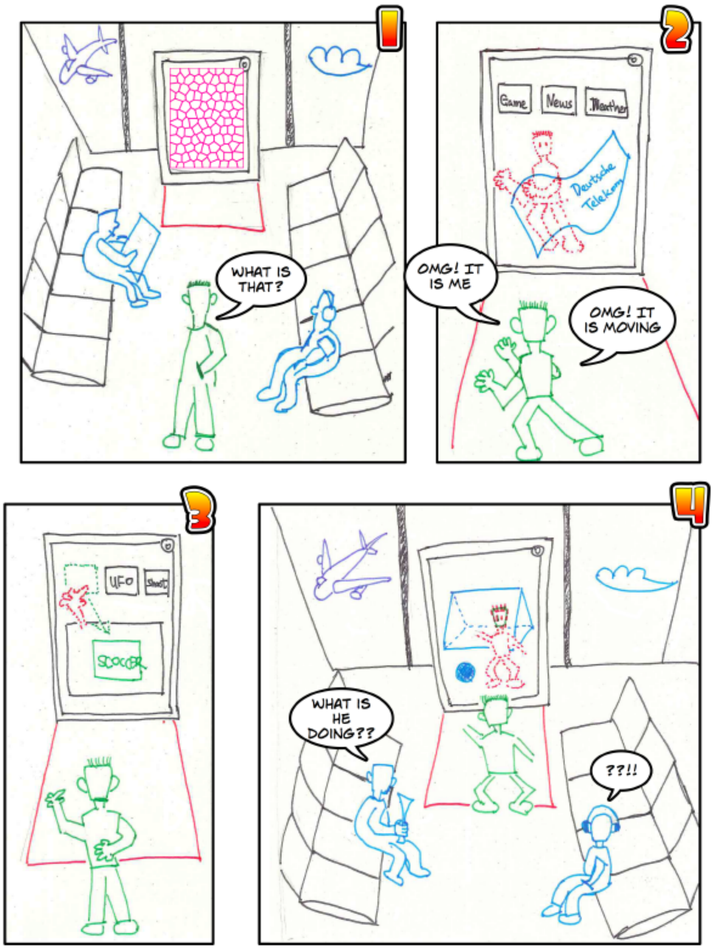


Figure 3.7: playing with ICLD in the waiting room

Paul plays soccer game displayed on ICLD in the waiting room.

In Figure 3.7, Paul is aware of ICLD in the waiting room for boarding and he wants to have a look at what is showing on ICLD. He finds a mirror image of himself attached a flowing flag. When he moves, the flag follows. There are three buttons on the top of the display, on which soccer, UFO, shoot are written. Paul tries to drag the button of soccer down to the middle, and a soccer games starts. Paul kicks the ball by controlling his mirror image, that catches the eyes of other passengers in the waiting room.

People need to play with ICLD with social acceptable gestures.

Analysis: In the waiting room of domestic gates, most of the passengers are business men who focus on their works or even arrive at the gate just 5 minutes before boarding. They are not interested in playing computer game and do not want to spend time on it. Contradictorily the international travelers normally wait 25 mins to 40 mins for the long journey for boarding. They are happy to play a accessible computer game at airport to kill time. Therefore, ICLD is supposed to install in the international gates. The game scenario and the gestures users use should be social acceptable. It is normal that playing with a public display draws attentions, but it is not suppose to arouse negative feedbacks, such as laughing or gossiping.

3.5 Passing-by Interaction

3.5.1 Concept

The concept and the model of passing-by interaction in public

Discussed with colleagues, I targeted 'check-in counter' senario as research focus, in which passersby have very short time, only 1-3 mins, for interacting with the public display. I extended another observation study in subway stations, which focuses on a walking-by scenario. The result indicated that the general rhythm in the subway station is faster than in airport, and people even have much less time, 15s - 1 min, for interaction. A typical application scenario (see Figure3.8) is: Terry is walking out of the subway station, when a football match is just finished. He is in a hurry, does not have a smart phone, but he wants to know the result. He is aware of the public display in the corner, which is however displaying an advertisement. Inspired byMüller et al. [2010], I model Passing-by Interaction into four steps(see Figure 3.9):

1. view the display,
2. perform gestures,
3. read the information,
4. and leave the display.

and define *Passing-by Interaction in Pubic*: Users do not need to stop to interact, but can interact with public displays while walking.

Figure 3.8: typical passing-by interaction scenario in the subway station

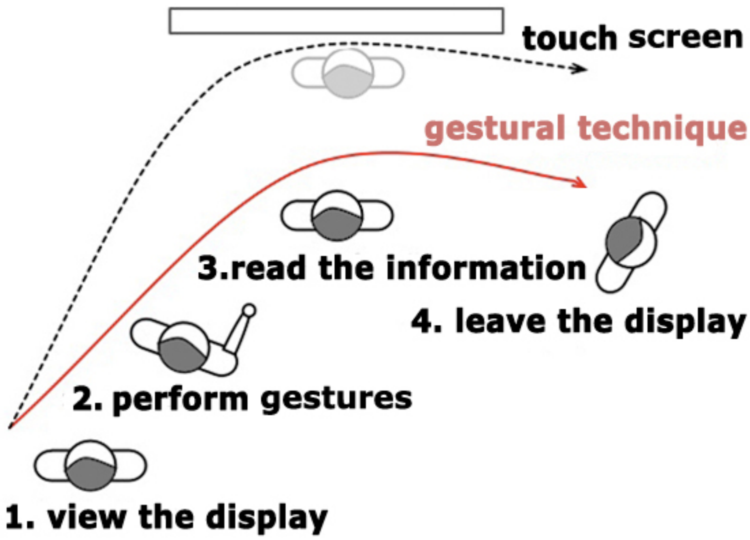


Figure 3.9: passing-by interaction model

3.5.2 Research Motivation

Requirements of passing-by interaction in public

Unlike traditional touch screen technique causing detour, I look for the interaction techniques, which do not slow down passersby and do not change their walking paths. Moreover, the information the public display provides should fulfill different individual needs, since broadcasting advertisements are not in active use. Finally, the frequent users who pass by the same interactive public display every day (e.g., in the subway station on their way to work) should be specially considered. Some obvious major requirements for passing-by interaction with public displays are:

- short interaction time
- interaction while walking
- immediate usability
- selection possibility
- social acceptance

Thereby, the research focus of my master thesis is how to design the interaction techniques to address these five requirements.

Chapter 4

Concept Study

4.1 Concept of Overall Design

How to invite users to interact with public displays?

As discussed in Huang et al. [2008], one major challenge of designing public displays is how to capture user's eyes and then invite them to interact with public displays. Inspired by Blythe et al. [2004], Huang et al. [2008], Vogel and Balakrishnan [2005], I carried out an interdisciplinary workshop to brainstorm how ICLD can draw users' attention and engage them with the interaction by arousing their curiosity and surprise.

4.1.1 Set Up

Interdisciplinary participants

Four computer scientists (specialized in HCI), two designers, and one psychologist participated in this workshop. They were divided into two groups randomly, each of which concentrated on causing either 'curiosity' or 'surprise'.

4.1.2 Methodology

Participants brainstormed interaction ideas with initial stimuli.

Brainstorming with initial stimuli Kelley and Littman [2001]. At the beginning of the workshop participants watched two videos with semi-controls (see Figure4.1), which only showed the interaction on the user's side (I acted as the user). In the first video called surprise + curiosity, the user was surprised by seeing something unexpected on the screen, and then was motivated to discovery it. In the second video called curiosity+surprise, the user discovered the system driven by curiosity at first, and then got surprised by the feedback. After the video session, I explained the context of ICLD system, passing by interaction in public, and presented the user study result at Tegel Airport . Afterwards workshop participants were grouped to discussed and presented their ideas.

Figure 4.1: video to present curiosity and surprise

4.1.3 Result

Hitting anticipation to surprise users.

After the brainstorming, we found out a kind of specific surprise, which is 'to hit users' anticipation'. This concept fits well the situations in the airport or train station. Because when passengers, especially tourists, depart in the airport, they are full of expectations for the destination. If they can foresee anything related to their destination, they will be surprised. Moreover, four of the seven participants thought public display should be able to provide public information, like weather forecast or daily news, as a basic feature. As the outcome of this study, I summarized the ideas, represented the mindmaps and categorized them into three groups:

Playful interaction

- coffee stain: When a user passes by ICLD, coffee stains will be rendered on her clothe, if a white T-shirt is detected.
- pet love: It is similar to Tamagotchi, but a public pet for all passersby. User can feed the pet through gestural interaction.
- oracle: Screen shows the information of the passerby, such as age and gender, based on facial recognition.
- photo booth: Passengers take photos by ICLD and share them online immediately.

Public information

- weather forecast: When a user passes by ICLD, an umbrella will be rendered above her head or a pair of sunglasses will be rendered on her eyes in terms of the current weather. The interface displays the temperature as well.
- local culture: Users can experience the local culture of travel destination. Eg. If the passenger flys to Munich, a pair of leather shorts (Bavarian traditional clothes) will be rendered on her body while passing by ICLD.
- city tour: It is a game to foresee the travel destination or make city tours. Users walk in four directions to navigate different cities.
- realtime announcement: Passengers monitor the situation at check-in counter or security check point through ICLD, so that they can choose the less busy gate. They zoom in/out the realtime video by gestures.

Pervasive advertising

- ambient advertisement: When people pass by ICLD, a flag with a brand logo will be rendered on their bodies.

- have a try: Passersby manipulate the 3D product presented on ICLD by gestures.

4.2 Concept of Menu Techniques

Results of the brainstorming confirm the necessity of selection possibility, though no concrete idea is applied.

After discussing the workshop result with the project team, I recognized that ICLD should have multiple features, rather than stick to one application simply. So we didn't go further to any concrete idea, but looked for a solution which was able to connect different applications together, a menu interface. Hence I carried out another workshop to brainstorm menu techniques.

4.2.1 Set Up

Expert participatory design

Three HCI researchers and two HCI designers participated in this brainstorming session. The whole process was video recorded for the further analysis.

4.2.2 Methodology

Participants brainstormed gestures and menu interfaces.

Brainstorming. Participants brainstormed the hands-free gestures which can be used to select a menu. They went to the stage to perform gestures one by one, and also draw the corresponding menu interface in their mind. They were required to finish many rounds continuously till no new ideas came out any more.

Participants thought aloud.

Think Aloud Protocol. While performing gestures, participants spoke out the meanings of those actions. After this session, participants went through the video together and compensate more mappings between gestures and menu interfaces.

4.2.3 Result

Menu interfaces and gestures to manipulate them

In Figure 4.2, Figure 4.3, and Figure 4.4, I generated a hierarchical relationships between menu interfaces and menu techniques from the result of the brainstorming. The two primary categories of menu are the linear menu, which can either be vertical or horizontal, and the non-linear menu which comprises marking, cube (polyhedron) and arbitary alignment menu. Users can select an item from linear menu (see Figure 4.5) continuously by looking at or point to it. They can also slap a controller, eg a highlighted frame, to indicate which item to choose. Meanwhile discrete menu technique provides an interesting but less efficient solution. If each item in the menu gets highlighted in turn, users can perform a special gesture to confirm the one they want to select. In principle, it is possible to involve any part of the body to hold a highlighted button. But I only list here those which are more natural mapping and socially acceptable. For instance, head shaking means to let highlighted keep going, and head nodding means to select the current one. Except linear menu, brainstorming participants also considered making menu items in sector shapes and aligning them as a semi-marking menu (see Figure 4.6), with which the user can select one item by twisting her body as a dial pointer. We thought a cube or polyhedron menu (see Figure 4.7), which contains an item on each surface, would have a high affordance of being rotated. One participant pretend to turn his neck and shoulders in oder to have a look other side of the 3D menu (to select items on other sides). Another participant suggested that walking or slapping in different directions can be used to rotate the cube interface, and stopping can be used to select the current side (item). Towards arbitary menu, all basic interaction techniques are suitable, such as pointing or pushing/pulling the item (an extended way of pointing). Additionally we found out a series of hand or body gestures from the brainstorming which I named them symbolic gestures . These gestures are meaningful and reveal individual mental model . For example, during the brain storming one participant extended one finger to select the first item, extended two fingers to select the second item, and so on.

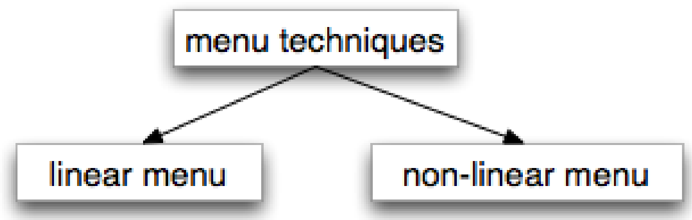


Figure 4.2: menu techniques and interfaces-1

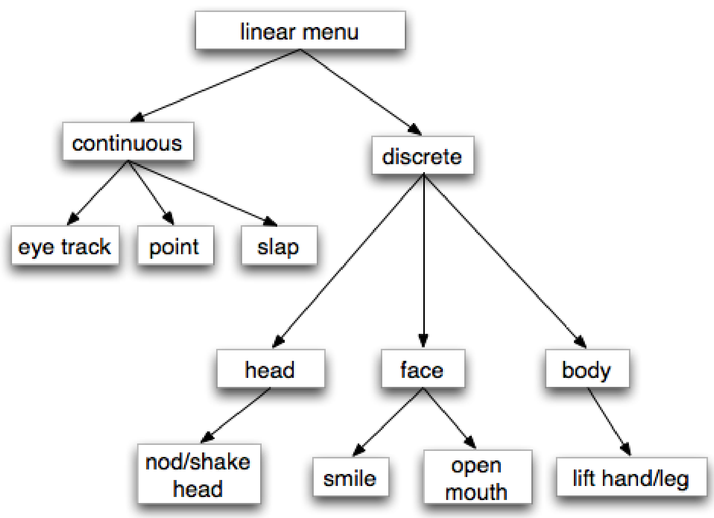


Figure 4.3: menu techniques and interfaces-2

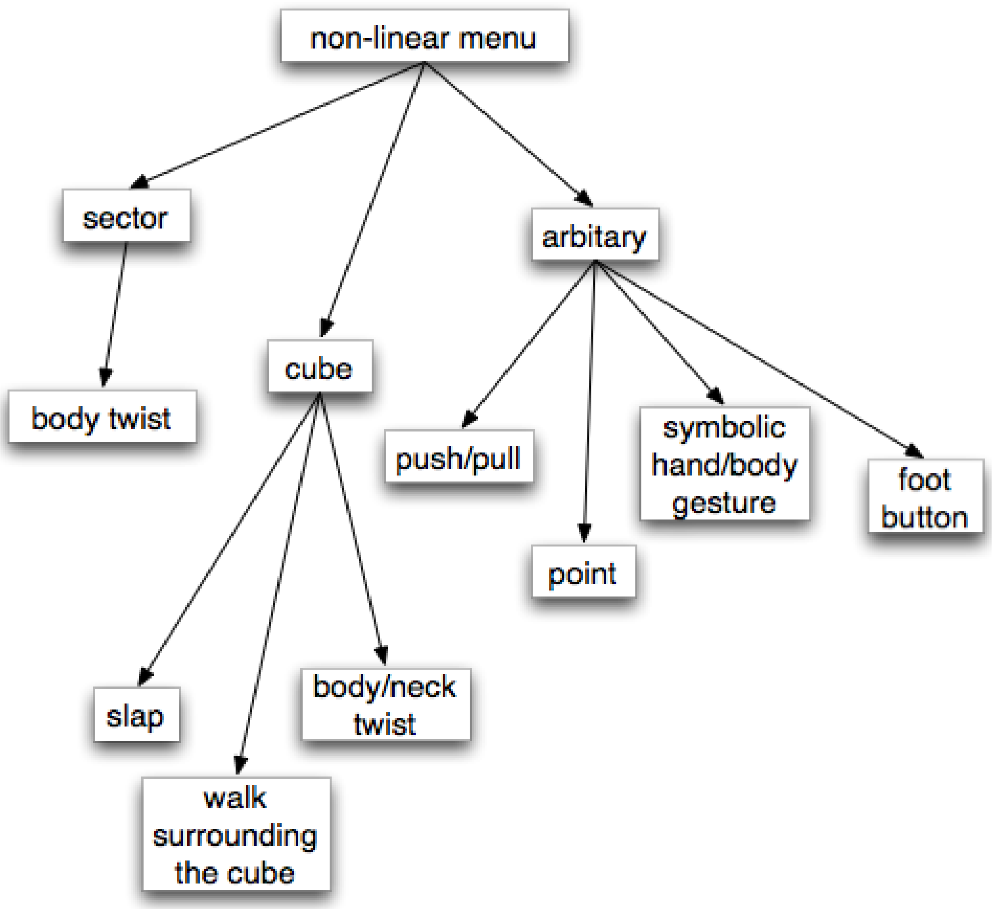


Figure 4.4: menu techniques and interfaces-3

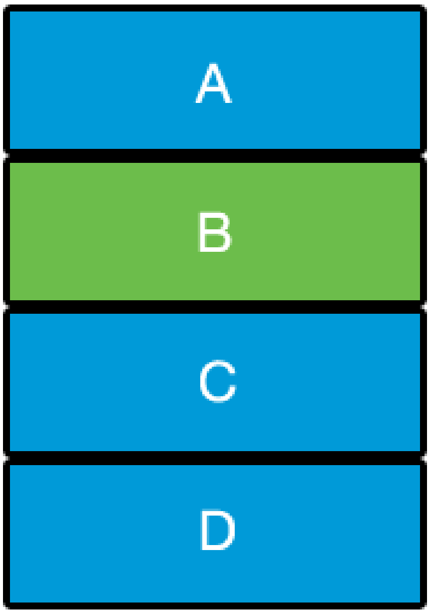


Figure 4.5: linear menu interface

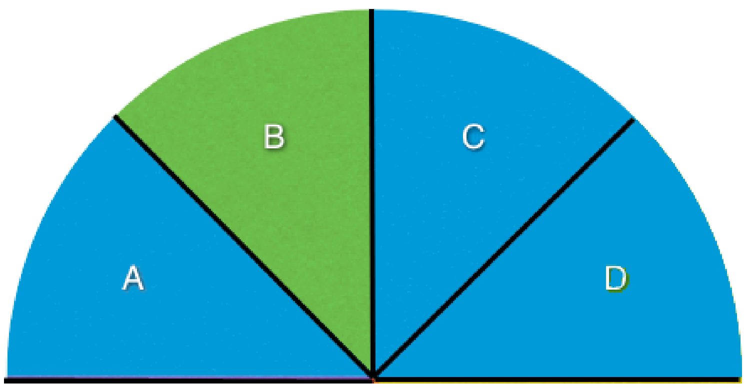


Figure 4.6: semi-marking menu interface

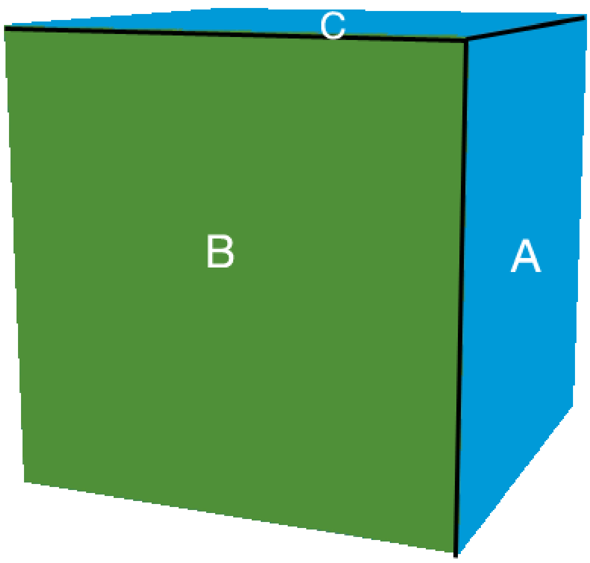


Figure 4.7: cube menu interface

Chapter 5

Menu Interface and Gestures Study

Focusing on 2D menu and symbolic gestures.

From the brainstorming in 4—"Concept Study", we got five kinds of menu interfaces and fifteen kinds of interaction techniques. However considering the complexity of the implementation and the evaluation, we decided to focus on 2D menu and explore the symbolic hand/ body gestures.

5.1 Study of 2D Menu

5.1.1 Set Up

ICLD has a menu with four new items.

The old design of ICLD had four full-screen applications, only one of which was running at one time. They were switched every certain minutes without giving an overall view to users. To maintain this style, I extended a four-item menu with putting the new content, which was inspired with the ideas from 4.1—"Concept of Overall Design". The four items are 'Advertisement', ' City Tour', 'News' and 'Weather Forecast'.

5.1.2 Methodology

Participants manipulate the paper prototype.

Paper Prototyping. I made a paper screen interface and four movable buttons with the same aspect ratio as real ICLD. I attached the paper prototype on a whiteboard where a huge canvas indicated the real size of ICLD. Similar to Liu et al. [2006], workshop participants got tangible feeling from manipulating papers physically.

Participants assemble four icons for a menu.

User Participatory Design. I invited nine persons to join this study, who didn't experience any research related to ICLD. They were 2 designers, 3 computer scientists, 2 secretaries, and 2 students majoring in human factors. I explained the background of this study and the meaning of each item, which was presented as an icon on the paper screen. Firstly participants were told to assemble the four 'icons' for a menu and then select one item with gestures. Secondly they explained why they preferred such a menu and how they interacted with it. Finally they were asked how to represent that menu on the ground, in order that users can select the menu with feet.

5.1.3 Result

Menu on the bottom and foot buttons were preferred.

Finally I got four kinds of menu interfaces, which were linear menu on the top or on the bottom (see Figure 5.1), linear menu on the right side or surrounding menu in the middle of four edges (see Figure 5.2). The participant who preferred surrounding menu put the buttons in the four corners at the beginning. When she he tried to select one item by dragging it to the middle space, she reorganized the menu as the one showed in Figure 5.2-right. Two designers agreed with the linear menu on the bottom and indicated it is simple and well ergonomically designed for such a 2.5m height portrait public display. Because Tetard and Collan [2009] suggested that user will most often choose the solution which fulfills her needs with the least effort in his lazy user theory. The menu on the bottom stayed around 1.2 m from the bottom, which was a natural height for lifting arms. Participants suggested to project the linear menu on the floor as foot buttons (see in Figure 5.3). The linear menu on the bottom of the screen were close to the projected menu on the ground, that facilitated users to map the menu on the ground to the one on the portrait screen. The menu buttons (or bars) on the two surfaces can be integrated into one continuous bended whole as well.

Figure 5.1: left: menu on the top; right: menu on the bottom

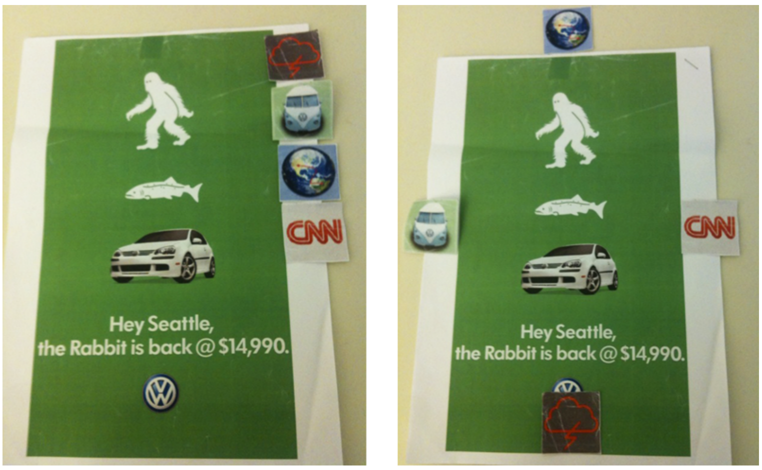


Figure 5.2: left: menu on the right side; right: menu in four directions

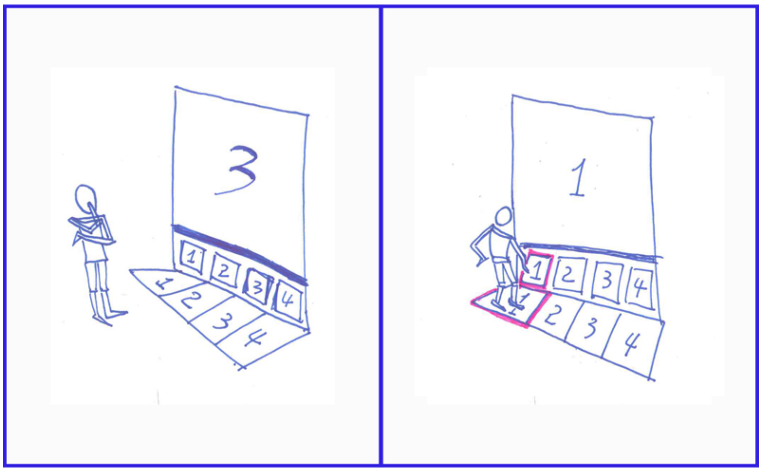


Figure 5.3: four foot buttons projected on the floor

5.2 Study of Symbolic Gestures

5.2.1 Set Up

Study on symbolic hand and body gestures.

Besides menu interface, discussed with colleagues, I selected and modified five interaction techniques from the fifteen: ’pointing’, ’slapping’, ’hand gesture’, ’ body gesture’, and ’foot button’. These techniques with touch (screen) technique as the baseline were compared and evaluated in a following experiment presented in 6—“Menu Techniques Evaluation”. Here introduce I the study on symbolic static gestures used for ’hand gesture’ and ’body gesture’ technique.

5.2.2 Methodology

Gesture collection

Grounded Pattern (Borchers [2001]) . As many as possible hand and body static gestures were collected and grouped. Afterwards general patterns were grounded recursively.

Each four hand gestures were a group.

Hand Gesture: I asked each of the eleven participants to perform 10-15 static hand gestures and took photos of them. Those gestures came from daily life, can be culturally distinguishing, can be either meaningful or meaningless, can be made by one hand or hands. Figure 5.4 shows an example of this process. Afterwards I put all hand gestures together with deleting the overlapping ones and requested them to attribute fours gestures a group, which they thought it made sense for them being together.

Participants use body gestures to express the meaning.

Body Gesture: The participant performed four body symbols which stood for or related to the content of four menu items: advertisement, city tour, news, weather forecast. It was a little difficult for participants to express one meaning by body gestures at the beginning. Following an inspiring talk with me, they started to perform creative gestures and explained their mental models. I photographed these gestures and put them into four groups. *Think Aloud Protocol*. During the whole gestures study, participants are need to speak out the meaning of personal metaphors of gestures while performing. Afterwards I matched gestural explanations with photos together as an important reference to look for patterns

Figure 5.4: collection of hand gestures

5.2.3 Result

Finger-counting is proper for hand gestures. Four topic related body gestures are grounded.

Most participants failed to group the hand gestures, but only select the finger-counting gestures as a group. Figure 5.5 shows the simple idea of finger-counting: one finger extended stands for the first item, two finger extended means the second item edc. However this strategy works only till number 5 (five fingers extended) due to cultural limitation. Moreover, I grounded the general patterns of the body gesture matching each item. Six of the eleven participants expressed ′ No Advertising′ by similar poses. So I chose the most typical one of ′pushing things away and turning head in the opposite direction′. Weather forecast got most agreement that eight of the eleven acted ′something comes from sky′ by lifting arms above the head. City tour caused a big diversity, because it was an abstract game, which did not appear in daily life. However hints from participants were using the pose of ′look into distance′ to interpret this content. Finally I designed the gesture of ′crossing arms in front of body′ for News item, because it is the pose people always do while reading and thinking, mentioned by the participants. The four body symbolic gestures used for menu technique are displayed in Figure 5.5.

Figure 5.5: selected hand gestures, body gestures, and their labels

Chapter 6

Menu Techniques Evaluation

The fourth study is based on previous three studies.

In 3—"Context Study" I found out several use cases of this ICLD system in the airport and subway station thereby generalized 'passing-by interaction' to serve my context based design. In 4—"Concept Study", I collected amount of interaction ideas in order to engage users with public displays and proved the necessity of using menu selection. In 5—"Menu Interface and Gestures Study", I improved the user interface design and grounded hand gesture and body gesture patterns. Based on the previous work and inspired by Wobbrock et al. [2009], I propose the following five hands-free menu techniques for passing by interaction with public displays, and compare them with Touch technique through a Wizard-of-Oz experiment.

6.1 Gestures and Menu Techniques

6.1.1 Taxonomy

Gestures taxonomy defines gesture in four dimensions.

Wobbrock et al. [2009] proposed a taxonomy of surface gestures as the result of their user-defined gesture study. I adopt this taxonomy and represent it based on my gesture study in 5.2—"Study of Symbolic Gestures". The following table (Table 6.1) shows the taxonomy of the gestures for menu techniques, which classifies each one three dimensions: form, semantic, and binding. In the form dimension, it is promising to distinguish hand and body gesture, since the former focuses on the specific part, but the latter focuses on the whole. Here hand gesture is applied separately to each hand, but not for two hands together. In the semantic dimension, physical gestures should have the effects that users have experienced in the real world. Because symbolic gestures occur when users succeed in building the metaphorical connection between what they see and what they do due to individual mental model. For instance, two hands crossed in front of body means 'stop'. This mental model forms through learning, that is going to be evaluated in 6.2—"Experiment". In binding dimension, it explains how the gestures relate to the user interface. Like pointing to select requires user's hand to aim at the target, while they can perform a symbolic gesture anywhere to activate one item as long as it can be captured by the camera. This taxonomy defines gestures for menu techniques in various aspects. Thereby it facilitates to address and analyze gesture problems in a detail from the result of the menu techniques evaluation experiment.

dimension	definition	exlanation
form	1. static hand 2. static body 3. dynamic hand 4. dynamic body	hand pose causes effect body pose causes effect hand movement causes effect hand movement causes effect
semantic	1. physical 2. symbolic	natural gesture irrelevant to mental metaphor gesture relevant to mental metaphor
binding	1. interface-dependent 2. interface-independent	gestures depend on interface design gestures independ on interface design

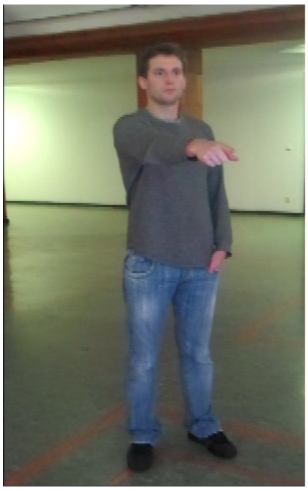
Table 6.1: taxonomy of gestures for menu techniques on passing-by public displays

6.1.2 The Six Techniques

Definitions of six menu techniques

Each technique employs an array relating to the three dimensions in the taxonomy followed with a short description to define its property.

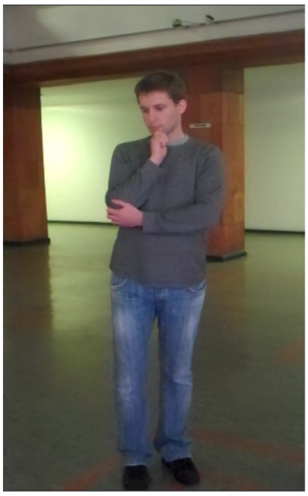
- Pointing Technique [3, 1, 1] : The user points towards the item with left or right hand 'in air' (see Figure 6.1-a).
- Slapping Technique [3, 1, 1] : The user slaps his hand horizontally to select a target in the same direction (to the left or to the right) of hand movement (see Figure 6.1-b).
- Hand Gesture Technique [1, 2, 2] : The user performs a static finger-counting gesture (see Figure 6.1-c). The number of extended fingers to show is equal to the position of the item on the menu bar, and also indicated by an icon next to the item (see Figure 6.4-2). For instance, putting up the forefinger means to select the first item from the left side.
- Body Gesture Technique [2, 2, 2] : The user poses his body (see Figure 6.1-d) to select the target item. Postures are related to the content of items as derived from 5.2—"Study of Symbolic Gestures" and indicated next to the item with icons (see Figure 6.4-3).
- Foot Button Technique [4, 1, 1] : The user steps on a physical button placed on the floor to select the corresponding item (see Figure 6.1-e). The user can step on the button with each feet or both of them.
- Touch Technique [3, 1, 1] : The user simply touches the corresponding item on the screen (see Figure 6.1-f).



(a) Pointing

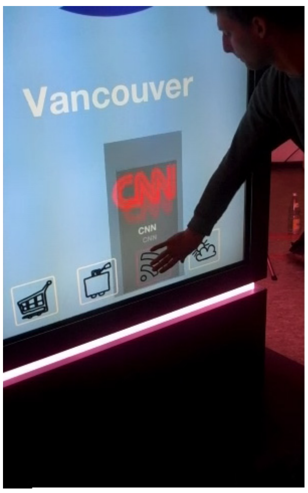
(b) Slapping

(c) Hand Gesture



(d) Body Gesture

(e) Foot Button



(f) Touch

Figure 6.1: six menu techniques

6.2 Experiment

6.2.1 Protocol

Wizard controls the behavior of ICLD through three cameras.

The experiment is based on the Wizard-of-Oz protocol. Thus, users were led to believe that the system had actually been implemented, while actually a human wizard was hiding behind the screen. The wizard could observe the user via three synchronized cameras, and controlled the behavior of the public displays with a keyboard. This procedure was rehearsed many times and tested by three pilot studies. In Figure 6.2, the camera installed on the top of ICLD was used to capture the front side of the participant, including facial expressions. The one on the left had a wide view to display the moving track of the participant, and the one on the right side kept monitoring the screen of ICLD. The participants' behaviors during the experiment were recorded, and the video was a significant tool to discovery different effects, which the six techniques have on users. With using this protocol, I purely tested the interaction without having to worry about recognition accuracy. However, I leaded every participant to believe this system was well implemented at the beginning of the experiment, since I introduced the three cameras as the functional hardwares serving to computer vision technique and required the participants to perform the gestures as accurately as possible. After each experiment, I asked the feedback that whether the participant recognized the system was controlled externally. Only one of the seventeen participant doubted the over-robustness of this system.

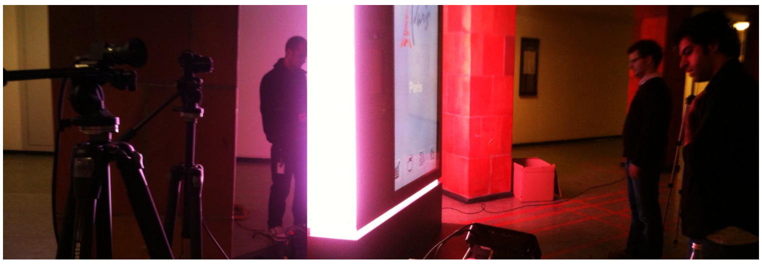


Figure 6.2: setting of Wizard-of-Oz protocol

6.2.2 Setting and Apparatus

Participants operate ICLD in a open hall.

I organized the experiment in a 7.5*7.5 m2 open hall (see Figure 6.3), where a commercially available Interactive City Light Display (ICLD) was installed in the corner. This kind of displays are installed in German airports and make it possible for users to select 4 items by touching a 17-inch screen beside it. I carried on with four meaningful items derived from 4—"Concept Study", advertisement, city tour, news, and weather forecast, in this experiment. A graphic user interface implemented with Processing(see Figure 6.4-1) was applied to link participants and the wizard. If an item was selected, it would be highlighted with a red frame and a random but topic related content would be displayed. For Slapping, the red frame moved in a track of a closed circle. For the Hand Gesture and Body Gesture, I labeled the concrete gestures beside items for the immediate usability (see Figure 6.4-2, 3). For Foot Button, I attached four buttons made by cardboard on the ground at 2 m distance from the display. The wizard was responsible for switching the graphic user interface between different techniques.

6.2.3 Task and Stimuli

Participants simulate passing-by interaction and speak out what they see on the screen.

The task consisted in selecting the item, which is indicated orally by the experimenter, speaking out loudly the content (one topic related picture and one simple english name) subsequently appearing on the display. An essential task was that the user must walk along the route marked on the floor (see Figure 6.3) to simulate passing-by interaction. Participants were asked to perform gestures as unambiguously as possible and were told that they were free to keep walking or stop while completing the gesture. Participants executed 12 trials, each of which started when the they crossed the starting point (see Figure 6.3).

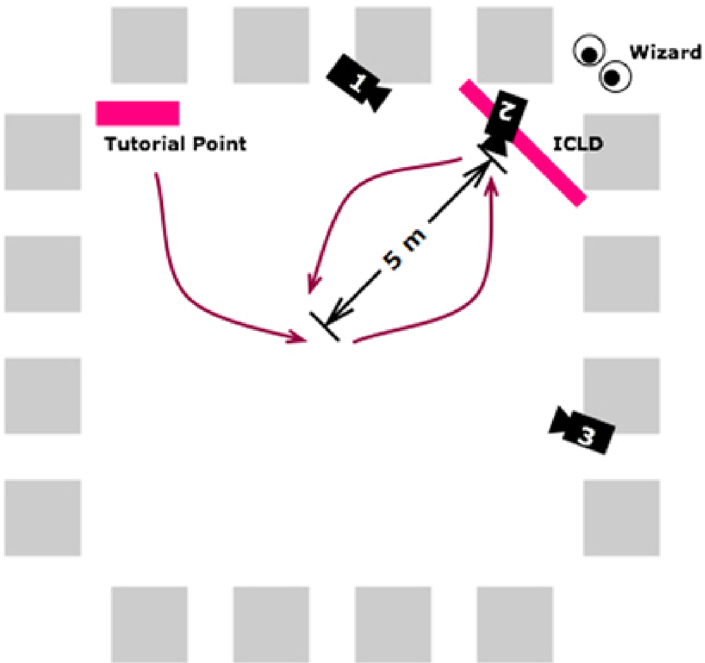


Figure 6.3: simulated passing-by interaction

6.2.4 Procedure

Tutorial, practice, questionnaires and open discussion

17 people (no computer scientists) between 16 and 48 years old participated in the study. 7 of them are female and 10 of them are male. Participants were recruited using public bulletin boards. At the beginning, participants watched a tutorial video to learn how to use six menu techniques. Afterwards they practised techniques for a while or ask questions till they fully understand each menu technique. In the practical session, I used a within-subject design. The participant tried six menu techniques one by one, and the order of techniques was counter-balanced between participants with a Latin Square design. For each technique, participants selected 3 blocks of 4 items appearing in a random order and spoke out the content when they walked by ICLD 12 times (see Figure6.5. After that, participants filled out AttrakDiff-2 (see Figure A.5)and NASA TLX (see Figure A.6) questionnaires for each technique. Then participants ranked their preferred technique twice, before and after watching a video to study social effect, which captured a

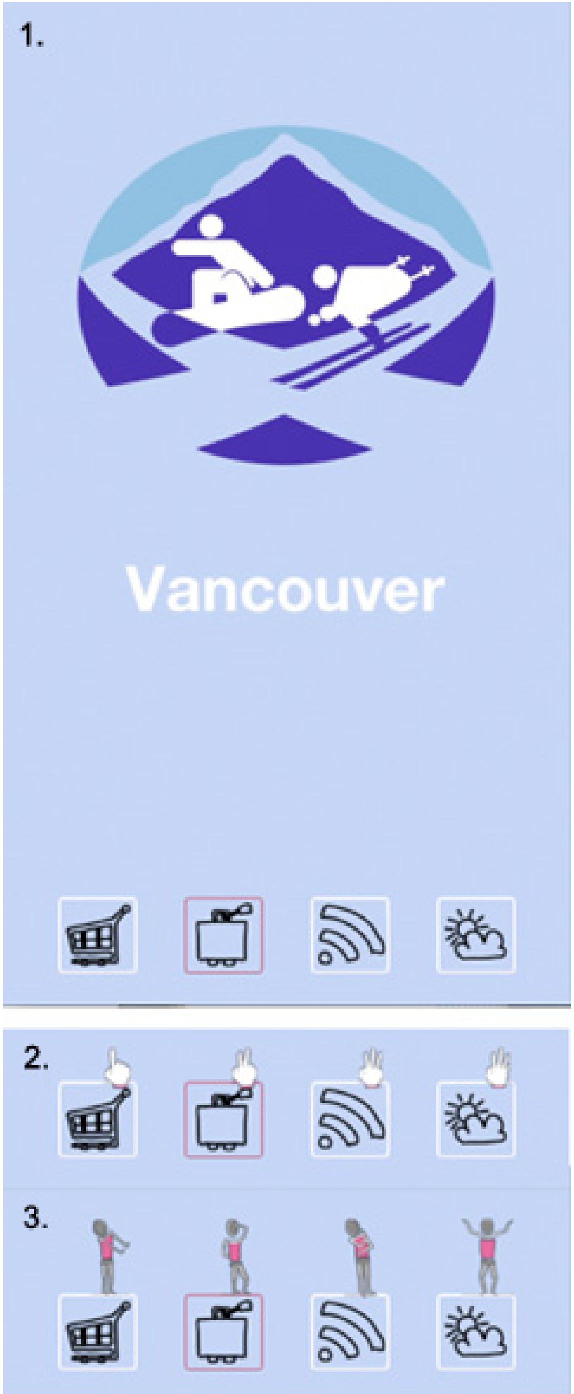


Figure 6.4: -1: general interface; -2: interface for Hand Gesture; -3: interface for Body Gesture

real passing-by scenario in a subway station in Berlin. The experiment ended with an open discussion. The participant was asked for questions according to the result of preference ranking as well as their performances in practical session. Three experimenters cooperated during the whole experiment together: one acted as the wizard, one gave oral stimuli, and the last one observed and noted participants' behaviors. The following situations the experimenter paid attention to and were addressed accordingly in the discussion session:

- when the participant suddenly stops performing gestures
- when the participant hesitates what to do
- when the participant prattles when she gets surprising/exciting/ annoying feedback
- when the participant makes a meaningful facial expression or gesture
- when the participant makes a meaningful facial expression or gesture
- when the participant makes a mistake
- when the participant gives the experiment up

User study protocol promises the quality of the experiment.

The whole procedure, including the scripts for experimenters, was documented in User Study Protocol. This way decreased the inconsistency in and between experimenters. Each participant received 15 euros as a reward, and signed one consent to promise their best performance during the 75 mins experiment. The installation of hardwares and experiment's procedures was rehearsed fives times in pilot studies, in oder that the cameras can capture optimal views and the wizard can achieve errors-free.

6.2.5 User Study Rational

Novice needs visible shortcuts to new menu techniques.

Why visible shortcuts? If this system is installed in a subway station, around 50% of the passer are frequent users,

Figure 6.5: a real situation during menu techniques evaluation study

who take subway there to work everyday and the other 50% are unfrequent users, who don't know how to interact with this large display well or meet it at the first time. Hand Gesture and Body Gesture can be regarded as shortcuts for frequent users. One use case is: one frequent user wants to know today's weather while passing by ICLD, but she was reading one email on her iphone screen. she can perform 'four fingers extended' gesture to select weather forecast from the large screen but still keep eyes on her small screen till she believes the weather situation has displayed yet. Thereby it seems that the gesture labels can be omitted. However, novice hardly becomes expert without learning cutting edge technologies. Menu techniques proposed in this thesis are quite original, thus, even frequent users need to learn how to select the menu with visible hints.

To maintain the old design style and functions

Why four items? The current design running on ICLD has four items and we want to maintain the general functions and style. Meanwhile the more items a menu bar has, the more times participants need to try for each technique in evaluation experiment, because bias should be avoided. The complex menu may cause participants' long experiment time, especially for Slapping, thereby arouses negative emotion and even affects the accuracy of the experiment.

Why concrete content? The current experiments on menu selection study widely apply abstract content to avoid users' bias. But in my experiment participants' bias does not affect their performance, since they need to execute their tasks under the commands each time. For instance "Please select news." "Please select advertisement."…. Not only testing concrete content makes more sense to guide our design of ICLD system in future, but also it influences directly the metaphorical mapping between items and body gestures for Body Gesture technique. In 5.2—"Study of Symbolic Gestures", body gesture patterns are exactly grounded in terms of the meaning of each item.

Concrete content does not cause bias, but makes sense for Body Gesture technique.

Why unified menu bar design? Though the unified interface design does provide different affordance to users due to different gesture approaches. For example users may expect a slider instead of the red frame to slap for Slapping technique. Design with lower affordance may influence user's learning curve. To compensate this drawback, participants learn how to operate every technique from videos and practice before really start the experiment. Moreover, the techniques we evaluate in this experiment focus on gestural approaches. Hence, one unified interface design is needed as baseline to compare different menu techniques. I set interface design as an independent variable and gestures as dependent variable.

Interface design is an independent variable.

Why AttrakDiff questionnaire? I apply AttrakDiff-2 questionnaire to measure the pragmatic quality and hedonic quality of each menu technique through users' perception. AttrakDiff-2 questionnaire, created by User

I use AttrakDiff questionnaire to access user's perception.

Interface GmbH , consists of 28 seven likert scale items. The two poles of each item are opposite adjective, such as menschlich-technisch (human-technical). The 28 items are divided into four groups, the average scale of which indicate pragmatic quality (PQ) , hedonic quality-identity (HQ-I) , hedonic quality-stimulation (HQ-S) and attractiveness (ATT) . The following are definitions of the four different product qualities:

PQ: Describes the usability of a product and indicates how successfully users are in achieving their goals using the product.

HQ-S: Indicates to what extent the product allows the user to identify with it.

HQ-I: Indicates to what extent the product allows the user to identify with it.

ATT: Describes a global value of the product based on the quality perception.

Figure 6.6 shows how I, as a designer, access users' perception and emotion by making use of AttrakDiff-2 questionnaire. The final goal is to discover and increase the pragmatic quality and hedonic quality of menu techniques, thereby to create better behavioral and emotional user experience. This logical relationship among human need, affect, and product quality was also presented in Hassenzahl et al. [2010]. They also used AttrakDiff-2 questionnaire to measure the product perception and evaluation for their own experiment. Though other quantitative data of traditional usability test, such as interaction distance, are also measured in this experiment, they hardly reveal the subjective satisfaction as well as AttrakDiff-2 questionnaire does. AttrakDiff is created by a German company which sets very precise german vocabularies for all the adjectives. This is particularly important, since most of our experiment participants are German. We also get positive feedbacks of AttrakDiff test result from the old projects done by T-Lab.

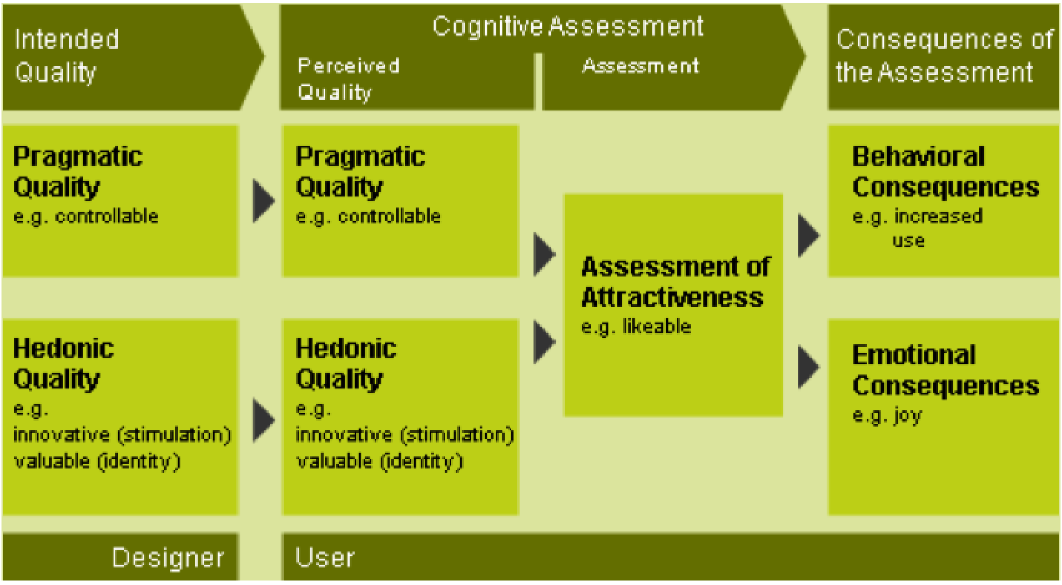


Figure 6.6: AttrakDiff model designed by User Interface GmbH

Why Nasa TLX questionnaire? Nasa Task Load Index questionnaire is a tool to access subjective workload. It is a multi-demisional rating procedure which can derive an overall workload from the average weight of six subscales. Considering the characteristics of menu selection and passing-by interaction context. This study only measures three of six subscales, physical demands, mental demands, and temporal demands. Hart and Staveland [1988] believe that Nasa TLX can be used to access workload of various human-computer interaction, including command and process control environments. Though to measure interaction time is a direct approach to measure workload, which is also widely used for usability test (efficiency). It does not fit this experiment. Because passing-by interaction happens in a very short while, the difference of interaction time among menu techniques is inconspicuous, like 0.01s. Comparing with objective time, subjective sense of workload, which reveals hedonic quality (6.2.5—"Why AttrakDiff questionnaire?") of the computer system is the research point of this study.

Nasa TLX can access subjective workload.

6.3 Result

6.3.1 Workload

Body Gesture causes most mental, physical, and temporal workload.

Mental workload. There is a significant main effect on mental workload for techniques (ANOVA, F5,75 = 17.97, $p \leq 0.0001$). A post-hoc Tukey's range test shows that Body Gesture (12.6) causes significantly more mental workload than others techniques. It also shows that touch (2.1) requires significantly less mental workload than hand-gesture (6.2), slapping (6.5) and body gestures (12.6).

Physical workload. There is also a significant main effect on physical workload for the techniques (ANOVA, F5,75 = 15.17, $p \leq 0.0001$). A post-hoc Tukey's range test shows that Body Gestures (13.2) require more physical workload than others techniques.

Temporal workload. Similarly, there is a significant main effect on temporal workload (ANOVA, F5,75 = 4.6, $p \leq 0.001$). A post-hoc Tukey's range test shows that Body Gestures (10.9) require more temporal workload than others techniques except slapping (7.8).

The diagram in Figure 6.7 presents the mental, physical and temporal workloads for each technique. Body Gesture causes highest workload in all the three aspects (mental: 12.5, physical: 13, temporal: 11) . In contrast, Touch (mental: 2, physical: 5.5, temporal: 6) causes lowest workload. Except Body Gesture, Slapping causes obvious higher temporal workload than other techniques.

6.3.2 Satisfaction

Statistical result of word pairs of AttrakDiff-2

Figure 6.8-Figure 6.13 present the statistical result of the word pairs, in which the particular interest are the extreme values (Table 6.2 shows the vocabularies in English). These diagrams reveal which specific characteristics are critical or well resolved for every technique.

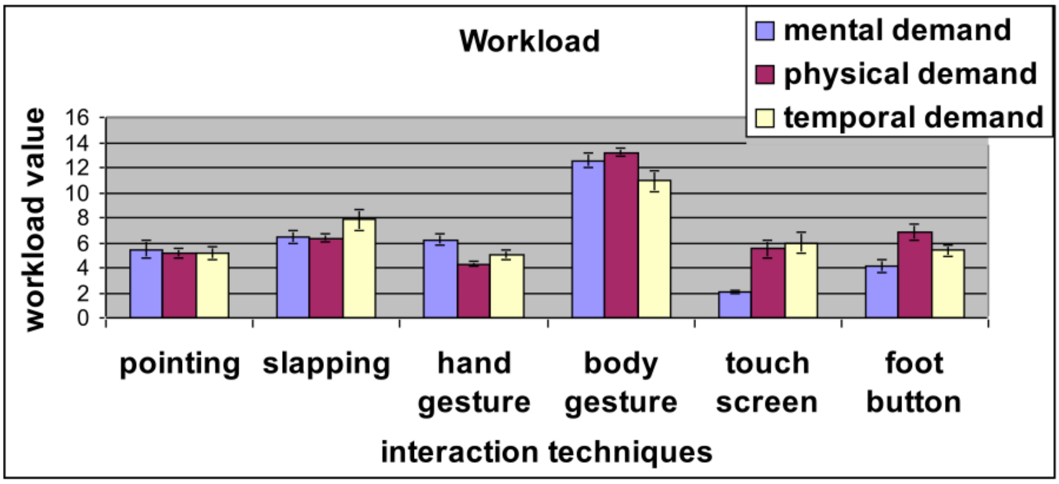


Figure 6.7: statistical result of mental, physical, temporal demand based on NASA TLX

Pointing (see Figure 6.8): 24 scales of 28 items are over four, that means experiment participants gave positive feedbacks in general to Pointing technique. The top positive characteristics were preferred are menschlich (human)-5.6, einfach (easy)-5.53, and praktisch (practical)-5.4/ angenehm (pleasant)-5.4. The worst qualities of Pointing are abstoßend (repelling)-3.4, trennt mich von Leuten (seperate me from people)-3.6, and laienhaflt (unprofessional)-3.6.

Slapping (see Figure 6.9): The statistical result is not desirable, because only 10 scales of 28 items indicate positive characters, and 8 of 10 are just over middle value. The top preferred are originell (original)-5.13, innovativ (innovative)-5.06, and Kreativ (creative)-4.63 / neuartig (novel)-4.63. The worst three qualities of Pointing are unständich (cumbersome)-3.31, technisch (technical)-3.63/ verwirrend (confusing)-3.63 /trennt mich von Leuten (separate me from people)-3.63 .

Hand Gesture (see Figure 6.10): The diagram presents a very promising result for Hand Gesture, since only the scale of one character, harmlos (undemanding)-3.87, is lower than middle value. But this is not in completely negative extreme, while considering about traditional concept of usability. The top preferred the characters are einfach (simple)-6, voraussagbar (predictable)-5.93 / übersichtlich (clearly structured)-5.93 / handhabbar (manageable).

Body Gesture (see Figure 6.11): This technique was not well rated in general, because 17 scales of 28 items are below four. Especially unständlich (cumbersome)-2.13, unpraktisch (impractical)-2.27 and kompliziert (complicated)-2.67 were the worst properties. However, though only 10 characters were selected as positive, 5 of them just got the scales over five. The top one is neuartig (novel)-5.67, followed by originell (inventive)-5.33, innovativ (innovative)-5.33 and herausfordernd (challenging)-5.33.

Foot Button (see Figure 6.12): This technique is overall well scaled. Only 4 scales of 28 items are lower than middle level and the most unsatisfied property is stillos (tacky)-3.47, followed by laienhaft (unprofessional)-3.67 and technisch (technical)-3.8. Contrastively it wan three 6 scales for einfach (simple)-6, voraussagbar (predictable)-6, and übersichtlich (clearly structured)-6.

Touch (see Figure 6.13): The characters of this technique are very discrete. 4 scales of 28 items are in the level of grade 6, which are übersichtlich (clearly structured)-6.23, einfach (simple)-6.2, voraussagbar (predictable)-6.2, and handhabbar (manageable)-6. At the same time Touch gets lowest scale of all characters for all techniques, konventionell (conventional)-2.8, followed by herkömmlich (ordinary)-3.2 and harmlos (undemanding)-3.4.

Figure 6.14 presents the pragmatic quality, hedonic quality-identity, hedonic quality-stimulation, and attractiveness of the six interaction techniques. In the diagram Pointing, Hand Gesture, and Foot Button locate above average region for all qualities, that means they meet the ordinary standards. Especially Hand Gesture has an optimal statistical result in terms of best PQ, HQ-I, ATT and second higher HQ-S. Touch and Body Gesture have are in very opposite situations. Touch has high PQ, HQ-I, ATT and lowest HQ-S, but Body Gesture has very low PQ, HQ-I ATT and highest HQ-S. Anyway Body Gesture and Slapping do not meet the ordinary standards, because three qualities of them locate below the average region.

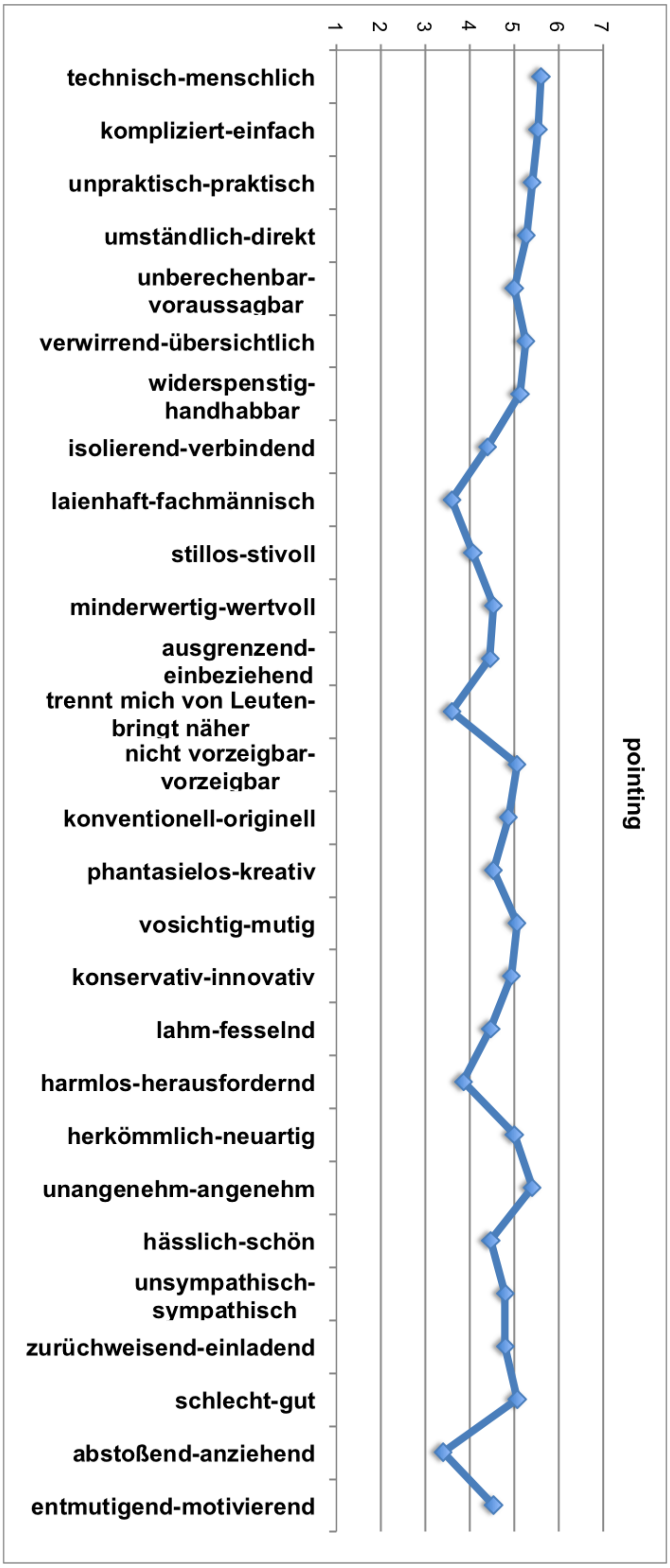


Figure 6.8: AttrakDiff-2 statistical result of words paired for Pointing

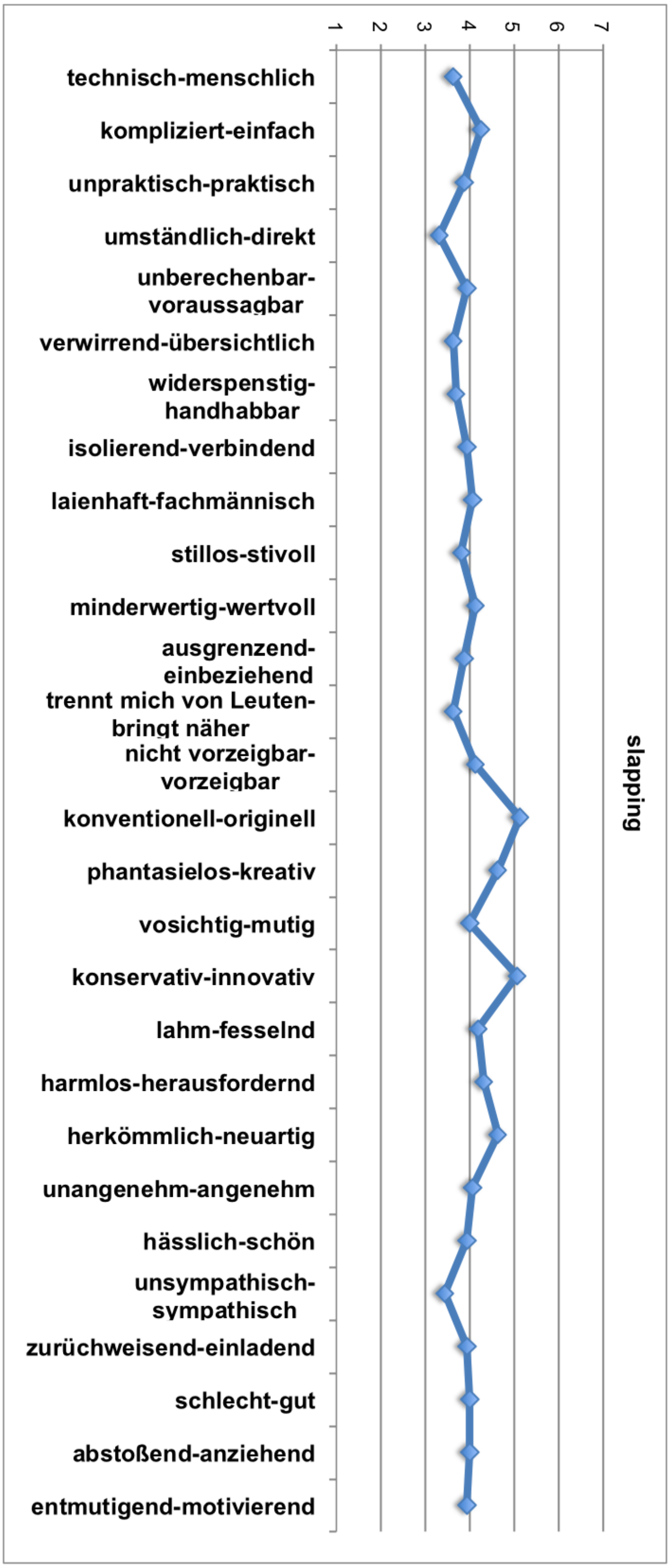


Figure 6.9: AttrakDiff-2 statistical result of words paired for Slapping

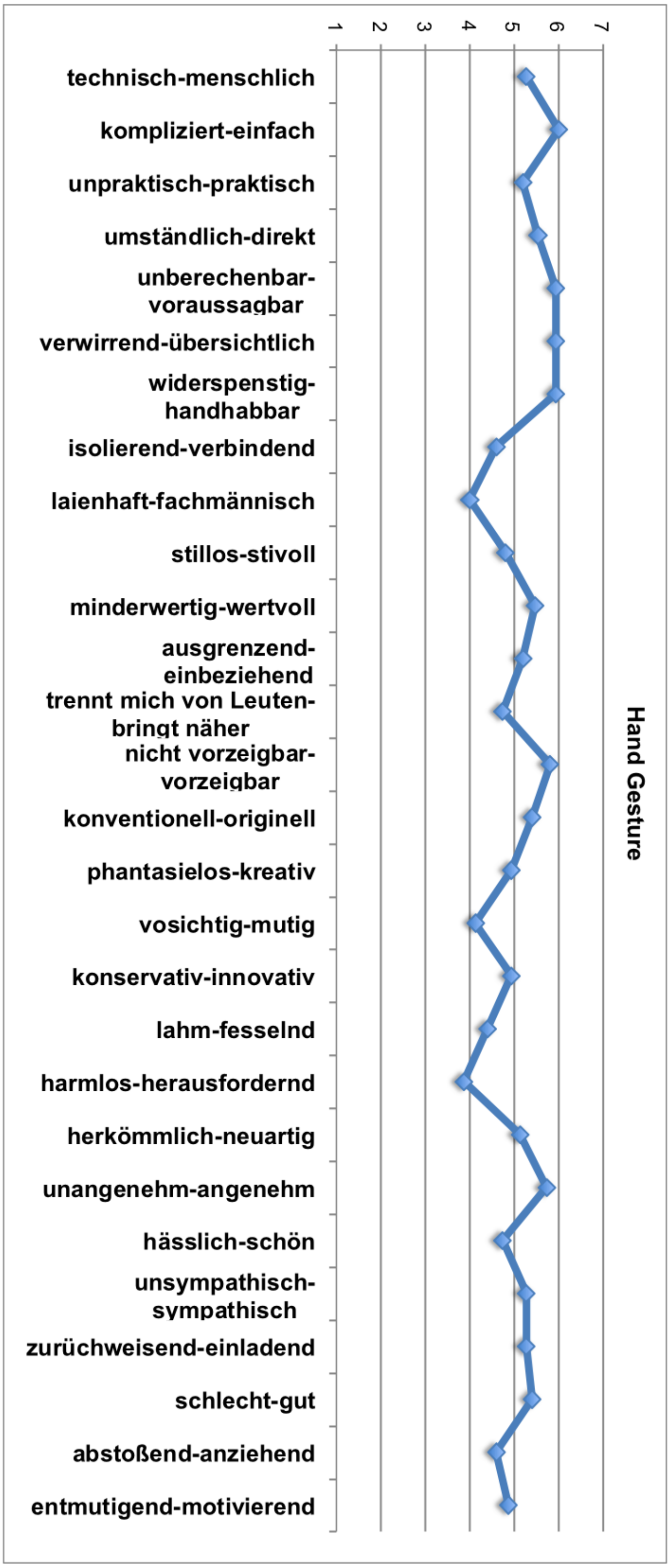


Figure 6.10: AttrakDiff-2 statistical result of words paired for Hand Gesture

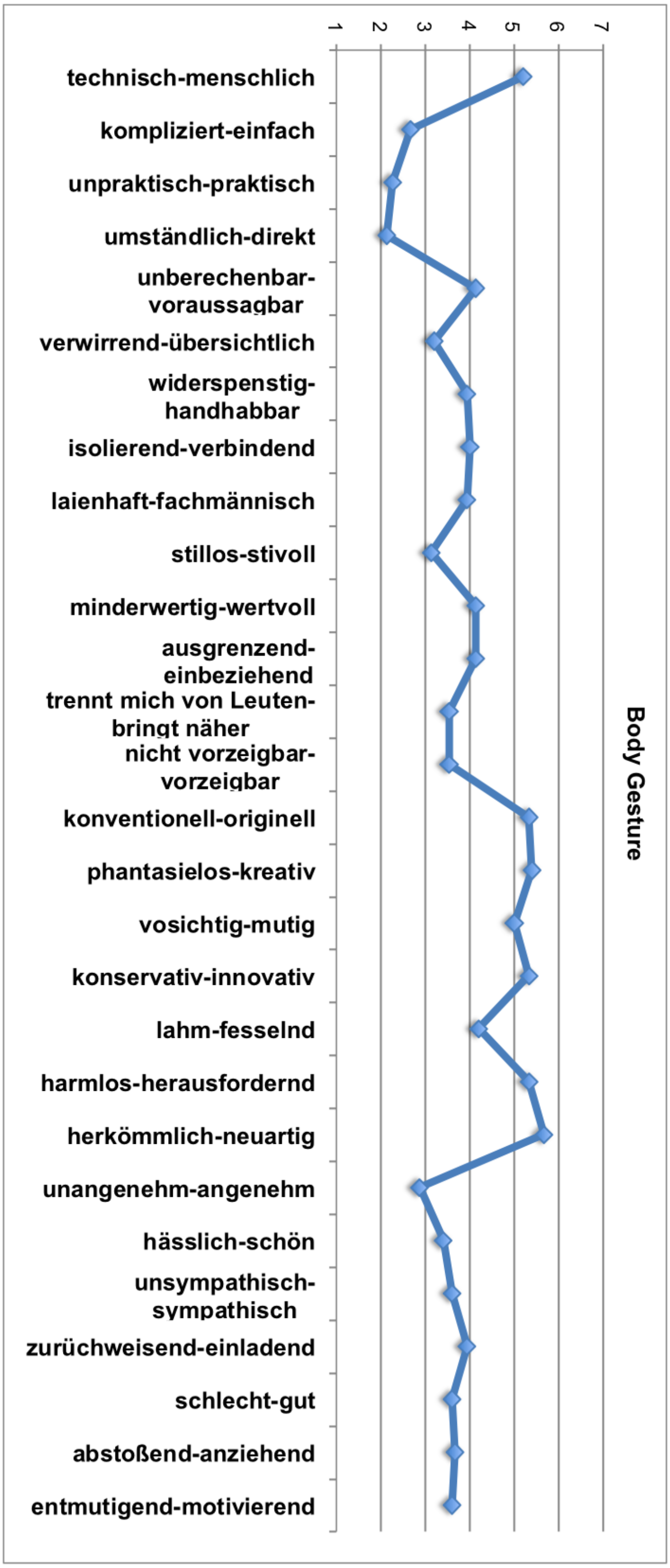


Figure 6.11: AttrakDiff-2 statistical result of words paired for Body Gesture

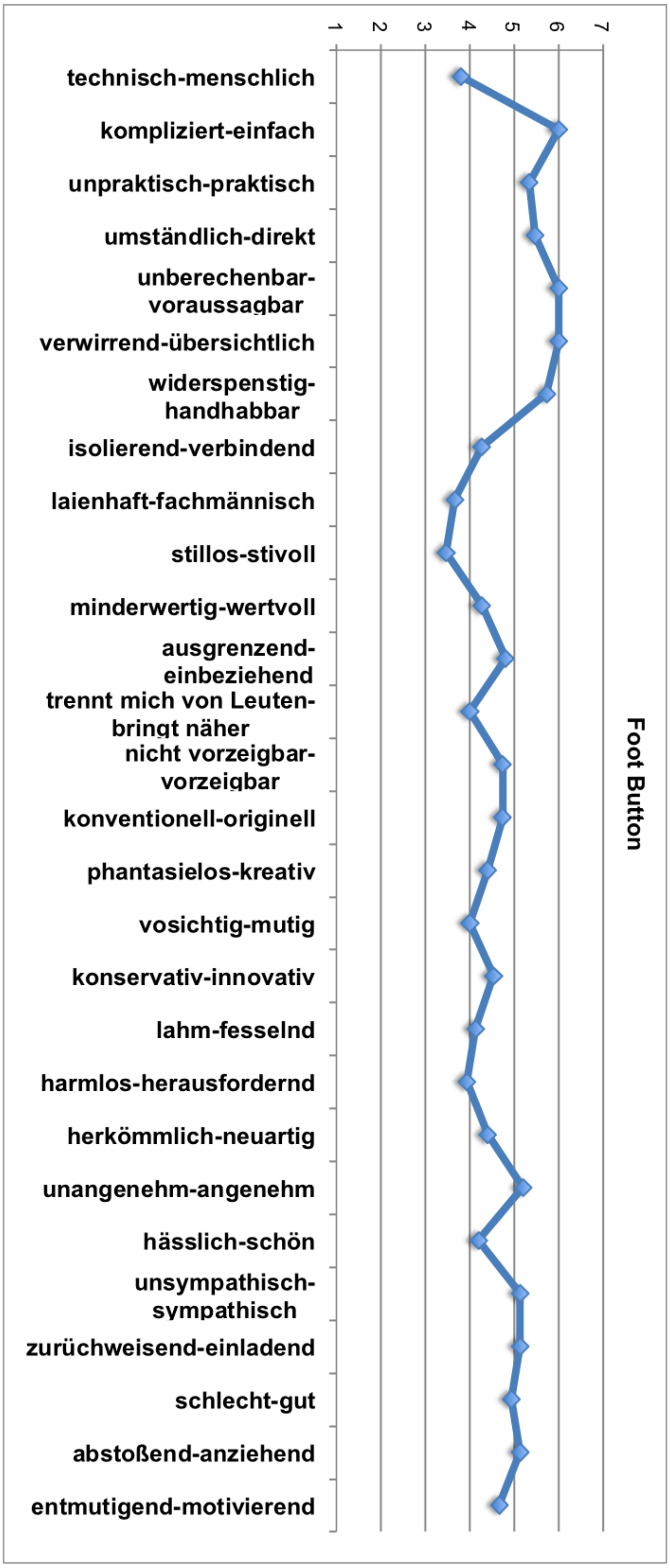


Figure 6.12: AttrakDiff-2 statistical result of words paired for Foot Button

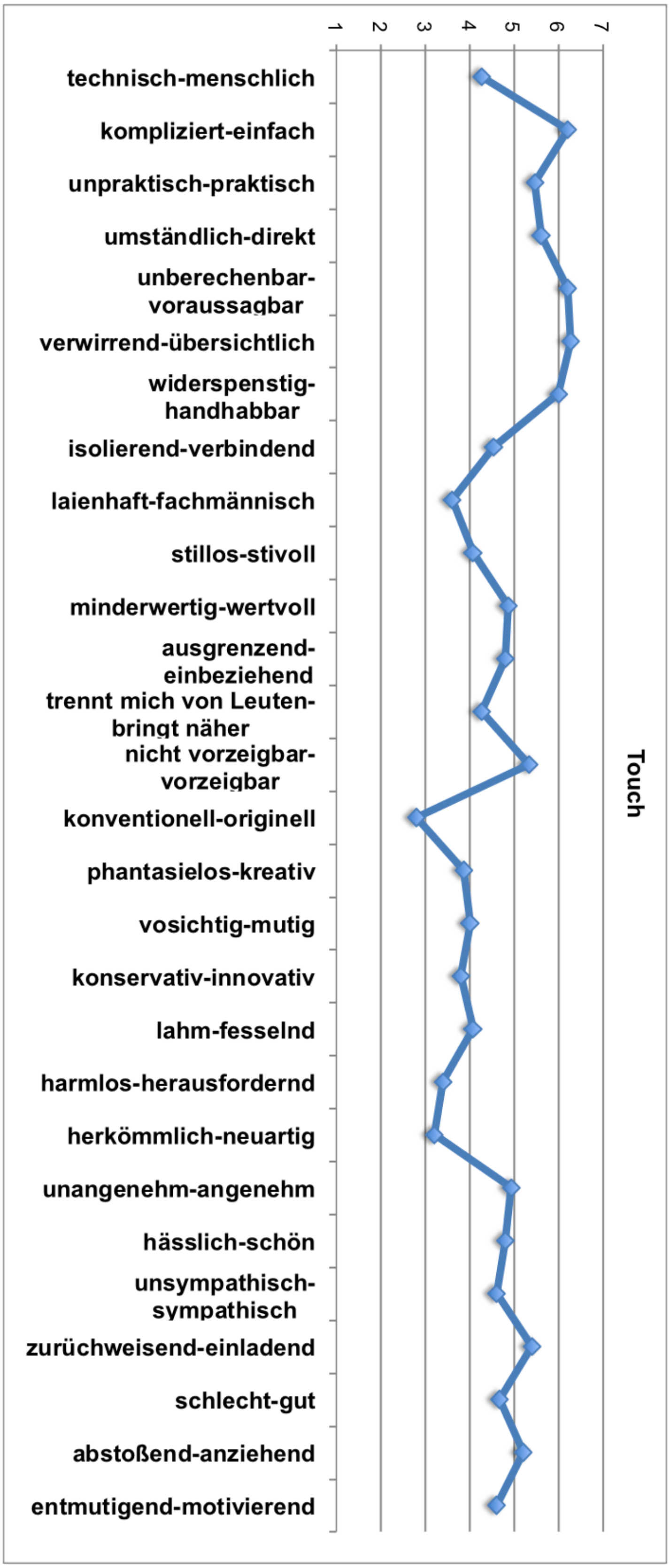


Figure 6.13: AttrakDiff-2 statistical result of words paired for Touch

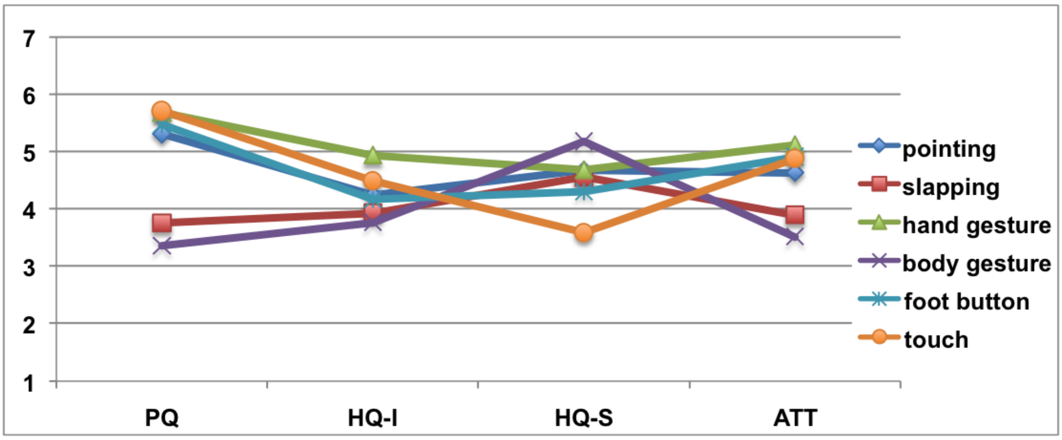


Figure 6.14: AttrakDiff-2 statistical result of pragmatic quality, hedonic quality and attractiveness for six techniques

6.3.3 Walking vs. Stopping

Participants perform Pointing and Hand Gesture while walking

ANOVA reveals a significant main effect on user behavior for the techniques (ANOVA, $F_{5,75} = 39.47$, $p \leq 0.0001$). A posthoc Tukey's range test shows that users significantly walked more with Hand Gesture (81.0%) and Pointing (76.4%) than Body Gesture (47.5%). Finally, users performed 66.7% selections with slapping technique by walking. For Foot Button and touch, in all cases participants stopped to complete the menu selection.

6.3.4 Interaction Distance

The average interaction distance is 3.7-3.8 m.

Figure 6.15 shows the statistical result of interaction distance in 3 blocks (12 trails). Touch (0m) and Foot Button techniques (2m) obviously force the user to interact at a specific distance. For other techniques, selection was done at about 3.7-3.8 m distance from the display, without apparent differences between the techniques. However, participants started with selection relatively close to the display (about 3.4 m) and they selected from a distance about 3.9 m (start distance was 5 m) after 9 trials. In the subsequent interview, one participant stated "At the beginning I don't know whether the cameras know which direction I point, so I stand close to it."

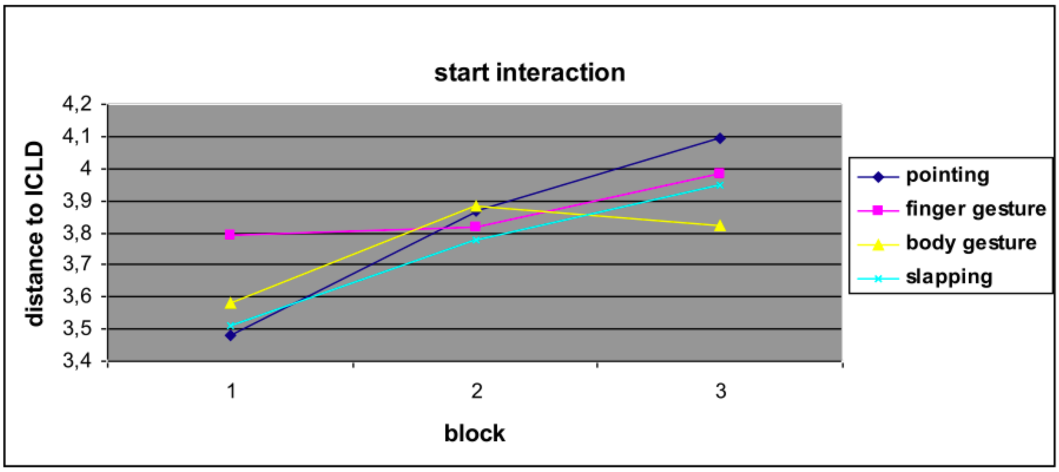


Figure 6.15: statistical result of interaction distance in 12 trails and 3 blocks

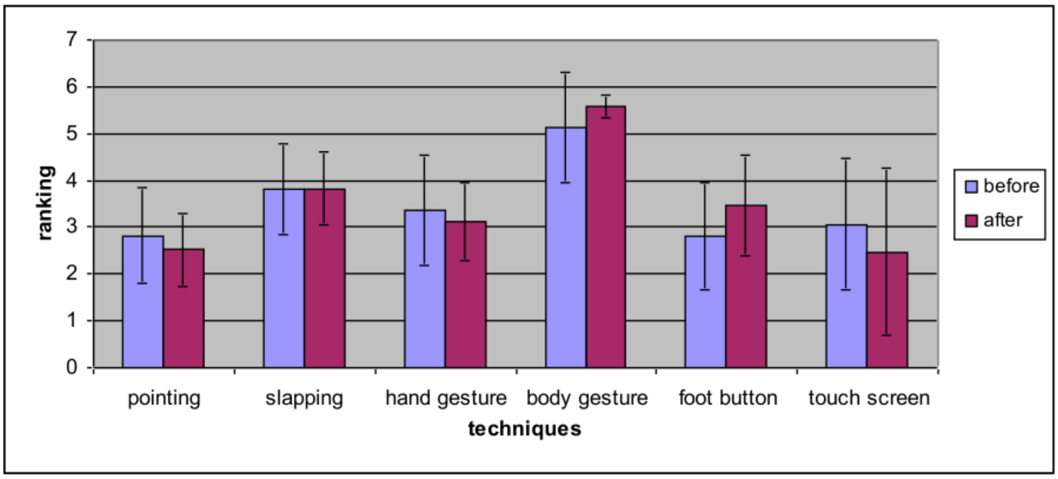


Figure 6.16: in-subject ranking before and after watching a social context video

6.3.5 Preferences with and without Social Effect

Foot Button was ranked differently with and without considering social effect.

Before watching a video showing a real passing-by scenario in Berlin subway station (no social effect), Pointing and Foot Button were preferred by participants, followed by Touch, Hand Gesture, Slapping and finally Body Gesture. After the video (social effect), Touch was preferred, but Foot Button was decreased to the fourth preferred position (see Table 6.3, Figure 6.16).

technisch (technical)–menschlich (human)
kompliziert (complicated)–einfach (simple)
unpraktisch (impractical)–praktisch (practical)
unständlich (cumbersome)–direkt (straightforward)
uberechenbar (unpredictable)–voraussagbar (predictable)
verwirrend (confusing)–übersichtlich (clearly structured)
widerspenstig (unruly)–handhabbar (manageable)
isolierend (isolating)–verbindend (connective)
laienhaft (unprofessional)–fachmännisch (professional)
stillos (tacky)–stivoll (stylish)
minderwertig (cheap)–wertvoll (premium)
ausgrezend (alienating)–einbeziehend (integrating)
trennt mich von Leuten (separate me from people)–bringt näher (bring me close to people)
nicht vorzeigbar (unpresentable)–vorzeigbar (presentable)
konventionell (conventional)–originell (inventive)
phantasielos (unimaginative)–kreativ (creative)
vosichtig (cautious)–mutig (bold)
konservativ (conservative)–innovativ (innovative)
lahm (dull)–fesselnd (captivating)
harmlos (undemanding)–herausfordernd (challenging)
herkömmlich (ordinary)–neuartig (novel)
unangenehm (unpleasant)–angenehm (pleasant)
hässlich (ugly)–schön (attractive)
unsympathisch (disagreeable)–sympathisch (likable)
zurüchweisend (rejecting)–einladend (inviting)
schlecht (bad)–gut (good)
abstoßend (repelling)–anziehend (appealing)
entmutigend (discouraging)–motivierend (motivating)

Table 6.2: english translation of vocabularies in AttrakDiff questionnaire

	no social effect	social effect
Pointing	1st	2nd
Slapping	5th	5th
Finger Gesture	4th	3rd
Body Gesture	6th	6th
Foot Button	1st	4th
Touch Screen	3rd	1st

Table 6.3: ranking with and without social effect

6.4 Discussion

6.4.1 Touch

Touch is not suitable for passing-by interaction, because it causes extra work.

Touch technique sets the baseline. From a mental workload perspective, this was the easiest technique. However, 10 out of 17 participants expressed in the interviews that it caused extra work: It forced users to make a detour, moreover, users had to "press the button and moved backward, lifted their head to read the screen." 5 out of 17 participants also mentioned that they would not like to touch the screens in the public places, due to the hygen reasons. Despite these drawbacks, in preference Touch was rated thirdly, before watching the video of social context and rated firstly after watching the video of social context. The statistical result of AttrakDiff explains the reason that participants believe Touch is clearly structured and predictable. Users' certain preference comes from their familiarity with touch screens in daily life. This factor is revealed from AttrakDiff questionnaire that participants rated Touch as a conventional, ordinary and undemanding technique. Actually Touch demands a lot of physical workload, but users are hardly aware of that. As in all cases participants stopped before touching, it is clearly not suitable for passing-by interaction.

6.4.2 Pointing

Pointing is suitable for interaction while walking, but the gesture itself causes social issues.

Pointing technique was preferred by the users, and this technique was operated without stopping in 76.4% of the cases. However, due to the wizard-of-oz setup, the recognition of pointing was almost perfect. In real scenarios, however, it can be difficult to accurately recognize the target item from the pointing direction, especially when the user is standing or walking relatively far from the display. After watching the video of social context, pointing is not scored as first priority, because some people dislike the social meaning of finger pointing. One participant said,' I don't want to point with my finger, it seems I am pointing somebody.' This problem is also addressed by the result of AttrakDiff questionnaire, because participants rated that Pointing technique "separate me from people". It seems that this gesture is similar to 'mouse over' for desktop interfaces and 'finger press' for touch screens. However, the public environment make it fail to directly transfer them from traditional to distant interfaces.

6.4.3 Slapping

Slapping can't provide a direct access to the target item.

From our observations, this technique is too slow for passing-by interaction. Because users walk when starting to slap, they often stop at 2.0-1.5m from ICLD to finish the interaction. This is due to the fact this technique do not provide a direct access to items: multiple slaps can be necessary to reach to desired target. Though this design has been popular for long time on iTouch/ iPhone, some participants still hesitated in which direction to slap on the way from the settled position to target position during the experiment. They addressed this problem also through AttrakDiff by rating 3.63 to verwirrend (confusing)- übersichtlich (clearly structured). Moreover, a more detailed analysis from camera records reveals that participants use both hands. They mainly slap in the right direction with left hand and the left direction with right hand.

6.4.4 Hand Gesture

Hand Gesture is promising for passing-by interaction, especially efficient for expert users.

Hand Gesture technique seems to be promising for passing by interaction. Users performed these gestures while walking 81.0% of the time, which supports the use for frequent users. In the scenario described in 6.2.5—"Why visible shortcuts?", the frequent user can perform Hand Gesture at a position relative far from ICLD, and continue walking till she reaches the good point of view, when exactly the new items show up. This technique makes experts' interaction very efficient. Moreover, it seems that during the first trials, the finger gestures were conducted at the longest distance. This technique was not ranked particularly high in user preference due to confusion over finger icons, not the gesturing itself. The subsequent interview revealed that this kind of finger-counting gestures are easy to remember for all participants. Furthermore, 'simple' was rated as the best positive quality of all for Hand Gesture due to the result of AttrakDiff, and 'predictable' / 'managable' 'clearly structured' were also rated well. Hence, Hand Gesture not only can provide the direct access to target item, but also a sophisticating mapping between human's mental model and the menu interface. Finally, expert users can use this technique eyes-free, as they do not need to look at the screen to select a known command. For instance, they can maintain their attention on their smart phone during the interaction.

6.4.5 Body Gesture

Body Gesture is suitable due to high workload and social unacceptability.

Body Gesture technique was not very well performed in this experiment. This is very interesting, because a large number of commercially applied gestures (for example on Microsoft Kinect) are body gestures. The approach of simply transferring those Kinect gestures to public displays may not be very successful. Because those body gestures have a significantly higher mental, physical and temporal workload than other gestures. Users perform such gestures less often while walking than with other techniques (only 47.5% of the times). Furthermore, users thought Body Gesture are cumbersome, impractical and complicated regarding to the result of AttrakDiff. The interesting thing is that this technique brings direct access to items on the menu as well as Hand Gesture, but users gave totally different feedbacks. The probable reason is that the four static body poses confuse users and cause too much workload. Nevertheless Body Gesture is not devoid of merit, since many experiment participants give very good grades for its innovation and challenge. This technique has a potential to be developed, and concrete gestures should be definitely redesigned. Finally, this technique was scored worst of all in user preference, since participants find this kind of gestures socially less acceptable for public situations. One participant said " Kids may like it, I definitely won't make the strange poses in the subway station".

6.4.6 Foot Button

Foot Button is clearly structured but causes high physical workload.

Foot Button Technique. During the interview participants expressed this technique was simple, such as one answered, "it is very clear, which button to press (step on)". This point was also reflected from the result of AttrakDiff, since participants give very good grades to 'simple', 'predictable' and 'clearly structured'. However, participants also mentioned that they need to stop at the buttons, looked down the ground, stepped on one button, then look up ICLD. That is why they rated this technique a high physical workload in Nasa TXL quesitonnaiare. Moreover, the ranking of foot button decreases after participants consider the environment factors in public. One subject said, " it blocks my way.", another subject said, " it must be problematic for wheel chairs." Participants also rated Foot Button as a tacky / unprofessional technique, that reminds me not only consider the interaction technique itself, but also how to decorate it in public environment properly and how to embed ICLD into urban life.

Chapter 7

Conclusion

Menu techniques for passing-by public displays come from four groups of causal studies

This thesis presents a design research work, which comprises four groups of user studies:

Context

Studies in group one are carried out in public places, such as in Berlin Tegel airport and aim for understanding passengers' need and behaviors in public. From the study result, I abstract several typical interaction scenarios between passersby and public displays. Furthermore I propose the characteristics of Passing-by Interaction in Public, generalize interaction model, and point out requirements of this concept.

Concept

The first study in group two tries to brainstorm the whole interaction concept of this project with the goal of drawing passersby' attention. Though this study does not bring a certain result, it drives a new concept, menu, which also exactly addresses one requirement of passing-by interaction. The second study mainly brainstorms interaction approaches of selecting a menu and corresponding menu interfaces. The result shows five kinds of interface design, including 2D and 3D menu, and fifteen menu techniques. While considering about the complexity of the short passing-by interaction, the project team decide to focus on the 2D menu with four items.

Interaction design

Group three also comprises two studies on solving concrete problems of menu interface and look for gestural patterns. In the first user/expert participatory design study, novice participants explaining their behaviors while operating the paper interface. Except that, the expert participants also indicate design suggestions. Base on the result, I propose a linear menu on the bottom of the screen and projected buttons on the floor for foot interaction. The second user participatory study collects a variety of static hand gestures and symbolic body gestures, thereby grounds general gesture patterns used for menu techniques. After complete these three groups of studies, I develop a gesture taxonomy and design five innovative menu techniques:

1. Pointing: The user points towards the item with left or right hand "in air".
2. Slapping: The user slaps his hand horizontally to select a target in the direction of hand movement.
3. Hand Gesture: The user performs a static finger-counting gesture. The number of fingers to show is equal to the position of the item on the screen, and also indicated by an icon next to the item.
4. Body Gesture: The user poses his body to select the target item. Postures are related to the content of item and indicated next to the item.
5. Foot Button: The user steps on a physical button placed on the floor 2m from the display to select the corresponding item.

Evaluation shows Hand Gesture and Pointing are promising for passing-by interaction.

In the last group of study, I compare the five menu techniques with Touch technique and evaluate them with a wizard of Oz experiment. In this experiment 17 participants with various backgrounds simulate passing-by situation and select menus with six techniques one by one. For this evaluation, I measure: mental, temporal, and physical workload (Nasa TLX questionnaire) techniques cause; pragmatic quality, hedonic quality, and user's satisfaction (Nasa questionnaire) of six menu techniques; stopping or walking while perform techniques; distance to the display when start to interact; social effect on user's preference. The experiment result demonstrates that Body Gesture is significantly different from other techniques, because it causes most workload, forces users to stop for interacting, is badly rated in satisfaction test, and is not preferred before and after watching the social context video. Hand Gesture(1st) and Pointing (2rd) seem to be suitable for passing-by interaction, since most of participants can select the menu while walking with these two techniques. Slapping is too slow and Foot Button causes high physical workload. Though Touch is preferred in the context of 'in public', participants also point out several problems which match my observation in subway station and research hypothesis.

7.1 Design Recommendation

It is hard to transfer whole body interaction from PC games to public displays.

This thesis, a design research work, conducts a series of causal studies: context 3—"Context Study" → concept 4—"Concept Study" → interaction design 5—"Menu Interface and Gestures Study" → interaction technique evaluation 6—"Menu Techniques Evaluation". As the final output of this work, the design recommendation is that Hand Gesture is a promising menu technique for passing-by public displays, since due to the result of evaluation it can be performed while walking, and have acceptable mental, physical, temporal workload and social meaning. Moreover, because of the high workload and social issue, it hardly transfers currently popular whole body interaction from the personal computer game to the passing-by interaction in public.

7.2 Future Work

Further developing of gestures used for Hand Gesture and Pointing.

In the future, it is planed to further develop Hand Gesture and Pointing in the following aspects:

Finger-counting applied to Hand Gesture is a general approach. But how to extend fingers drives some questions. One example is that users should extend thumb or index finger to select the first item. Another example is that users should keep palm, back of the hand or fingertips facing to camera when they perform hand gestures.

For Pointing, it is need to investigate another hand pose, rather than simply pointing with index finger, which has been thought as an impolite manner in public by experiment participants. We also wonder whether an isolating gesture to confirm a selection is in need. If so, how to combine the pointing gesture and ending gesture will be a new research question. If not, whether to keep pointing for a while to activate an item is a promising solution.

In addition to gestures themselves, it is planed to extend the linear interface to a 4 multiple 4 hierarchical menu, and try the same interaction techniques on marking menu (see Bailly et al. [2011]).

Moreover, it is planed to further explore the social effect of Hand Gesture and Pointing. Hence the well implemented ICLD system will be tested in a real public context. How difference between concrete environments affects passing-by interaction in public will be put on the table.

Appendix A

Questionnaire

A.1 Questionnaires for the User Study at Tegel Airport

QUESTIONNAIRE
PASSING-BY INTERACTION IN PUBLIC

1) Participant

Gender	male	female			
Age	15-25	26-35	36-45	46-55	over 55
Industry	engineering	art	finance	sport	medical care
	media	law practice	policy	service	other:
Travel reason	private	business			
Travel frequency	weekly	monthly	seasonally	yearly	
German level	native	communicable	only understand simple words	not at all	
Education	Professional School	Bachelor	Master	Doctor	

2) About airport

	strongly agree	agree	neutral	disagree	strongly disagree
You are familiar with this terminal (1)					
You are in a hurry at airport today (2)					
You fly in company today (3)					
You mind that people around you talk very loud or children cry (4)					
You have a look at the displays at TXL (5)					
You like shopping at duty-free shops (6)					

Figure A.1: questionnaire for the user study at TXL-1

3)About digital devices

	strongly agree	agree	neutral	disagree	strongly disagree
You use digital gadgets at airport, cell phone, mp3, portable play station... (7)					
You think this airport is modern, automatic and intelligent (8)					
You use the public resource provided by airport, eg: phone, internet... (9)					

4) Open questions:

(1) How many times have you departed from TXL? How much information of your trip did you prepare before and after arriving in TXL, what is the information?

(2) How long time have you already been at TXL today, and how long time in this area? What have you done so far?

(3)If yes, what did you/ or are you going to do with them, your friends, colleagues, family.....?

If no, what would you like to do while waiting? Please tell me your preference during a long time wait and a short time wait?

(4) If yes, why? How do your feel it?

Figure A.2: questionnaire for the user study at TXL-2

If no, do you mind attracting other's attention in public, such as moving your body or dancing here? How do you think it ?

(5) If yes, which kind of programs do you like to watch, why?

If no, why? How do you feel the TV or just the digital screens at TXL?

(6) Do you want to know more information of the shops here, which kind of information are you interested in?

- If you have some questions at airport, (such as get lost, forget the flight number), how do you solve the problems?

- What is your impression of TXL?

Good points:

Bad points:

Your advices:

Do you think there are landmarks at TXL? Do we need any landmark here, and how does it look like in your mind?

(7) What are your digital gadgets ? How do you use them?

(8) If yes, please show me some examples? Do you like them?

If no, do you like the current airport or you think it needs to become more automatic and intelligent?

Figure A.3: questionnaire for the user study at TXL-3

(9) If yes, do you like them? Could you please describe me your experience when you use them last time?

If no, why not? Please tell me the points you dislike

- Do you like playing computer games? Which kind of games do you like to play?

- Can you hear the broadcast at airport clearly, do you care what they are saying?

- Do you understand what the man in the picture is doing? Please sketch out the story in your mind?

To Layman:

- Do you know what is Xbox 360 Natal, have you watched the video?
  If so, do you also want to play it at airport?

- Do you know what is augmented reality? If so, tell me what is your understanding?

Figure A.4: questionnaire for the user study at TXL-4

A.2 AttrakDiff-2 Questionnaire

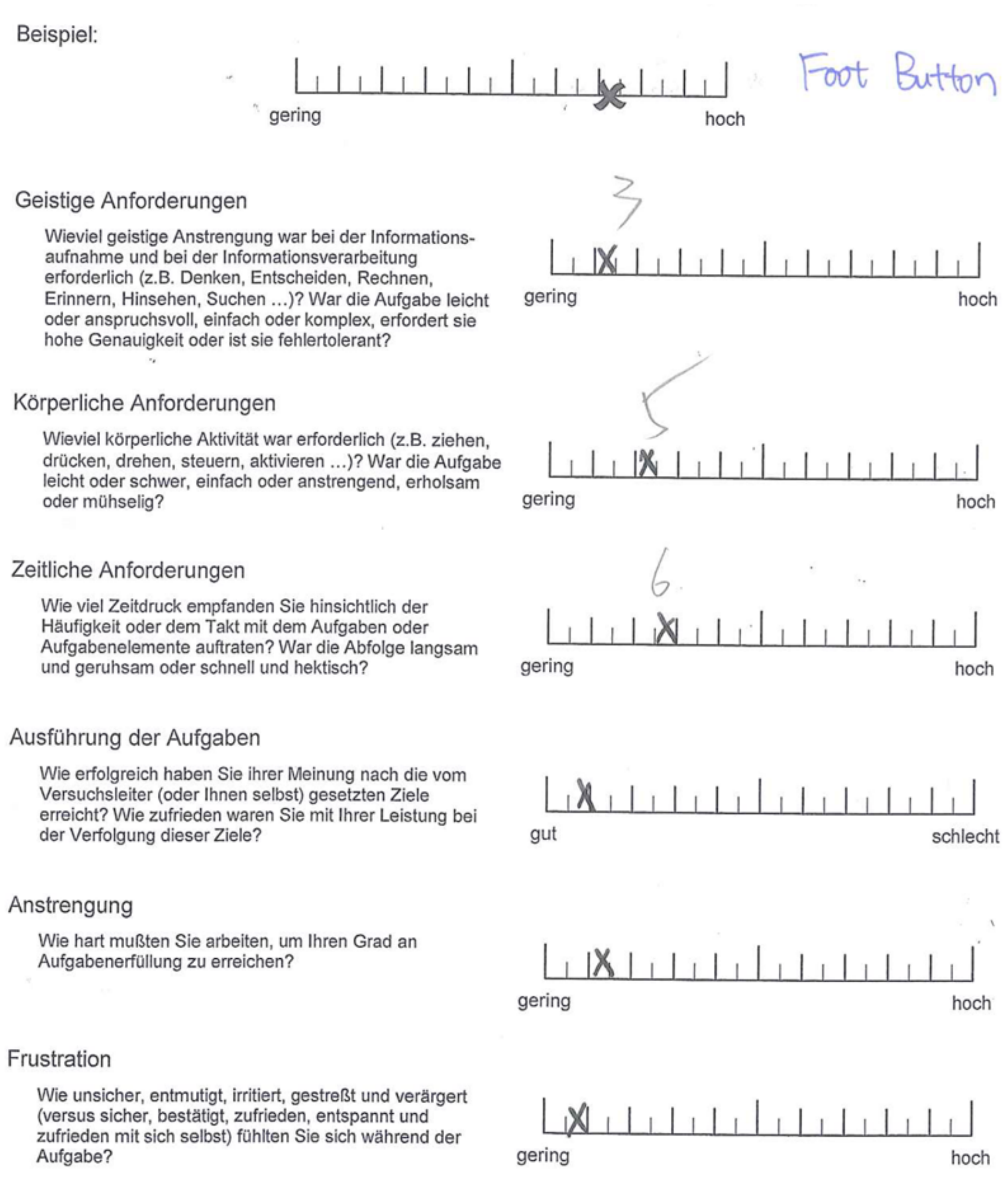
Foot Button

Beispiel:

fachmännisch	O	O	O	X	O	O	O	laienhaft

menschlich	O	X	O	O	O	O	O	technisch
isolierend	O	O	O	O	X	O	O	verbindend
angenehm	O	X	O	O	O	O	O	unangenehm
originell	O	O	X	O	O	O	O	konventionell
einfach	O	X	O	O	O	O	O	kompliziert
fachmännisch	O	O	O	O	O	X	O	laienhaft
hässlich	O	O	O	O	X	O	O	schön
praktisch	O	X	O	O	O	O	O	unpraktisch
sympathisch	O	O	X	O	O	O	O	unsympathisch
umständlich	O	O	O	O	O	X	O	direkt
stilvoll	O	O	X	O	O	O	O	stillos
voraussagbar	X	O	O	O	O	O	O	unberechenbar
minderwertig	O	O	O	O	X	O	O	wertvoll
ausgrenzend	O	O	O	O	X	O	O	einbeziehend
bringt mich den Leuten näher	O	O	X	O	O	O	O	trennt mich von Leuten
nicht vorzeigbar	O	X	O	O	O	O	O	vorzeigbar
zurückweisend	O	O	O	O	O	X	O	einladend
phantasielos	O	O	O	O	X	O	O	kreativ
gut	O	X	O	O	O	O	O	schlecht
verwirrend	O	O	O	O	O	O	X	übersichtlich
abstoßend	O	O	O	O	O	X	O	anziehend
mutig	O	O	O	O	X	O	O	vorsichtig
innovativ	O	O	O	X	O	O	O	konservativ
lahm	O	O	O	O	X	O	O	fesselnd
harmlos	O	O	O	O	X	O	O	herausfordernd
motivierend	O	O	X	O	O	O	O	entmutigend
neuartig	O	O	X	O	O	O	O	herkömmlich
widerspenstig	O	O	O	O	O	O	X	handhabbar

Figure A.5: AttrakDiff questionnaire



Beispiel:

gering hoch

Foot Button

Geistige Anforderungen

Wieviel geistige Anstrengung war bei der Informationsaufnahme und bei der Informationsverarbeitung erforderlich (z.B. Denken, Entscheiden, Rechnen, Erinnern, Hinsehen, Suchen ...)? War die Aufgabe leicht oder anspruchsvoll, einfach oder komplex, erfordert sie hohe Genauigkeit oder ist sie fehlertolerant?

3

gering hoch

Körperliche Anforderungen

Wieviel körperliche Aktivität war erforderlich (z.B. ziehen, drücken, drehen, steuern, aktivieren ...)? War die Aufgabe leicht oder schwer, einfach oder anstrengend, erholsam oder mühselig?

5

gering hoch

Zeitliche Anforderungen

Wie viel Zeitdruck empfanden Sie hinsichtlich der Häufigkeit oder dem Takt mit dem Aufgaben oder Aufgabenelemente auftraten? War die Abfolge langsam und geruhsam oder schnell und hektisch?

6

gering hoch

Ausführung der Aufgaben

Wie erfolgreich haben Sie ihrer Meinung nach die vom Versuchsleiter (oder Ihnen selbst) gesetzten Ziele erreicht? Wie zufrieden waren Sie mit Ihrer Leistung bei der Verfolgung dieser Ziele?

gut schlecht

Anstrengung

Wie hart mußten Sie arbeiten, um Ihren Grad an Aufgabenerfüllung zu erreichen?

gering hoch

Frustration

Wie unsicher, entmutigt, irritiert, gestreßt und verärgert (versus sicher, bestätigt, zufrieden, entspannt und zufrieden mit sich selbst) fühlten Sie sich während der Aufgabe?

gering hoch

Figure A.6: Nasa TLX questionnaire

A.3 Nasa TLX Questionnaire

Appendix B

Document Used for User Study 4

B.1 Experiment Introduction

B.1.1 in English

Table B.1

session	task
1. tutorial	In this session, you watch a tutorial video, comprising six interaction techniques, to learn how to interact with the big display. The techniques are Pointing, Slapping, Hand Gesture, Body Gesture, Foot Button and Touch.
2. practice	In this session, you have to select items with different techniques. By using each technique you need to pass by the big display 16 times, and select the item each time according to the stimuli given by the experimenter.
3. questionnaires	In this session, you fill in 6 times Attrak Diff and Nasa questionnaires in terms of your experience while using six techniques. You are asked to rank the six techniques twice, before and after watching another video captured in a subway station.
3. discussion	In this session, you are asked the experience during the practice session. The conversation will be recorded.

Table B.1: introduction of the experiment in English

B.1.2 auf Deutsch

Table B.2

session	task
1. Einführung	In diesem Teil werden Sie ein Video sehen, in welchem sechs Interaktionstechniken vorgeführt werden: Pointing, Slapping, Body Gesture, Hand Gesture, Foot Button und Touch. Anhand des Videos können Sie sich mit den sechs unterschiedlichen Techniken vertraut machen.
2. Praxis	In diesem Teil geht es darum Menüpunkte auf auf dem großen Display auswählen. Hierfür werden Sie sich immer wieder auf das Display zu und von dem Display weg bewegen und dabei alle Techniken ausprobieren. Mit jeder Technik werden Sie 16 Mal Display bedienen. Der Versuchsleiter sagt vor jedem Durchgang an, welchen Menüpunkt Sie wählen sollen.
3. Fragebögen	In diesem Teil werden Sie verschiedene Fragebögen ausfüllen und die Techniken nach Ihren Präferenzen beurteilen.
4.Diskussion	Am Ende werden wir Ihnen noch einige offene Fragen zu Ihrer Meinung über die Techniken stellen. Dieses Interview wird mit Ihrer Einverständnis aufgezeichnet.

Table B.2: introduction of the experiment in German

Appendix C

Digital Content

An attached DVD-Rom contains all documents of four user studies presented in this thesis and the source code of the interface prototype.

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