Designing Interaction with Media Façades: A Case Study

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Figure 1. Light emitting media façades embedded into contemporary architecture that may display interactive content (from left): Dexia Tower, Brussels, Belgium (Photograph by Eddie Janssens), Kunsthaus, Graz, Austria (Photograph by Nicolas Lackner) and the ARS Electronica Center in Linz, Austria (Photograph by Nicolas Ferrando & Lois Lammerhuber).

ABSTRACT
Media façades are one prominent example of how new technologies currently augment urban spaces. At the same time, they offer new, ubiquitous opportunities for novel applications. To achieve a usable and enjoyable outcome, however, designing interaction with media façades demands a structured design process. In this paper, we present our experiences designing *iRiS*, a system for remote interaction with media façades. We approached the development following a user-centered design approach and addressing the process at two points with additional means: (1) using a purpose-built prototyping toolkit testing and exploring both, content and hardware before deploying the system on the actual façade and (2) experimental use and adaptation of *user experience* (UX) evaluation methods to investigate the users actions and emotions more holistically in this context.

Author Keywords
Media Façades, Interactive Lighting Design, Interaction Design.

ACM Classification Keywords H 5.2. Information interfaces and presentation.

General Terms
Design.

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INTRODUCTION
Urban public spaces are emerging prime locations for systems embedded in a city's landscape, as demonstrated by Seitinger et al. [36] or Frenchman [14]. They extended architectural structures with interactive, light emitting elements situated on a building's outer shell. Such projects address the design operation of *media façades* [41]. This term describes the idea of designing or modifying a building's architecture to transform its surfaces into giant public screens [8, 14, 35].

Researchers and technology enthusiasts recently started to explore these interaction opportunities in different projects with different approaches [39]. For example, they studied public crowd experiences with ports of popular arcade games (e.g., *Pong*) to media façades [5]. However, each project designed for a media façade is highly tailored to the façade's unique features in terms of display technologies, size and resolution [18]. The features of such façades, as well as the spaces they are located in, present new design challenges that are critical for successful applications. Dalsgaard et al. described eight important ones [12]. They specifically highlight the importance of media façades being a new type of interface that differs from existing displays in several ways. Thus, the design processes and methods used for traditional, desktop-based graphical user interfaces (GUI) may not be appropriate or, at least, have to be altered to fit this new type of interface.

Besides the technical aspects of media façades, the context in which they are deployed and the exposure of their content to a large audience increase the need for a tailored design. Since situated in a highly public context, people will behave differently when interacting with a media façade than with a desktop-based graphical user interface, since they are acting in front of a large audience [16].

In this paper, we describe our approach in designing and developing an interactive installation on a media façade using an extended user-centered design process to suit the context.

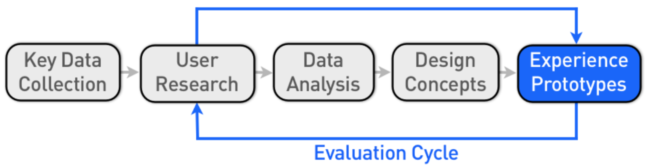

Figure 2. A user centered design process [28, 34] and our focus on extending the experience prototyping and evaluation phase (highlighted in blue) to suit the context.

We present our design process (see Figure 2) that allowed us to: (1) test and explore the interaction concept and underlying hardware before deploying it on the actual façade, thus performing more design iterations [10], and (2) make experimental use of user experience (UX) [2] in combination with human computer interaction (HCI) [23] evaluation methods to investigate the implemented interaction concept more holistically. During this process, we gained experiences that may guide other researchers when facing such domain-specific challenges.

MEDIA FAÇADE INTERACTION: DESIGN CHALLENGES

As has been pointed out, designing interactions for media façades presents different challenges compared to traditional graphical user interfaces. We considered additional differences when designing novel interfaces between media façades and regular GUIs : (1) the physical properties, such as their size, resolution and display technology; (2) testing and exploring both concepts and hardware before the actual deployment; and (3), evaluating the system *in the wild*.

Physical properties of media façades

Although a (rather gigantic) display, the physical properties of media façades differ from regular desktop (or even mobile) screens. Most importantly, they come with much larger display dimensions (edges of several tens of meters), and thus different viewing distances. Many media façades even span more then one side of a building's façade, which gives them a 3D non-planar form factor. Their resolution also may vary greatly depending on the display technology used. Haeusler et al. characterized six different display technologies for media façades [18]:

- ***Front projection façades*** project media content directly onto the façade via one or more video projectors.
- ***Back projection façades*** project media content from behind the façade and onto translucent areas integrated into the building.
- ***Display façades*** deliver content through the integration of commercially obtainable "Very Large Screen Video Displays" into the surface of a building.
- ***Window animations*** make use of the existing windows in a building by illuminating them so that they are perceived as *pixels*.
- ***Illuminant or light-emitting façades*** integrate light-emitting elements into their surfaces (see Figure 1).
- ***Mechanical façades*** use mechanically movable elements to change façade appearances.

The first three façade types usually feature high resolution, while the later ones may have lower resolution as they rely on the building's architecture (e.g., one window equals one pixel). In this work we share the design process of an interaction system in conjunction with a light emitting display façade, and thus cannot judge the transferability to other media façade types.

Pre-testing media façade content and interaction

As previously mentioned, Dalsgaard et al. identified eight key challenges for urban media façade design [12]. The first, media façades being a new type of interface, also leads to the question of how to prototype such an interface before deployment. Their fourth challenge refers to the potential of media façades largely depending on developing content to suit the medium and vice versa. A common way to improve the design, as well as determine the final outcome of the content's appearance before the system's permanent deployment, is usually carried out through low and high fidelity prototyping [33]. For regular GUIs, researchers can easily construct a prototype and choose from a variety of tools and approaches [10].

However, media façades limit this type of prototyping: most of the light emitting media façades are not visible and active during daylight, which restricts the times suitable for pre-testing to only a few hours. Another aspect that makes pre-tests difficult is that the outcome of early experiments is already visible to a large audience, as media façades are mostly situated in prime urban locations, with many passer-by. For these reasons, not many design iterations are feasible on the façade itself. This leaves designers and developers with pre-testing both novel interaction and/or content on regular displays with different characteristics before deploying the resulting system on the target façade.

One way of addressing this matter is carried out by simulating the façade's behavior and pre-testing it on a PC: To create a more realistic environment, designers and developers can use 3D renderings and/or animations which they can change in real-time. Since 2008, the ARS Electronica Center [1], for example, allows for exploring content on a 3D rendered scene of its building and environment. Artists can test their ideas via specialized software before deploying them on the actual façade. However, performing the simulation on a regular computer display (i.e., liquid crystal display) differs from testing on the actual façade: The brightness levels (and the encapsulated view on a display) do not represent the behavior in the real setting (i.e., the emotional experience triggered by colored, bright lights is completely lacking). Further, the interplay of involved hardware components (e.g., lighting elements, server, digital multiplex (DMX) system etc.) with the façade may be hard to test on regular displays – especially when direct and absolute techniques are used.

The aforementioned problems demand new ways of prototyping both content and interaction for media façades. Especially if the façade's lighting technology differs from regular displays, simulating them on a desktop computer may lead to varying results. Thus, results of evaluations regarding experiences as considered by Hassenzahl [19], in a lab environment, using the previously described tools, may not be transferable to the setting at the actual site.

Evaluating media façade interaction 'in the wild'

Since this discipline is still emerging there currently is only limited knowledge on how to evaluate interactions with media façades. While standard methods [11, 23] are an appropriate tool for measuring usability and performance of an interface, the *experiences* [19] are usually not extensively taken into account. We argue that the *users' experiences* of an interaction with a media façade are more crucial for success than with regular GUIs, and have a significant influence even on usability and acceptance. Thus, a combination of usability- and experience-related evaluation methods could lead to a broader investigation to address the special nature of media façade interactions. In particular the aforementioned differences between media façades and regular GUI display setups require considering a variety of additional factors.

Previous research focusing on interacting with large, public displays [6, 31, 40] usually simulated this on TV-sized screens [3, 27]. When applied to media façades, however, this approach does not consider the unique factors such as the façade's size, visibility, and inherently large audience. On the other hand, these factors may influence potential interactions with them: (1) they may be out of the user's reach (partially or totally), requiring interaction at a distance [3]; (2) they allow for multiple users interacting simultaneously; and (3) others (i.e., not just the experimenter and participant) will observe the interaction. Aside from influencing the emotional experience, these factors may also affect the usability. In settings with situated public displays that allow for direct touch input, users are aware of each other's actions and a social protocol (crucial for the perceived joy of users) [31], which are however, both missing on media façades with users not necessarily seeing each other. As an example, concurrent interactions on the façade may lead to frustration, decreasing the user's enjoyment, and thus weakening the overall experience.

To address some of the aforementioned problems for regular GUIs, evaluation methods in HCI commonly contain a mixture of both quantitative (e.g., task completion time, error rates, etc.) [23] and qualitative methods (e.g., open questionnaires, diary studies, semi-structured interviews, etc.) [11]. However, neither of them fully considers the users' experiences as described by Hassenzahl et al. [19, 20, 21], which is of substantial importance, especially in this context, as the result is visible to a large audience. At the same time, interacting with such technology can be considered an experience itself, as compared to how well the technology performs in terms of usability.

We believe that since the challenges described in this chapter all have an impact on interaction with a media façade, they need to be taken into account when designing and evaluating such systems. In the remainder of this paper, we review existing approaches in this domain. We then describe our design process related to user-centered design practices, and our focus on finding appropriate solutions in particular for the *experience prototyping* and *evaluation phase* (see Figure 2, highlighted in blue).

RELATED WORK

The work presented in this chapter builds on previous research in the areas of *experience prototyping* and *evaluation of experiences* in general.

Experience Prototyping

A systematic design process, as proposed by Buxton [10] or Sharp et al. [37], allows for developing a successful application. Moggridge [28] stressed that the core phase of an interaction design process is to create interactive experience prototypes [7] gathering constant user feedback. This phase is usually carried out at the end of every design iteration (see Figure 2). Pre-testing the design concept with actual users allows for more design iterations to ultimately achieve an outcome that is enjoyable for the user. Buxton refers to this procedure as in getting the *design right* [10]. Both low-fidelity and high-fidelity experience prototypes of interactive systems are usually created during the design process [33]. The choice of these depends on (1) how accurately they need to represent their real-world counterpart, and (2) the number of details and/or functionalities they have to include. They closely correlate to the aim designers pursue with a prototype, which is commonly referred to as the prototype's *scope* [24]. Our scope was to pre-test early explorations of design concepts that deal with media façade interaction. Methods for creating such experience prototypes [7] include, for example, *Wizard-of-Oz* techniques [10], *acting out scenarios*, or electronic prototyping platforms [17, 26]. Such tools help designers to create prototypes early in the design process in a more time- and cost-effective manner. When designing for media façades, however, there is no common ground for creating experience prototypes.

Evaluating Experiences

Compared to controlled experiments in the laboratory, evaluating the interaction with media façades can be complex in many facets. For example, in our setting we were confronted with the following: (1) *Dynamic Conditions:* We conducted the evaluation during a public festival involving a live, fluctuating audience and a large number of users. (2) *Limited Time:* The public setting limited timeslots for each user to interact with the prototype and participate in an additional interview. (3) *Multiple Users:* Our setup allowed multiple users to interact simultaneously with the façade and with each other through the façade. (4) *Goal of the interaction*: The reason for users to interact with our system was not to test one specific function, but instead the *experience* of the interaction itself. To evaluate user experiences when interacting with media façades, considering the previously described setting, we investigated methods from UX approaches, which are discussed next.

A crucial aspect of understanding and evaluating UX is to get acquainted with the user. Wright and McCarthy review emerging design and UX methodologies in terms of dynamically shifting relationships between designers, users, and artifacts [44]. They use *empathy* to relate the methodologies with respect to each other. They point out that if experience is central to designer-user relationships, empathic methods have to be understood and used in an appropriate way. Furthermore, in [45], Wright and McCarthy describe their understanding of experience-centered design as a humanistic approach to designing digital technologies and media that enhance experiences. We refer to this matter in our research by evaluating UX at the final stages of the development process. Forlizzi and Battarbee [13] addressed the diversity of experience for interactive systems. They characterize existing approaches to experiences and present a framework for designing experiences originating though interactive systems. Further, they argue that for novel technologies, an experience-oriented design approach is the only way that user-centered design can have a valuable impact on the design. Similarly to Hassenzahl, we related our research goals and understanding of UX in a final evaluation setup to "positive emotions and affect that people experience while interacting with products" [19, 20, 21, 25].

A meta survey of Bargas-Avila et al. [2] exemplified various methods suitable for designing and evaluating UX. They demonstrated that UX methods refer rather to *emotional aspects* of an experience when interacting with a system. We also aimed for this in the final evaluation of our system. To investigate such matters, Hassenzahl et al. developed AttrakDiff [19], a scientifically-applicable tool which measures the *pragmatic quality*, *attractiveness*, *identity*, and *stimulation* of the interaction with a product or service. However, these values are focused on the product itself and not on the experience generated while interacting with it. The positive and negative affect schedule (PANAS) [42] measures and explains positive and negative effects of a retrospective experience. Creating *experience diaries* [22, 30] is another commonly used approach. Here, participants write a report about their use of a product over weeks. Geven et al. [15] proposed storytelling as tool to evaluate user experience in narrative interviews [30]. In the form of experience reports [22], storytelling is used to collect data on meaningful experiences with interactive products or services. However, triggering participants to state their experiences in the interview sessions was accomplished by making reference to familiar electronic products. This practice was not applicable to our setup, as our participants interacted with a novel system in limited time-slots. In summary, the described techniques evaluate the experience in retrospective, over longer time spans, and do not tackle the *in-situ* experience during the interaction, as highly relevant for our context.

To the best of our knowledge, none of the aforementioned methods have been tried and/or explored in the context of media façade interaction. Thus, our goal was to find a method suitable for in-depth evaluation of meaningful **positive experiences** [2, 19] with media façades in a short period of time (i.e., one or two hours). Burmester et al. described the *valence method* [9], an approach that evaluates the emotional quality of an interaction in two phases: (1) In the formative phase, the user marks positive and negative feelings while interacting with a product or service. (2) In the summative phase, the interviewer asks participants about reasons for their actions during the interaction, using an in-depth interview method [32], until they can be matched to the underlying psychological need [38]. This model is also based on Hassenzahl et al.'s UX model [20]. It reduces the complexity of UX with the help of positive psychological needs (such as the feeling of autonomy and competence).

DESIGNING INTERACTION WITH MEDIA FAÇADES

To design a system that allows for remotely interacting with a media façade (see Figure 3), we followed a user-centered design approach [28, 34, 37] and carried out different process phases (see Figure 2):

- ***Key Data Collection:*** In this phase, we looked at reference projects dealing with media façade interaction, interaction design processes, and evaluation methods suitable for this context (see previous section).
- ***User Research:*** Next, we investigated insights on how potential users may perceive (1) the general concept of interacting with a media façade, and (2) which of our initial *concepts* for content might be favored.
- ***Data Analysis:*** Based on the previous phase, we picked the most promising interaction *concepts*.
- ***Design Concepts:*** We turned the identified *concepts* into *scenarios.* We considered the most crucial key elements of the interaction, from the users' perspective.

Figure 3. (a) Users can interact on the entire façade using their mobile device. (b) They choose their individual color and tool and apply these to the façade directly through live video [4].

After presenting these *scenarios* to project partners, we created both paper-based low-fidelity *prototypes* as well as high-fidelity ones through a toolkit specifically created for this purpose.

- ***Evaluations:*** To ensure improvements in usability for each of the design iterations, we conducted evaluations throughout the process. For our low-fidelity prototypes, we chose methods to evaluate the usability of our system [29]. For evaluating the interaction *on the actual façade*, we additionally adapted UX methods [9] to cover a holistic investigation of the users' actions and emotions.

We will now share the experiences we gained in each individual phase of the design process in more detail.

User Research

To obtain a better understanding of how potential users perceive our initial design ideas we conducted a series of interviews *in the wild*. To explain a complex, emerging technology to passers-by in a short time-frame, we conducted the interviews next to the lit-up façade of the ARS Electronica Center in Linz, Austria [1], which also was the site of the actual installation. Each of these semi-structured interviews lasted 15 minutes and was video-taped. In total, we conducted 48 interviews with passers-by at the façade (average age was 27 years). We structured the interviews in three consecutive phases: after a short introduction to media façades and interaction models, we discussed (1) whether they were in favor of any envisioned applications and (2) whether they would consider using them if implemented. We confronted them with early design ideas that covered a broad range of interaction possibilities: interactive games, painting with light on the façade, music visualizations, city mobility animations that would depict traffic in real time or façade visualizations triggered by full body interactions.

Overall, we received positive feedback about interacting with a media façade as an interesting opportunity. For example, a 30 year old female interviewee stated: *"It is an interesting aspect. Why should a façade be plain grey when instead it could be used to interact with multimedia content?"* On the contrary, we also recorded critical statements concerning the envisioned interaction in the public space of a city. A 36 year old male commented: *"I would not appreciate everyone playing around with the façade, especially for the residents' sake."* However, the two critical responses were outnumbered by 46 participants who had general interest in the overall concept and would participate in further experiments with interactive prototypes.

Concepts

During the user research phase, we identified two interaction concepts that were consistently mentioned positively during our semi-structured interview sessions: (1) a mobile *spray-paint* application that enables users to change the façade's color using a touch-screen device, and (2) a jig saw puzzle that requires users to rearrange colored *tiles* to a pre-defined order on the media façade. Based on these concepts, we created three different GUI variations which we present in the next section.

Low-Fidelity Prototyping

To explore and pre-test variations of potential graphical interfaces for the two applications previously described, we conducted a initial paper-prototyping session with five participants (one female, average age 27 years). All participants were recruited from a tech company, which was also where we held the sessions. All participants rated their expertise with mobile devices and emerging technologies as being high. We documented the paper prototyping sessions on video and took additional photographs of the setup. We instructed the participants as follows: First, the experimenter explained the intended project and the envisioned applications in five minutes. At the same time, the experimenter also showed imagery of the ARS Electronica media façade [1] to give a better understanding of the project. Subsequently, we asked them to imagine interacting with the façade using an iPhone. The participants had to complete two tasks with each of the three paper prototypes. Both the tasks and different prototypes were assigned in random order. In the first task, they had to locate the *color selection tool*, *pick* a specific color and *apply* it to the building (i.e., by *sweeping* over the paper image) from the bottom right to the upper left corner. The second task required locating the *color selection tool*, *selection* of a specific color, locating the *filling tool*, *activating* it by *touching* the icon, and *applying* it to the façade by tapping the image's center. For each task, we encouraged our participants to use the *think-aloud technique* [29] while interacting with the paper prototypes.

After the experiment, we interviewed the participants and asked them about their experiences during the session. Regarding *ease-of-use,* three of five participants voted for the interface that contains all elements in one screen (see figure 4a). Two users preferred the solution with all GUI elements accessed via a slide gesture (see figure 4b). No one opted for the third solution, resembling a combination of both approaches as depicted in figure 4c. Similar results were found when we asked which design they considered the most *appealing*.

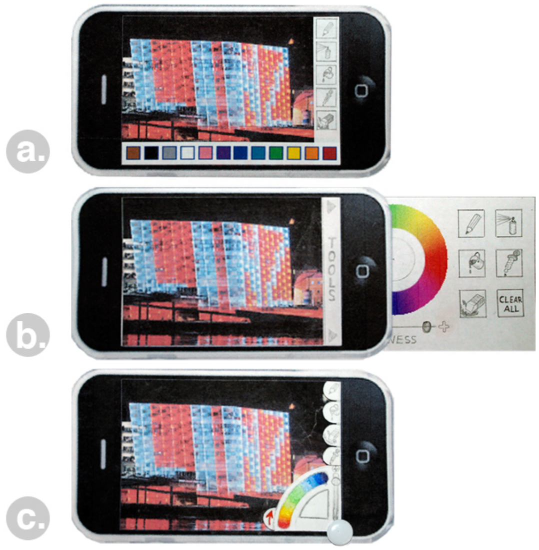

Figure 4. Three different interface solutions as paper prototypes. Top: Tool elements and color selection in one screen. Middle: Tools and color picker on multiple screens, accessed via a slide gesture. Bottom: A combination of the previously described GUI approaches. Basic functionality in one screen, additional features accessed by sliding.

The *color selection tool,* as a crucial part of the interface, differed the most in each prototype. For this reason, we asked our participants more detailed questions regarding this matter.

The majority of the participants (four of five) favored the hue, saturation and value (HSV) color wheel, accessed via a swipe gesture, (see Figure 4b), as it “offers the most freedom for choosing a color”. Only one subject was in favor of a fixed color palette with selected colors (see Figure 4a). Again, the *hybrid* interface solution (see Figure 4c) was considered the most complex, and hence ranked last.

This exercise helped us to decide on general directions for further development of the GUI components. Even with our results, however, we were now confronted with creating a high-fidelity, interactive experience prototype to test our vision in action. With the façade only being operable for a few hours per day and thus frequently in use by others, we had to create a prototype that does not require access to the façade, but results in a similar appearance. To address this challenge, we created a mobile experience prototyping toolkit, which is discussed next.

High Fidelity Prototyping

It is a rather difficult and challenging task to imagine how content will appear from different viewpoints (and in low resolution), if displayed through multicolored light emitting diodes (LEDs) as depicted in Figure 1. For this reason, we decided to build a miniaturized version of the actual façade’s components that allows for exploring both possible applications as well as the interplay of the involved

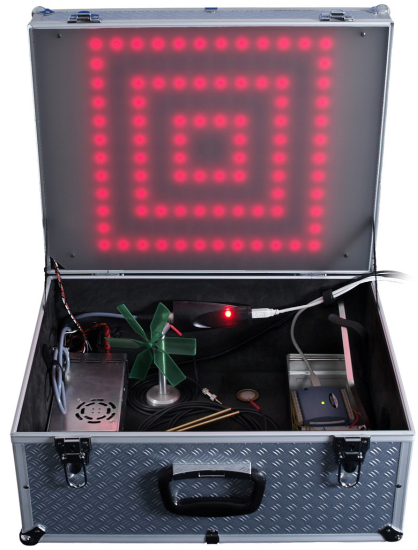

Figure 5. Pre-testing design concepts using *Lightbox* [43], a mobile experience prototyping toolkit to simulate media façade interaction.

hardware components, without deploying the system on the actual façade.

Lightbox [43] consists of an aluminum box measuring 48 × 38 × 25cm. The box’s lid holds a panel of 12 × 12 LEDs, created with 12 single 24V / 10W high power colormix RGB LED strips (see figure 5). We chose this setup as it closely simulates the low resolution of the ARS Electronica Center façade [1]. The LED strips are controlled through DMX signals, an industry standard for controlling lights which is also used at our target façade. Further, the box contains a PC running custom software, as well as a 24V and a 9V power supply to power and control the LED panel and experimental setups.

Using this prototyping toolkit, we implemented the previously described *paint* application (see figure 6) together with a mobile device (here, Apple’s iPhone 3G), allowing users to *paint* multicolored light on the LED panel via touch input. At this point, we were able to investigate two fundamental aspects of the system: (1) the interplay of technical components (i.e., iPhone, Wi-Fi router, application server, DMX lighting system, and LED lighting elements) in general, and more specifically without any delays. We considered real-time feedback to be a crucial aspect with respect to usability, as users may perceive a system, with even minor delays as faulty and unpleasant [33]. (2) We also judged whether the generated lighting colors matched the GUI components and if our applications were still presented recognizably in such a low resolution. (3) Investigating the usability of the GUI concepts depicted in Figure 4 a-c was performed under similar conditions as in the low-fidelity setup previously described, confirmed the preliminary results of the paper prototyping session and is therefore not extensively discussed.

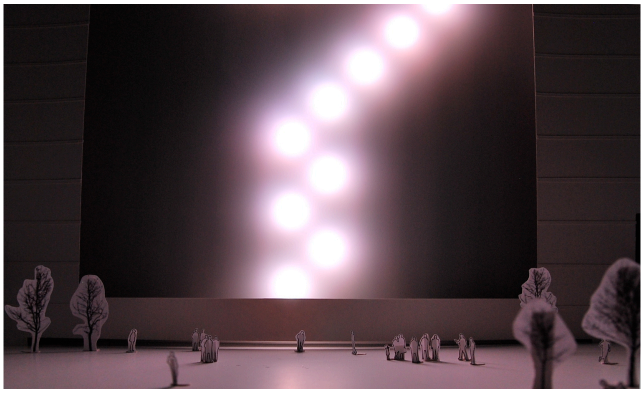

Figure 6. Prototyping a mobile *paint* application in conjunction with *Lightbox* [43] and an iPhone.

After several performance evaluations with the prototyping toolkit, we were (from a hardware perspective) ready to deploy our applications on the actual façade.

Pre-Testing iRiS

We conducted the final experiment on the façade of the ARS Electronica Center (see Figure 1, right). Its 1087 windows (addressable through DMX) host approximately 40000 LEDs. The size of the building allows a viewing distance of up to 300 meters, with an optimal distance being about 50 meters. To allow interaction and manipulation on the façade, we adopted the concept of interacting through live video at-a-distance [3]. The system runs on a camera-equipped mobile device (here, Apple iPhone 3GS) turning it into an interactive see-through panel (see Figure 3b). All mobile clients are connected to a server that manages both tracking mobile devices and coloring the façade. Input occurring in live video on mobile devices is forwarded to the server, which then applies the interaction to the façade.

For the final experiment, we created an application that allowed users to freely *paint* on the façade in a collaborative or competitive fashion. To avoid visual clutter on the shared canvas, we distributed the content as follows: (1) content relevant for all users is shown on the façade, and (2) individual content (e.g., tool palettes) is only shown on the mobile display of the particular user (see Figure 4b). To keep the interaction canvas as large as possible, controls and tool palettes are shown on demand by performing a sliding gesture, as this was the favored design concept for color selection in the low-fidelity prototyping phase. During the experiment, up to three users (we ensured that at least two interacted at the same time) *painted* simultaneously on the façade without any restrictions (i.e., every pixel of the façade was accessible at any time for each user). The façade was shared on a first-come, first-served basis.

Primary Evaluation Cycle

To further improve the usability of the GUI on the mobile device, we conducted an additional preliminary study. In contrast to the former experiments, this evaluation was conducted (1) on-site, (2) under real conditions and (3) with each of the user interfaces of the paper-prototyping sessions implemented (see figure 4 a-c). The software ran on an iPhone 3GS and on a computer connected to the lighting system of the façade.

Setup and Tasks

The six participants (one female, average age was 30 years) received a 3-minute introduction to the application. Then, we explained each of the GUIs with their additional functions (tool palettes). The participants did not receive any up-front training with the system. We instructed the participants to interact with the application and perform three pre-defined tasks with each of the three user interface prototypes. The order of presentation for the prototypes was counterbalanced using a 3 × 3 Latin square.

Task 1. Locate the *color selection tool*, select a given color (e.g., bright green), and *paint* a line onto the building's façade. Subsequently, select another color and *paint* a line.

Task 2. Locate the *color selection tool*, copy-paste an already visible color on the building (i.e., *pipette tool*), and fill the whole façade.

Task 3. Locate the *erase feature* in the tool palette, select single windows (i.e., pixels) on the façade, and clear their color by *tapping* on each of the windows.

Preliminary results

After finishing the tasks, we asked our participants to fill out a questionnaire with 12 questions (5 point *Likert* scales, ranging from 1, meaning *totally disagree*, to 5, meaning *totally agree*) regarding the prototypes' usability.

In summary, the participants preferred having the control elements separated from the actual painting screen and accessing them by a sliding gesture, since they enjoyed this GUI feature the most. One reason why this was the case was that most of the participants claimed familiarity with the gesture and platform. Although the interface with one screen and buttons for selection of predefined colors (see Figure 4a) was again ranked highest in terms of *ease of use* with a mode of 5 (4 times) compared to interfaces 4b with a mode of 4 (3 times) and 4c with a mode value of 3 (3 times) (see Figures 4b-c) (on 5 point *Likert* scales ranging from 1 meaning *hardest* and 5 *easiest to use*), the participants preferred the interface depicted in Figure 4b as their *overall favorite design concept*, including the controls on a separate screen (mode=5) in contrast to the interface prototypes depicted in Figure 4a, (mode=3) and Figure 4c (mode=2).

With the data collected from this setup we were able to (1) choose the final design of the interface and (2) improve its usability for the final setup. However, the data gathered in this process phase was targeted towards aspects concerning the general usability of the system. As a result, we did not collect any data on the users' experiences *while* interacting with the media façade. Thus we investigated the users' deeper underlying motivations when interacting with such a system in the following setup, using UX methods as the means of evaluation.

Secondary Evaluation Cycle

Setup and Tasks

To address the initially discussed challenge of evaluating the interaction with a media façade more holistically, we designed our method as an adaptation of Burmester et al.'s approach [9]: Users received a three minute introduction to the system and its features (as before). We then instructed users to take a *mental note* for each occurrence of both negative and positive emotions. All participants were recorded on video during the actual task, for later analysis. Users were finally asked to interact with the building using the aforementioned *spray-paint* application for exactly five minutes. During this phase, users were allowed to freely pick a color from a palette and *spray-paint* the building in different colors and patterns.

Immediately after the interaction phase, we interviewed each user for 10 minutes. The interviews were audio-recoded for analysis. We used an investigative two-step interview process based on the laddering technique [32], deducing the fulfilled needs based on positive emotions. We started each question by directly referring to the *mental notes*, in which users remembered a positive or negative emotional aspect during the interaction phase. Based on these *mental notes*, we asked them why they thought that a positive or negative aspect occurred. For example, one user stated that he enjoyed the freedom of *picking, mixing*, and *applying* any possible color to the building. Based on this statement, we continued to ask why he perceived this experience as positive. He stated further: *"Because I can do it completely by myself and it does not happen automatically."* We recorded these statements and allocated them to a specific positive need, based on classifications of specific human needs in correlation with technology (see figure 7), as set out by Sheldon et al. [38]. In this case the allocated need was mapped to two needs: *autonomy* and *competence*. These were suggested by the expressed keyword phrases *"do it by myself"* and *"not automatically"* during the second phase of the interview.

The second evaluation cycle focused entirely on the users' experience of the interaction. We conducted the experiment on two consecutive days during the ARS Electronica Festival (one hour each). Out of 50 users interacting with the façade, we interviewed 15 (5 female; average age was 26.1 years) for the investigation of UX purposes. Each interview lasted 10 minutes, while the users had 5 minutes to experience the system beforehand. Again, all participants were recorded on video during the interaction and interview phase for later analysis.

Preliminary results

Figure 7 lists the analysis and classification of confirmed needs gathered from the interview data. Apart from the obvious result of participants having fun while interacting (11 were allocated to pleasure stimulation), the most interesting result was that 12 of 15 participants expressed statements that were mapped to the need for *competence*.

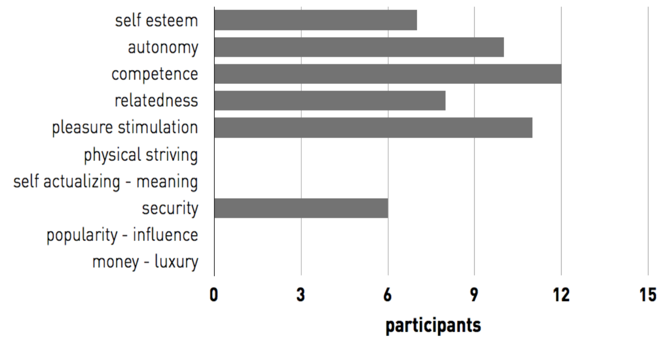

Figure 7. Identified confirmed needs after the laddering technique interview [31] from 15 participants.

Through the second part of the interview, we analyzed the reasons why this need was fulfilled: Participants felt empowered to accomplish something technologically complex (from an outside perspective) while others were watching. In analyzing the transcript interviews, we concluded that 10 participants felt confirmed in the need for *autonomy,* as our system allowed them to interact simultaneously or alone, according to the users' choice, indicating that the autonomous operation of the system was considered quite important by the majority of the participants. The need for *relatedness* was repeatedly mentioned by 8 participants in the second phase of the interviews through quotes such as: *We were able to simultaneously communicate with the person next to us while interacting, which made it indeed a richer group experience*. Here we considered the (a) communicational aspect and (b) mentioning a shared *group* experience as adequate keywords for an appropriate mapping to a specific need [38].

DISCUSSION

In summary we reported on our experiences while designing, prototyping, deploying and evaluating a system for interaction with media façades.

We tested and explored the applied concepts and the utilized hardware with a prototyping toolkit that was tailored to the properties of the façade and the deployment context. With the aid of the prototyping toolkit, we addressed aspects that were crucial for the later deployment on the actual media façade. It allowed us to pre-test content and hardware on a small scale without facing the limitations previously highlighted.

During the evaluation cycles, a consideration of the users' experiences through the preliminary use of UX methods in the second evaluation cycle led us to results that covered users' experiences more holistically. However, in a further setup, the method of referring to a *mental note* could be simplified by, for example, providing additional buttons integrated in the interface that would trigger a log mechanism. In this way, the allocation of the *mental note*, which incorporates important aspects regarding the users' experiences in a specific moment in time, can be tracked more accurately during the interaction and subsequently serve as basis for the mandatory follow-up interview. We believe that these measures are more critical when dealing with media façades compared to traditional GUIs, and should therefore be taken into consideration. At the same time, methods targeted at improving general usability, as applied in the primary evaluation cycle, are of high value as well. They provide the basis on which the experiences happen in the first place. Based on our initial research on this topic, we recommend using methods that consider both factors equally and thus lead towards designing usable and enjoyable interactions in this domain.

Looking at the conducted evaluation cycles, we addressed the investigation into the user experience of the interaction rather late in the design process. Addressing this matter already at the beginning of a future project can lead to a design process that is directly tailored to the users' needs and addresses certain experiences directly as a design goal (e.g. supporting competence).

By using available off-the-shelf hardware components to pre-test our implementations, we provide the opportunity for others to replicate this course of action when facing similar challenges. However, the chosen approach of miniaturization in this context strongly depends on (a) the lighting elements used by the façade type and (b) the appropriate scaling of the resolution that should be taken into account. Further, we applied UX evaluation methods in this design context as preliminary experimental setup. To further substantiate this practice, we are considering a comparative setup using a variety of these methods in consecutive project phases.

We believe that the design process exemplified here can assist research into interactive systems in this domain by providing starting points. However, we consider challenges one has to face when extending and applying this approach to other contexts. Due to the diversity of conditions and specifications of media façades, how we can transfer our approach to different interfaces and façades in this domain remains an open question. These challenges raise further research questions that need to be addressed in order to design successful systems in this emerging domain.

CONCLUSION AND FUTURE WORK

In this paper, we reported on our experiences designing interaction with media façades. We consider our lessons learned as valuable insights for designers and researchers that face similar domain-specific challenges. We described our results combining and adapting evaluation methods to obtain a method suitable for covering both improvements in usability as well as revealing insights on users' experiences interacting with this form of interface. We extended standard user-centered design processes: developing a prototyping toolkit that allowed pre-testing content and hardware, simulating the conditions determined by the deployment context, early in the design process.

The results obtained had a direct impact on the further process. We iteratively derived a combined and adapted evaluation approach covering both areas in order to have the ability to evaluate all aspects that are important for a successful system.

To substantiate the validity of our approach, we plan to apply the described concepts in further field studies involving different scenarios, different technologies and interaction methods. This may lead to more profound knowledge regarding which form of interaction is appropriate for achieving a particular experience. Hence, the design process in such a context could in future setups directly be driven by aiming at certain experience related goals.

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