Dusk: Adaption and Perception in Interactive Theatre

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Abstract
Our case study explores how interactive systems may influence and enhance theatre performances. We produced a short play featuring four interactive systems. Using a mixed-method evaluation approach we strive to answer two main research questions: How do users (actors and directors) adapt to the technology, and how do spectators perceive interactive scenes? We found the success of using interactive systems in theater to be based mainly on how interaction is conceptualized in reference to the script. Adaptions are done on both sides – system and user need to "understand" each other, and the audience's perception is not necessarily characterized by recognizing interactivity per se but rather by experiencing it in a theatre play as a whole.

Author Keywords
Mixed-method Approach; Design Process.

ACM Classification Keywords
J.5. Computer Applications: ARTS AND HUMANITIES: Performing arts (e.g. dance, music)

Introduction
In winter term 2014/15 we ran an interdisciplinary student project that explored the use of interactive technologies in theatre performances. With eleven students

Stage Design

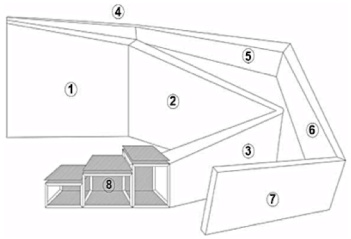

Figure 1: Stage design built of wooden frames symbolizing a big city as a maze – 1) interactive background video projection wall, 2) paper-wall, 3) 4) and 6) empty frames, 5) and 7) small video projection walls, and 8) the interactive bench continuing the city's alignment.

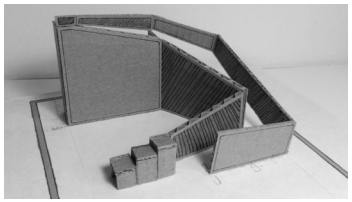

Figure 2: Paper mock-up of the stage. The dangers and adventures of the city are symbolized by light and shadow in the stage design created through (interactive) projections. Risk can be taken by venturing out to the city at night. The actor changing the light to shadow ratio on the projection walls symbolizes this.

from *Computer Science and Media*, *HCI*, *Media Architecture*, *Media Art and Design*, and *Product Design*, we developed an interactive theatre play based on the short story 'Dusk' by Saki [11]. We collaborated with a drama educator/ theatre pedagogue practitioner who led us in developing the script and directed the staging process, and semi-professional actors who performed the 17-minute play. The production took around 18 weeks, from ideation and script preparation, over building and testing the various interactive elements, to rehearsals and stage set-up. Most time was spent on designing and developing the interactive parts. One intense week before the public presentation was reserved for rehearsals. In March 2015, the play was performed on two evenings for around 100 visitors in total.

The interactive systems are: a *background video wall* controlled by a Kinect Sensor (fig.1 no 1), a *foreground video wall* manipulated by an actress' voice and heartbeat (fig.1 no 7), an *illuminated bench* influenced by sitting postures (fig.1 no 8), and a *hand-held soap* as a symbolic prop activated by distance sensing (fig.16). All react to specified actions on stage. Our goal was to explore how interactive elements can enhance a theatre performance, subordinated to two research questions: how do director and actors (referred to as 'users' in the following) adapt to interactive systems, and how does the audience perceive them? For this case study, we chose a mixed-method approach. First, our creation process of interactive systems can be understood as research-through-design [3], as we generated knowledge on how to integrate them into a play by building them in collaboration with its director (who also was an actor). Further, our data collection includes video observation of rehearsals and performances, interviews with actors and director, and an audience questionnaire.

Figure 3: The final stage design.

Related Work

Some examples of how to integrate interactive systems in theatre performances can be found in the literature. Most explore motion tracking technologies and/or interactive projections [2, 4, 8, 9, 12, 14]. A few investigate so-called off-stage operations [12, 14], effects triggered by a person (actor or technical operator) who is off-stage. Others involve the audience and enable it to influence a play [4, 9], or investigate how spectators perceive interactive elements of a performance [10], but none so far discuss how users adapt to interactive systems in theatre. In other areas of the performing arts, such as dance, interactive technologies are used more often than in theatre or opera. Here, technology is typically attached to the moving human body and generates sound [1, 7, 15] or influences interactive projection [5, 6, 13]. While these examples demonstrate how to apply interactive systems, only some investigate the audience's perception, and none study adaption by different stakeholders.

Room Plan

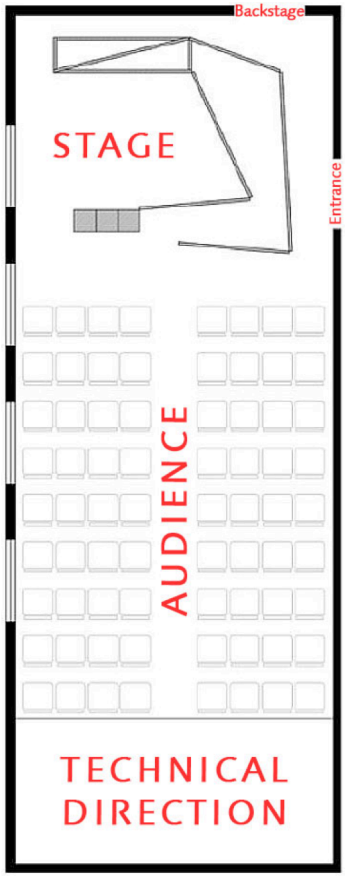

Figure 4: Setup of the room where the performance took place. Behind the stage is the dressing room. The technical crew running the show sits behind the audience.

Conceptualization of Story and Play

'Dusk' [11] is a short story by British author Hector Hugh Munro a.k.a. Saki (*1870, †1916). The story takes place in London's Hyde Park. It starts with the main character Norman Gortsby sitting on a bench, absorbed in his thoughts about modern society and people's judgment (but clearly, himself being a result of society, influenced by prejudices). Then, a poorly and shabbily dressed old man sits next to him. After a while, the man leaves and a young, well-dressed man takes a seat. He seems angry about something, which prompts Gortsby to ask what happened. The young man, a visitor to London, explains he forgot his soap at home and after checking into a hotel, went out to buy some. After doing so and having a drink in a bar, he realized he could not find the way back to his hotel and had forgotten its name. He now has nowhere to spend the night. Gortsby wants to see the soap as proof of his story, but the man cannot find it. Gortsby doubts the story and the young man leaves, offended. Later, Gortsby finds a bar of soap underneath the bench and feels guilty of judging the man. He tries to follow him to apologize, finds him and offers money to help. He then returns to the bench, still irritated by his own prejudices. Arriving there, the old man is back searching for something. Asked, the old man explains he lost his soap. This is the twist and end of the play.

Our first step was developing the script, deciding which themes to prioritize, and what technology to use in the stage performance. Together with the play director, we agreed on emphasizing three core themes: the ambience and ambivalence of a big city, a tiered society, subjective thoughts and prejudices. Furthermore, we found the soap and the bench to be central symbols requiring special consideration. We then started to match potential input and output technologies to themes and symbolic objects (e.g. biometric sensors to reveal inner thought). Finally we developed conceptual designs for four interactive systems: one evokes the city's light-shadow atmosphere of danger and adventure (background projection wall), another represents inner thought and prejudices (foreground projection wall), the soap as symbol of a class society (only rich people could afford it), and the bench was conceptualized as a contradictory place of equality and encounter. Students then worked in small interdisciplinary teams to build the interactive systems.

Due to limited budgets, stage design was minimalistic (fig. 1-3). In addition to the interactive systems, traditional theatre lighting, playback sound, and video projections were used in agreement with the director. The actors chose their own costumes and make-up.

The Interactive Systems of "Dusk"

In the following, we explain each implementation of the four concepts. During the show, all were monitored by the tech crew situated behind the audience (see fig. 4).

City Atmosphere - Background Video Wall

Going for a minimalist stage design, we created atmosphere with background projection on a 2x3m screen and sound. The graphics show the dark silhouettes of buildings and lights, creating an ambient city scene with high visual contrast. The graphics were interactive in two scenes, using a Kinect depth camera hung from the ceiling to capture the space in front of the screen. In one scene, Gortsby could switch the lights in the houses on and off by walking along the screen and back (fig. 6). In another scene, Gortsby used his hands to wipe out the fog, revealing the city again (fig. 7).

Background Projection

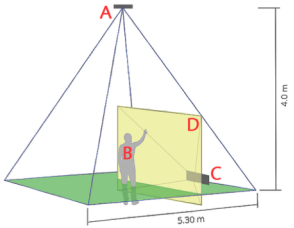

Figure 5: Setup – A) ceiling-mounted Kinect sensor, B) actor in front of screen, C) short throw projector, D) projection screen.

Figure 6: Interactive scene, revealing the city when the actress walks past.

Figure 7: Interactive scene, wiping away the fog. The actress actively influences the projection by waving and swiping with her hands.

Equality and Encounter - Illuminated Bench
The bench is the meeting place of the three characters. Three attached cubes form an abstracted bench (fig. 1, 8, 9, 10) – one per character, of different heights representing their social hierarchy. In the script, the bench is a medium that characters of different class use as a place to think, express their feelings and to communicate. Each cube has a tilt-able plate on the top, which the seated actors can manipulate by shifting their weight left, right, or sitting straight (fig. 9). We implemented this with two simple switches underneath each seat that triggers sound and light (fig. 3, fig. 8).

Inner Thoughts - Foreground Video Wall
The stage further included two smaller non-rectangular screens (no 5 and 7 in fig. 1) showing close-up videos of nature contrasted with abstract shapes. These symbolize societal prejudices that influence Gortsby's thoughts. We connected the actress conceptually with the stage: biometric parameters symbolize the inability to counter prejudices (projected water ripples aligned with the heart beat, fig.12) and at the same time symbolize possibilities to act on prejudices (the video's brightness is influenced by voice, fig.13). Data from a microphone and pulse sensor inside the actress' jacket were transferred wirelessly to the video computer. The projections were created and managed in Processing.

Class Society - Hand-held Soap
The Soap as a symbolic prop stands for innocence, abundance and cleanliness. We designed a transparent bubble-shaped casing, reminding of foam, and making it larger than a bar of soap to be visible for the audience (fig. 14-16). We integrated a toy soap bubble gun and modified it to be triggered by a proximity sensor. On one side of the case, the bubbles come out of a hole (fig.16). In the scene where the soap is found, the actors control the prop by triggering the sensor at 35 cm distance, which activates a set of integrated multi-colored LEDs and the bubble gun.

Evaluation

For this case study, we followed a mixed-method approach. Our data collection consists of direct and indirect observation during rehearsals and public performances, interviews with actors and director and an audience questionnaire after the performances.

Illuminated Bench

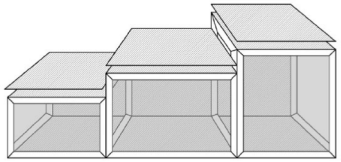

Figure 8: Bench design, from the back. Wooden frames are covered with diffusing paper and a tilt-able plate on top. The electronics (Arduino and LED strips) are hidden inside. The back is open for maintenance access.

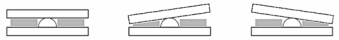

Figure 9: The bench's tilt mechanism consists of three copper tape switches on top of each seat; this enables differentiation of sitting postures (straight, leaned to left or right).

Figure 10: Final bench design.

Observation and Interviews with Director and Actors
Video was used to document introduction of the interactive objects to the actors, their use during rehearsals and the two shows. The introduction and rehearsals were recorded with one camera, capturing actions and conversations between actors and our team on stage. Three cameras were used to capture the performances, mainly for documentation purposes. We analyzed the collected data to classify usage of, familiarization with, and behavior towards the interactive technologies. Further, we took note of actors' reactions and activities during rehearsals, audience reactions during performances, and logged users' activity. While observing the actors, we focused on their first reactions when encountering the interactive technologies, their body language indicating when feeling (un)comfortable while using them, and comments or bodily expressions.

Semi-structured interviews were carried out after the performances with the three actors and were video recorded. Specific questions related to the interactive systems, probing actors' opinion of them, their understanding of the operating mode, usage (ease of use and dealing with dysfunction), and proposals for improvement. General questions concerned actors' prior experiences with interactive theatre, preferences among our interactive systems, visibility of technology, future potential and added value of interactive theatre. Each actor was asked about the experience made with the systems they had interacted with (only Gortsby's character interacted with all four systems during the play), or, from an observer's point of view, their opinion of those systems they had not actively used.

Audience Questionnaire
We handed out questionnaires in German and English at the end of both performances to get the audience's perspective on the general idea of interactive theatre and their opinions on our play. Open and closed questions were used to collect demographic data and audience opinions. Next to questions about their general interest in theater and performance arts, we asked why they attended, if they noticed that the actors controlled some of the technological devices in the play and how, one question for each system, and had them rate (on a 5-point Likert scale) how they liked the use of interactive technologies during the play.

Findings

The results presented here focus on how users adapt to the tech systems (e.g. change of choreography or pacing, stage direction refinement, degree of freedom while improvising), and how the audience perceives interactive effects (e.g. the comprehensibleness or the popularity of the interactive systems).

Observations
From our observation, we can say that the interactive systems worked reliable during performances, although we faced various technical trouble during rehearsals, when we repeatedly improved or slightly changed features and/or the interaction with them. The actors were very curious and open-minded about the interactive systems, they smiled and appeared positively surprised when introduced to them. It only took a few minutes for the actors to understand the working principle of each. But how to work with the items turned out to be different for each system and actor.

For instance, working with the bench was no problem for the actors of the young and the old man, but the actress playing Gortsby was not tall enough to put her feet on the ground when seated (fig. 12). This caused difficulties to move relaxed to the left and right to trig-

Foreground Projection

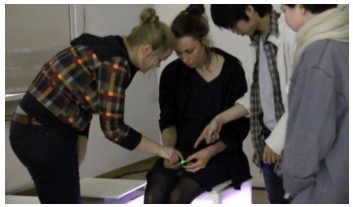

Figure 11: Testing the heartbeat sensor with the actress (sitting) and director (left). During the play, the actress put it conspicuously on her finger for the specific scene.

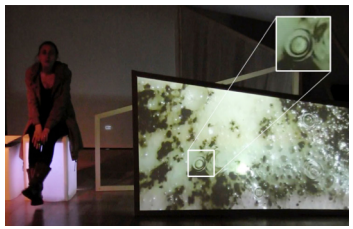

Figure 12: Foreground screen influenced by the actress' pulse. The biometric input generates random water ripples rendered atop a video of soap foam (ripple effect in enlarged area).

Figure 13: Foreground screen influenced by the actress' voice. The louder she speaks, the more the projection is visible.

ger the bench's light effects. We solved this by choreographing exactly how she acted in this specific scene. Further, the biometric sensors were difficult to use since physical activity had no discernible effect on the projection effected by the actress' pulse (fig. 11). Also, the concept of using voice input had to be modified after the first user tests to achieve a clearer input-output relationship (fig. 13). During rehearsals, the soap often was triggered accidentally. So we had to resolve where to place it on the stage. Together with the actors and director, we planned how to move across the stage so as to only trigger the bubble effect in the right moment. Similarly for the Kinect application - the actors and director took a while until they found suitable walking paths inside the tracking area on stage, so they could integrate the system into their overall acting.

Interviews - The Actors' and Director's Perspective
The interviews confirmed most insights from observation. One actor and the director already had prior experiences with interactive theatre costumes. In general, comments of our interview partners were very positive, they liked using the interactive technologies and were very open-minded. In addition, they made suggestions how to improve concepts and technology development.

For instance, the actors found it quite difficult to focus on speaking/ acting and simultaneously tilting the bench correctly. While the bench was visually beautiful, a more subtle interaction would have felt more natural to them. The young man actor would have wanted to receive system feedback, as he could not see the effects while sitting on it. Further, the director and the actress described the biometric sensors as challenging. They found the idea of a pulse sensor interesting, but not fitting for the plot. The actress felt uncomfortable using it. Actors suggested to make output more obvious for the audience, and to use the sensor for bodily exertion scenes where there is a more direct connection between action and increasing heartbeat. They also proposed moving the projection of voice input and Kinect interaction away from the screen, to show it somewhere else in the environment. They thought this would improve the stage design, and make it more appealing.

Although there were a few restrictions with the Kinect, it did not affect performance of the actor or disturb. The Gortsby actress said she really enjoyed this system because "you exactly know what to do" although an occasional issue was the time delay of output. The actors thought this interaction concept fits the story well as, in the director's words, "it's pretty obvious for the audience that there is interaction here". Further, the soap was the "little star" as phrased by the director, bringing mystery and magic to the play. Its direct interactive feedback was well liked, although the young and old man actors found it a bit fragile to carry around, which required extra attention.

Questionnaires - The Audience's Perspective
82 audience members filled a questionnaire (around 50% female). Although the play was in German, international guests received an English questionnaire. Participants' age varied from 18 to over 60, with around 60% between 20 and 30 years old. Most spectators were pupils or students, others were professors, employees, freelancers, and managers. 57% of the audience members were from the creative sector. The majority had visited other plays before, and regularly visits performances every half year.

Around 80% observed that the actors controlled some of the technology involved in the play (see fig. 17). They noticed that actors' gestures influenced projection

Hand-held Soap

Figure 14: Soap model from modeling clay, with vacuum-formed case, and electronics stored in a styrofoam bowl.

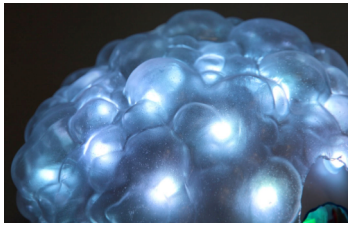

Figure 15: Final look of the soap.

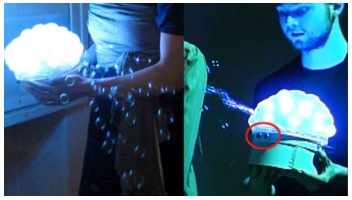

Figure 16: The soap in action, controlled by ultrasonic distance sensor (highlighted on the right).

of the city, with 76% selecting the option of "hand waving" and 74% "walking" (both are correct, fig. 6 and 7). More than 90% had seen the soap but only 30% noticed that it was triggered by the actors. Most assumed it to be activated by a pre-set timer or off-stage operations. This was similar to the water ripples projection affected by the actress' heartbeat, which most spectators assumed to be controlled by technicians (45%) or the actress' voice (21%). Only 13% realized it was her pulse. Furthermore, audience members associated the abstract projections in the middle of the play with the concept of nature rather than with abstract thoughts. 31 of 82 respondents did notice that the actors could influence the bench's illumination, but very few could recall how. Many audience members noted that people seated behind the first rows could not see the stage well enough, and hence were not able to notice the interaction taking place, in particular for the bench.

On a five point Likert scale, 42% rated the use of interactive technologies with "I liked it a bit", 34% said they "liked it a lot" and 22% rated it neutral (see fig. 18). Regarding why the audience liked the play, most answers revealed that it was perceived as creative, well done, aesthetically pleasing, simple, modern, and the technology use as interesting. Further comments were that the play inspires thoughts and imagination, the soap created a comical moment, and the whole show was described as personal and unique. A few spectators wrote that the interaction was too subtle to be noticed well or too difficult to understand, and that the play was too short to notice all the interactive technologies.

Lessons Learned

Next, we describe our insights and discuss our research questions of how director and actors adapted to the interactive systems, and how the audience perceived them. We found that the success of interactive systems in theatre relies on fit with the play. Interactive technologies enhance theatre performances if they add value to the outcome and support staging of the script. Technology should not just be an addition, but an integrated part of the play, supporting actors' expressivity in conveying deeper meaning and aspects of their role and the play. Nevertheless, adaptions occur due to various reasons and can compromise artistic intent.

Support Adaption by Actors

In our case study, the actors as users and the director as stakeholder were very open-minded towards interactive theatre technologies. They understood the operation mode after a short introduction. Nevertheless, acting with and integrating it seamlessly into a play was not without issues, such as correct usage, fitting the performance's concept, adequate feedback, reliable functionality, and robustness. The actors only had the chance to experience the interactive systems the week before the first public performance, although the director knew early about our plans. Most adaptions occurred in this week. We conclude that it makes sense to involve users and stakeholders more in the creation process, and recommend providing first prototypes at an earlier stage during the production process. An iterative design process and early user explorations can enable a more seamless integration of interactive technologies into a theatre performance, and adaptions can be more deliberate, supporting the artistic concepts.

Furthermore, to avoid usage errors and support the activity on stage, we cued the interactive scenes and choreographed actors' actions. This might limit the power of an interactive system because cueing means to plan in detail when or how the system's reaction on the ac-

Questionnaire Results

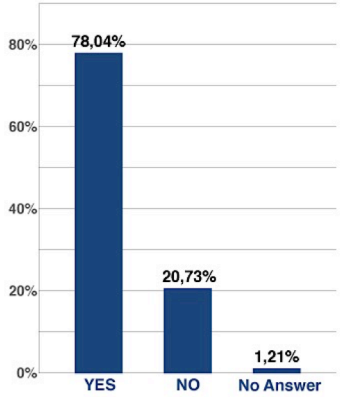

Figure 17: Did you notice that the actors controlled some of the technological devices involved in the play?

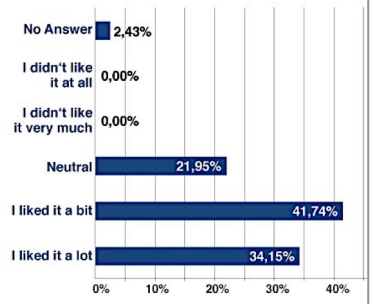

Figure 18: How would you rate the use of interactive technologies (projections, cubes, soap) during the play?

tor's behavior starts. Similar, the freedom of improvising might be restricted when the actor has to follow an exact step sequence for interacting with a system. But the advantage of cuing and choreographing interactive systems is that the whole performance remains on track regarding time and effectiveness.

Supporting the Audience's Perception

The audience coming to our performance was strongly interested in interactive theatre applications. Although curious to watch the outcome, for some of our systems, the viewers could not relate actors' action to output, and some effects were not in their visual field (e.g. the bench's illumination). Other interactive effects (Kinect interaction with the projection screen) were easier to observe and understand. Abstract mappings (such as heartbeat and water ripples) did not connect input and output effect clearly enough for the audience. According to our experiences, we suggest employing a clear mapping of input and output instead of abstract/complex interactive effects, for visitors to notice the interaction concept. Additionally, visibility of interactive objects has to be ensured when planning and setting-up stage design and audience seating. This is related to decisions on whether the audience should be able to notice how interactive effects work. A discussion and classification of how spectators may perceive interactive technologies (hidden/exposed) can be found in [10]. From our perspective, it is important to decide whom to address with a performance, and vital that the (inter)action reaches the audience and supports the story.

Conclusions

In this case study, we have presented DUSK, a theatre production that included four different interactive technologies. With those various systems, we have explored a range of artistic expressions and their impact on the audience. We believe that interactive systems can add additional value to the experience of a theatre play when selected and presented thoughtfully. Evaluation revealed that stakeholders need support for successfully interacting with them, and it can be helpful to cue interactive scenes or to choreograph the acting in them. That means adaptations are needed on both sides: system design needs to take into account how actors act, and actors need to learn how to work with them. We further found, from a spectator's perspective, that interactive systems can support story telling when perceivable. For this, it might not be important if the audience always fully understands how the interactive system works, but rather it is important that the narrative moment of interactive technologies is seamlessly integrated into the whole stage performance. Concluding, we suggest considering carefully which interactive technologies are appropriate to express conceptual goals and to keep the overall gestalt of a performance in mind when creating it. We hope our case study gives insights to artists, engineers, and researchers working on interactive theatre performances. How exactly interactive systems enhance expressiveness of actors, which levels of adaption are required throughout production, or how exactly a spectator's perception is influenced by interactive systems, needs to be further investigated.

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