

Overcoming Reserve – Supporting Professional Appropriation of Interactive Costumes

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ABSTRACT

Deploying wearable technologies in the performing arts not only concerns costume wearers but affects further stakeholders whose work is impacted by the interactive effects or who help maintain the technology. Beyond the wearer, literature neglects how these other stakeholders engage with interactive costumes, though a performance production is based on the contribution of many parties. We conducted a longitudinal study to examine how stakeholders of a youth ballet production experience and appropriate interactive costuming. Our findings suggest that user experiences vary according to stakeholders' closeness to the costume, background and taste, the costume interaction mode and social environment. We expand existing models of technology appropriation with two novel technology relations: *professional reserve* and *polite indifference*. Based on these, we suggest *integration into existing practices*, *to design for the show*, and *create positive experiences* to incorporate interactive costumes in the performing arts and discuss relevance for other professional fields.

Author Keywords

Appropriating technologies, user experience, wearable costumes, performing arts, theatre, ballet, action research.

CSS Concepts

• Human-centered computing~Human computer interaction (HCI)~Empirical studies in HCI

INTRODUCTION

Interactive costumes – *theatre-based wearables* [33] or *wearable costumes* [35] – are increasingly incorporated into theatre and performance. Related literature typically focuses on the design and experience of wearing such costuming [20, 25, 26, 35, 36, 38, 39, 41]. Yet, creation, deployment, and maintenance of costumes, as well as the design of their in-context use, are not typically executed by the designer or

wearer. Rather, secondary or tertiary stakeholders undertake these roles. Secondary stakeholders include choreographers, directors and fellow performers; tertiary stakeholders: lighting, sound and set designers, technicians, tailors, and dressers who help create, deploy and maintain the costumes. All of these stakeholders must consider the interactive costumes as they fulfil their roles. Interactive costuming is used under particular conditions. Its use may not be voluntary; takes place within a predefined timeframe, with precise timing; involves professional handling, different than for conventional costumes. These conditions impact how stakeholders perceive and work with interactive costuming. They distinguish interactive costuming from other use cases of wearables, though the formality of the constraints may find parallels in other professional landscapes.

Our study investigates how primary, secondary and tertiary stakeholders in a professional theatre setting experience working with wearable technologies. We examine how these stakeholders appropriate interactive costumes into existing practices, as well as how they struggle with them. To investigate these issues, we developed and helped stage three interactive costumes for a youth ballet over a period of two years. We worked closely with the theatre stakeholders; interviewed and observed participants during development and deployment. To analyse our findings, we developed a theoretical framing based on a literature review of user experience and technology appropriation [4, 5, 9, 10, 13, 14, 15, 24, 32]. Our objective is to better understand how to support designers of interactive costumes to work within the professional theatre landscape, and to enhance theatre professionals' experience of wearables so they might appropriate them into their practice.

We identify several aspects related to the user experience of interactive costumes, some concern a costume's design and interactive features, others a stakeholder's background, individual perception, and how they can integrate a costume into their practices and infrastructures. We expand existing models classifying technology appropriation on three levels: A) reservations and familiarization, B) indifference and dependency, and C) emotional attachment. Our insights contribute to theatre practitioners planning to work with interactive costuming and designers of such costuming, and may inform wearables and e-textile development for workwear, as we learn how professionals appropriate wearable technologies and their needs in this process.

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BACKGROUND AND RELATED WORK

Characterizing Interactive Costuming

Costumes are an important part of any theatre or dance performance [23], they come to life through scenery and lighting [2, 26] and need to fit the overall design of a performance production [26]. Costumes can fill up and constitute space [26]; disguise a performer; show a character [18, 23], and in doing so, support performers in developing a role [18, 23, 26]. Costumes show status, social and historical context of a character; and can furthermore show a character's progress and psychology [18, 23]. They help spectators interpret what they see and understand the show [2, 18, 23, 26]. From a practical perspective, a costume needs to fit the performer [2, 23], be sturdy [23], and allow the movements related to the role [2, 23, 26].

Interactive costumes require a performer to engage in new ways with on-stage clothing and can impact other stakeholders. Sicchio identifies three types of technologies in interactive costumes: *sensing systems*, *on-body sensing and actuation* and *energy harvesting* [35]. Little is known about how such technologies impact wearers or other stakeholders. Clearly, technology integrated into costuming commands extra attention [20]. Specifications particular to interactive costuming include: Technological *functionality*, the need for early *prototyping*, design team *interdisciplinarity* (combining costume design and engineering), early *rehearsals* with a functioning prototype and *maintenance* of components [19]. These requirements indicate a shift in stakeholders' activities. Yet, little is known about how stakeholders experience or appropriate the costumes.

Interactive Costuming within Theatre Productions

The production of a professional theatre performance – a stage play, ballet, or opera – typically takes 6 to 12 weeks. Within this schedule all costumes are crafted, fitted, and staged [18]. The technical rehearsal is conducted a few days before the premiere and the final dress rehearsal usually the day before [18]. In contrast, interactive costume development can take months [20]. Research projects addressing the creative processes behind interactive costuming emphasise the need to prolong multi-disciplinary production processes because wearable costumes impact the creative process of all parties involved (directors and choreographers, engineers, designers of visual effects, costuming, props, set, lighting, etc.) [26]. In response to this challenge, researchers propose integrating the processes of interaction design into costume design [12] and revisiting design and deployment processes of interactive costumes for theatre stages [20]. Interactive costuming requires more time for in-costume rehearsals as stakeholders need to become familiar with the technology, understand how it works, and train the interaction [12, 19, 20]. Research on design and deployment [12, 20, 26] neglects to detail how stakeholders experience and appropriate interactive costuming. Rather, it primarily investigates the performer as wearer of interactive costuming, e.g. examining how perception and movement can be restricted or changed through costuming [25], how

wearable costuming can extend a performers body and thus, impact perception of the environment and self-positioning [38]. Additionally, some research investigates how spectators engage with interactive costumes as observers [39] or as inter-actors, when touching and pulling a costume [41]. There is less insight into how wearable costumes impact directors, choreographers, costume, light and set designers, wardrobe, other performers and employees of the production. Sicchio et al. explore vibration as a medium to enable dialogue between two performers or choreographer and performer [36]. However, their investigation is focused on the design space of the costuming and does not discuss the impact of costuming on performers or choreographer.

Experiencing and Appropriating Technologies

In the literature, the terms *experience* [9, 13, 14, 15] and *appropriation* [4, 10, 32] are mostly used separately though both relate to how users accept technology into their lives [5, 24]. Rogoff defines appropriation as the “process by which individuals transform their understanding of and responsibility for activities through their own participation” noting that “through participation, people (...) become prepared to engage in subsequent similar activities” [32]. Appropriation is thus active. It constitutes a change in attitude and/or behaviour during and after technology use. In contrast, user experience is “a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service” [14]. It relates to the passive perception of self and situation while using a technology, and suggests that experience influences appropriation of technology. We unfold the relevance for interactive costuming.

Frameworks on technology appropriation tend to place the primary user at their centre [4, 10]. In a theatre context, the performer may be the primary user, but many others have a strong stake in the interactive costume. Fellow performers need to engage with a costume's output; theatre dressers maintain the costume, often without training. The stakeholders classified in our introduction appropriate costume technology differently, depending on background knowledge, prior experience, and closeness to the costumes. Literature on technology appropriation [4, 10, 32] and experience [9, 13 24] assumes technology usage is a choice of the primary user. In theatre, this is often not the case. The decision to use interactive costuming is made by the head of production, director, or costume designer.

Karapanos et al. [24] developed a framework for user experience, using *appropriation* and *user experience* interchangeably. In their framework, user experience is a temporal sensation characterized by three phases each driven by an underlying force: i) *orientation* by *familiarity*; ii) *incorporation* by *functional dependency*; and iii) *identification* by *emotional attachment*. They explain that prior to use, humans form expectations based on anticipation [24]. Their framework appears helpful for studying wearable costume use as it covers different levels of engaging with a technology by different stakeholders, different usage

scenarios, users' predispositions, and different appropriation effects over time.

RESEARCH DESIGN

Our study is based on a 2-year collaboration with a local youth ballet company, during which we created and staged three interactive costumes for “The little Mermaid”. The production involved ~100 semi-professional dancers. We worked in close collaboration with the performers, the director-choreographer and the costume department. Interactive costumes were created for two supporting roles (Seahorse, Figure 1; and Jellyfish, Figure 2, left) and for the antagonist of the leading role (Sea Witch, Figure 2, right). Over the course of the study, we repeatedly interviewed and observed participants and maintained close contact with departments who handled the costumes: stage management, set and lighting design. To analyse our data, we followed the theoretical frameworks of Hassenzahl and Tractinsky [15] to consider individual experience, and Karapanos et al. [24], to understand the dynamic processes of how different stakeholders were engaging with the technology (whereas [4, 5, 9, 10, 13, 32] do not cover these aspects).

Three Interactive Costumes in a Theatre Setting

Following a successful prior collaboration [29], the director-choreographer invited us to develop interactive light costumes for three roles in their upcoming production. In the following months, we developed the costumes in close feedback loops with the director-choreographer and dancers. The three costumes provide a mix between sensing and



Figure 1. (l-r) Typical ballet hand posture, thumbs held near the middle fingers; Positioning of conductive fabric (in red).

actuating on performers' bodies [35]; two involve implicit interaction [34] – the performer does not need to actively concentrate on the interaction, and the system reacts autonomous to the user's movements. Accelerometers integrated into Seahorse and Jellyfish translate wearer motions into light patterns on the costumes (Figure 1, and Figure 2, left). These implicit interactions subtly underline the motions of the sea animals. In contrast, Sea Witch (Figure 2, right) is designed for explicit interaction [34] – the performer actively controls the system. The dancer closes two fingers in a ballet hand posture (**Error! Reference source not found.**) to close an electrical circuit and illuminate addressable RGB LEDs in the shoulder area of the jacket. This explicit gesture demonstrates the Sea Witch's ability to perform magic. Jellyfish and Seahorse were created by an interdisciplinary group of design and engineering students, supervised by authors 1 and 3. Seawitch was created by author 1, working as external interaction designer, in collaboration with the theatre's costuming staff. Two HCI students assisted with dressing and collecting data.

As described in [20], we had struggled to integrate interactive costumes in a professional theatre setting due to structural, political and individual challenges. For this study, we collaborated with a youth ballet because their ideation and choreographic work takes place over ~six months (an adult production takes 2-3 months), and youth performers were curious to explore interactive costuming.

Methodological Approach and Research Process

A model of the research process is at Figure 4 and a timeline at Figure 5. We conducted a longitudinal case study to realise an in-depth investigation of how stakeholders experience and appropriate interactive costuming over time [8], with emphasis on qualitative data and analysis [27]. We used an action research approach for the field work; actively engaged with the theatre production and closely collaborated with all costume stakeholders while “incorporating a new piece of technology into daily practice” [16]. The theatre setting enabled us to examine the deployment of interactive costumes in the stakeholders' natural environment while collecting different types of data [27]. Method triangulation [8] was key for our longitudinal study to collect and combine multiple perspectives on the object of study. Our data collection methods include:

- multiple *interviews* with costume wearers and the director-choreographer;
- regular *informal conversations* with: costume, set and lighting designers, wardrobe supervisor, tailors, theatre dressers, lighting technicians, fellow dancers;

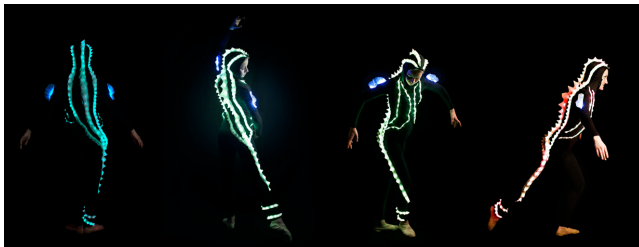


Figure 3. The implicit interaction mode of the Seahorse: while moving the light color changes.



Figure 2. (l-r) Jellyfish; and Sea Witch.

- continuous *observation* of costume stakeholders as participants in the production;
- *field notes*, recording informal conversations, observations and the social/ environmental context;
- the first author kept a *research diary*, collecting organizational details and media material (e.g. flyer, rehearsal plan, contact details, photos, video); production-related information (e.g. emails, protocols of early informal meetings, dancer measurements); reflections on the research progress (e.g. intermediary discussions of the researcher team, early data reflections and interpretations); and for recording personal impressions on the whole study.

The Figure 5 timeline includes pre-production and ‘the run’ (the period when public performances take place). Pre-production included creation of Seahorse and Jellyfish costumes and a rehearsal prototype of Sea Witch. Sea Witch was completed in the production period, shortly before the run. A preview and 5 public performances were presented over 18 months (Figure 5). During this time, we observed the performers using the costumes in rehearsals and performances. Key stakeholders reported here are:

- 6 performers – 2 for each costume/role: Jellyfish (JF1, JF2), Seahorse (SH1, SH2), Sea Witch (SW1, SW2); SH and JF performers changed post performance three, SH2 participated in costume testing from the beginning. SW1 and 2 started together. SW2 left after performance two.
- The director-choreographer – one person performed both roles: creative director and choreographer.
- Costuming and wardrobe staff: inhouse costume designer and tailoring staff (present until the first run); wardrobe supervisor (present at the beginning of each rehearsal period); and dressers, (only one present the whole run).
- Lighting staff – the lighting master, who was also light designer, and the lighting technicians.
- Fellow dancers (present throughout the study).

Additional stakeholders include wardrobe mistresses, stage manager, theatre director, sound and stage technicians, parents, the first author and student development team.

For data analysis we used thematic analysis [3] to structure and sort the interviews and observational notes in a first pass (cp. Figure 4). We then used affinity diagramming [30, 28] to revise the themes and arrange them in relation to other data, including notes on the design process and intermediary reflections of the research team.

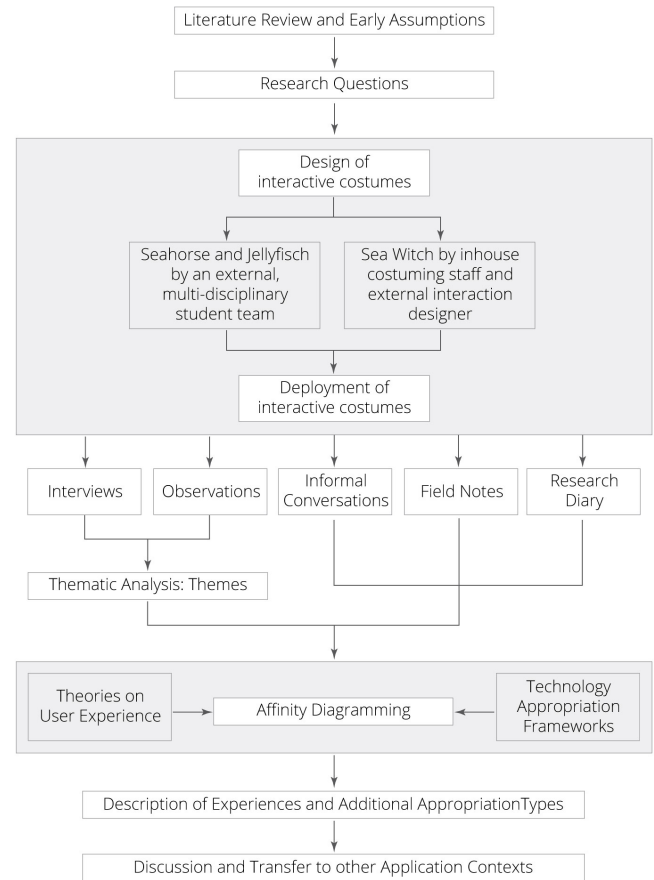


Figure 4. Research Process Model

Operationalizing Experience and Appropriation

Our literature review guided our analysis of how wearers and stakeholders experience and appropriate wearable costuming. We summarised it into a conceptual framework (Figure 6). As illustrated, the experience of (inter)acting with a wearable costume comes first, and results in different levels of appropriation (indicated by the large downward-pointing background arrow). According to Hassenzahl and Tractinsky [15], experience has three main aspects. In theatre settings, these are: 1) *expectations, thoughts, and feelings of all stakeholders in contact with the wearable costume*. 2) *The design of the costume, its system architecture, interaction, and intended usage*. 3) *The systemic and contextual structures of the theatre setting in which the wearable costume is deployed*.

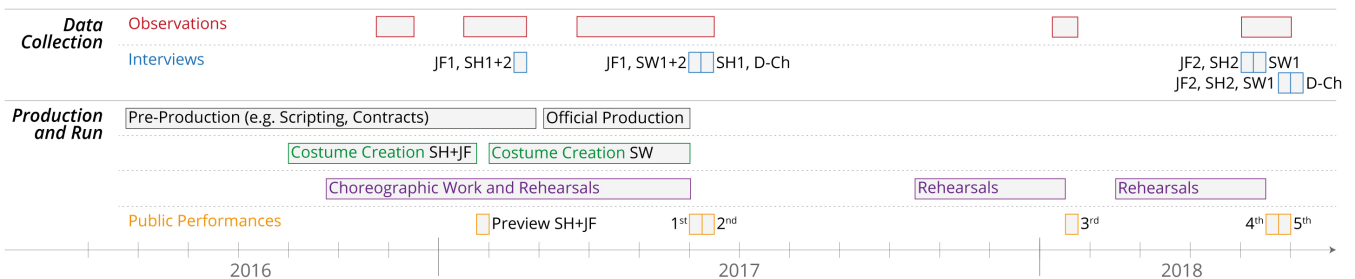


Figure 5. Study timeline. JF: Jellyfish Dancers; SH: Seahorse Dancers; SW: Sea Witch Dancers, D-Ch = Director-Choreographer)

For the appropriation part of our framework, we build on Karapanos et al. [24]. We expected A) *familiarity effects* to arise first, through contact with interactive costuming. Next, B) *functional dependency effects* occur when the costume becomes meaningful for stakeholder activities. Finally, the highest form of appropriation arises when the garment becomes part of the stakeholders' identity and they display C) *emotional attachment effects*.

Here, we discuss our insights into the experience of working with interactive costuming. We analyse how stakeholders appropriate such costuming developed for a youth ballet. We begin with Karapanos et al.’s framework [24] and extend it with two additional types of appropriation: *professional reserve* and *polite indifference*.

Our data suggests that it is not ‘an’ experience [9], but a set of experiences that stakeholders of interactive costuming go through over time. Following a bottom-up approach, we cluster these experiences into how wearing an interactive costume feels (*wearability and feeling disguised*), how stakeholders perceives the technology (*levels of trust in technology differ*), how a performance is influenced by the costume (*performative freedom and mode of interaction matter*), how the costumes are perceived (*perception of special features diverges*), and how interactive costuming changes work routines in a theatre environment (*challenging the existing theatre ecology*).

Here, we focus on psychological and physical sensations of primary stakeholders: the wearers of interactive costumes. The costumes allowed for all possible movements – a crucial requirement of SW dancers and choreographer. All dancers stated that the costumes were comfortable to wear. They reported only on a few minor issues that restricted comfort. For instance, SH and SW felt very warm in their costumes. After the first use, both SW dancers mentioned they sometimes feel the cables inside the left sleeve. Both JF dancers felt the battery pack on their back in early rehearsals. However, in the final interviews, all dancers stated that they did not feel the integrated technology. SH2 explained “it was a costume like every other.”

illumination. The JF dancers explained that the shape of the balloon dress helped them feel like a jellyfish sliding through the deep sea. The SW dancers explained, the enlarged shoulder area, hat and make-up helped immerse them in the role, in addition to the effect of performing magic. This influenced their body posture, made them feel elegant and powerful. In contrast, SH dancers could not provide a good reason why the costume helped immerse them in the role. SH1, found that the costume was not recognizable as seahorse, a prior comment by her family.

[illegible]

Figure 6. Conceptual framework for experiencing and appropriating interactive costumes, over time: 1) *Psychology* and 2) *physical sensation* relate to the person experiencing the 3) *costume* within a 4) *given context*. This experience leads to appropriation effects of different valence, from A) *familiarity* through B) *functional dependency* to C) *emotional attachment*.

Our findings: i) *Over time, the wearers hardly notice the technology anymore.* ii) *The shape of a costume is more important than light effects for immersing into a role.*

Levels of Trust in Technology Differ

Here, we focus on how wearers, the director, and theatre dressers perceive the fragility and construction of interactive costumes, how they finally trust the wearable technology. All SH and JF dancers mentioned the need to be very careful with the costumes. Yet, our observations revealed that dancers regularly forgot not to sit on them and did not handle them carefully after undressing. We interpret this carelessness to indicate that the dancers trusted the technology after a familiarization period. In their first interview, SW dancers reported concerns about breaking something. Almost a year later, SW1 said she trusted the robustness and stability of the costume very much. Notably, she always had positive experiences with the costume technology. In contrast, SW2 had less rehearsals with the technology, so was less familiar with it, her costume repeatedly failed, and she was more sceptical.

We found that dressing needs clear instruction and extra help to decrease reservations about wearable technologies. Although the choreographer could explain the operating modes of all costumes correctly, she explained that “help for (un)dressing and maintenance seems to be needed due to complex construction of costumes.” We observed issues when support for dressing was lacking: Both JF dancers forgot to unplug connections before undressing. This costume had the most complex hardware design and was only to be handled by the costume creators. Differently, the SW and SH dancers were able to dress without external help and easily insert batteries to start the system, though forgot were to put the batteries after a long pause between rehearsals or performances (around half a year).

The director-choreographer, lighting designer, technicians, and all dancers were very open minded and curious to wear the interactive costumes and integrate them into this particular production. However, the theatre dressers showed apprehension of the wearable technologies. At the beginning, the dressers avoided to touch the interactive costumes (e.g., to hang them in the dressing room). Their apprehension diminished over time. After more than half a year, the dressers would hang the costumes when external staff were unavailable. In the final two performances, one dresser, who was in contact with the costumes throughout the study, helped dress SW. Based on our observations and informal conversations, we discovered that theatre dressers are usually less interested in technologies, and thus need positive experiences handling costumes to become familiar.

Our findings: i) *The more positive (or negative) experiences are made, the more the stakeholders trust the wearable technology (or not).* ii) *Level of trust varies depending on the stakeholders' general interest in technologies.*

Performative Freedom and Mode of Interaction Matter

Here, we focus on how primary stakeholders and the choreographer assess handling of the costumes, and perceive working with them. SW1 appreciated being independent from offstage operations through the interactive freedom she had – her costumes is not controlled by technicians behind the scenes and she does not need to synchronize with it. She had the power to decide when and how long the costume shall light up. We observed that she started to improvise at the end of the first rehearsal period while performing magic in some scenes. From an observer perspective, this seemed more natural and intuitive. Although both SW dancers stated in early interviews that they need to frequently rehearse the interaction gesture, SW1 later – once she was confident to perform on an improvisational level – declared more rehearsals were not needed. This indicates that the perceived performative freedom made it easier for her to represent the role.

All dancers started interacting with their costumes on a *cognitive* level (cp. [9]) because it was a new experience and the wearers learned how to interact with the costumes. Later, SH and JF developed what can be described as *fluent* experience with their costumes [9]; their costumes did not require direct attention due to the implicit interaction modes. The dancers did not wish more rehearsals. The interviews with all dancers of SH and JF also revealed that they neither cared about the costumes functionality onstage nor did they recognize how exactly the costumes worked. In contrast, SW dancers could explain their costume's functions. The costume was based on explicit interaction and thus provided an *expressive* experience [9] once the wearers became familiar with them.

The choreographer reported her impressions that all dancers appeared more confident after rehearsing. The explicit interaction of SW needed extra time to train the gesture, and the dancers were involved in the development of choreography due to their first-person experience. For SH and JF, the choreographer considered how the light effects appear onstage and developed the choreographic score without their involvement.

Our findings: i) *Explicit interaction requires more rehearsal time than implicit interaction but provides more improvisational freedom.* ii) *Explicit interaction mode further involves performers in choreographic work due to their first-person experience.*

Perception of Special Features Diverges

Here, we focus on how all stakeholders and other people (e.g. the audience) perceive interactive costuming. All were impressed by the light effects, and when asked how they like the design solution, most dancers referred to the light as ‘something special / extra-ordinary’. SW1 was continuously happy about the costume and interaction effect and stated that the costume is an incentive to dance better; even if spectators might not see that she controls it, for her it is part of the magic. Similarly, JF2 stated in a later interview that

she became more fascinated by her costume after wearing it a few times. The director-choreographer confirmed that all dancers were excited to work with this new type of costume and the dancers who wore them appeared very proud. She personally had never seen interactive costumes at a theatre stage before. She found the illumination effects exceptionally fascinating (“zauberhaft”). However, two other dancers, supposed to dance a quadrille with SH and JF, expressed concern to the choreographer that their performance might disappear next to the highlighted costumes.

All interviewees confirmed they only got positive reactions from the environment (other dancers, theatre staff, parents). Parents were reported to have said that the lighted costumes fit the underwater topic very well. We could observe, that other dancers became quite pleased and expressed admiration when the interactive costumes appeared. We interpret this as an indicator of excitement. We observed that the younger ballet dancers seemed impressed when seeing the lighting costumes backstage. In comparison, the older dancers seemed less overwhelmed after seeing the costumes multiple times, but were still fascinated.

The lighting technicians gave positive feedback. They were interested in how the costumes work (what technology is in there and for what else could it be used). In contrast, staff members who work professionally with costuming (designer, dresser, wardrobe mistress) did not give their personal opinions on the effects during our informal conversations. Similarly, the director-choreographer told us that the theatre’s director did not mention the illuminated costumes at all, although he seemed to support the piece in general. This indicates that some professionals perceive interactive costuming as ‘just another piece of technology’ within the theatre context because there is already a large range of technology involved in a performance, from light and video projections through microphones and speakers to lifting and rotating platforms.

Our findings: i) *The majority thinks the light effects are a highlight for a performance show.* ii) *A few professionals do not say at all that interactive costuming are special.*

Challenging the Existing Theatre Ecology

Here, we focus on concerns the director-choreographer and theatre staff regarding creation, staging, and maintenance of interactive costuming. Although initially intended, it was not possible to fully hand over the interactive costumes due to their fragility and high maintenance needs. The director-choreographer mentioned this as an issue. Interviewing her and informal conversations with the wardrobe supervisor revealed that they appreciated the ongoing support of the external team. According to the director-choreographer, the tailoring and wardrobe staff would not have been able to create and maintain the costumes without the knowledge and skills provided by the externals. She remarks this is a new situation for the theatre staff and requires higher efforts. It is a new challenge, compared to traditional costumes. The

lighting staff were responsible for recharging the batteries after each performance, and fulfilled this task without complications. The dancers perceived few challenges for the theatre processes: SW commented that “the costume could be easily integrated in the flow behind the scenes” although she was aware she was not fully informed about what is happening backstage.

The director-choreographer further stated that staging a performance with interactive costumes generally needs more time and consideration with regards to choreographic work, lighting, maintenance, dressing. She commented on the challenges that appear during 1) the costume design process, 2) choreographic work, and 3) the run. 1) The costume designer is reported to have said that creating an interactive costume was more work for the tailoring department because they often needed to wait for feedback from the external interaction designer and cannot simply work on the costume when they have resources to do so. 2) It took longer to develop a balanced choreography than usual. For SH and JF, it was because she needed to balance the illuminated costumes with the non-illuminated ones for a quadrille, so that no costume overwhelms the others. For SW the challenge was to create less complicated scores during the moments of performing magic. 3) Lighting of the scenes with the interactive costumes also needed more time to ensure the stage light did not overwhelm the costumes’ illumination. Finally, dressing the costumes was perceived as a huge challenge, as described above.

Our findings: i) *In general, it is experienced as more time-consuming working with interactive costumes than with usual costumes.* ii) *The creative staff needs to balance the interactive costumes with all other elements of the show.*

Appropriating Interactive Costuming

Based on stakeholder experiences described above, we observed five types of appropriation for wearable costuming, over three levels (Figure 7): i) *time-based familiarization* and *professional reserve*; ii) *functional dependency* and *polite indifference*; iii) *emotional attachment*. Appropriation increases from level 1–3 (from outer to the inner circle, Figure 7) and depends on a range factors: closeness, time working with, interaction modality, personal taste, social influence. Additionally, effects on one level can interweave or change polarity (e.g. from *time-based familiarization* to *professional reserve*). A more detailed description follows, including the interrelations.

Time-Based Familiarization

Most stakeholders and all wearers became familiar with the technology over time. Once achieved, dancers in this phase of appropriation deem further rehearsal time unnecessary. We could not identify a particular timespan needed to achieve this level of familiarisation. We found it depended on a person’s closeness to the interactive costuming (e.g. dancers wearing the costume vs. fellow dancers). The less time spent working with the costume and more respect shown for technologies (e.g. the theatre dressers in our

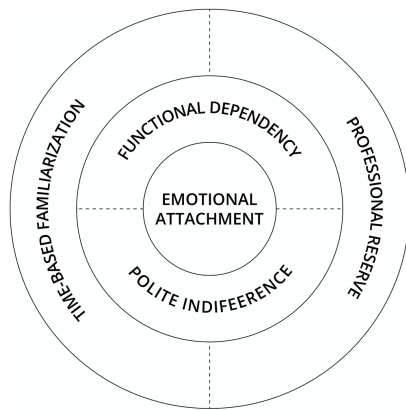


Figure 7. Appropriating interactive costing (adapted from [24]). Appropriation evolves from outer to inner. Some remain on the first level (time-based familiarization / professional reserve).

example) the more time was needed to achieve this first level. There was a loss of fear observable when dressers collected numerous positive experiences with the interactive costumes – they literally came closer to the wearable technology after a while. On the other hand, if stakeholders showed general interest in (innovative) technologies, they were even faster in establishing a daily routine with the costumes, for instance, the lighting staff.

Time-based familiarization also means that costume users became only fully engaged with the technology when using it on a regular base. Then, they got more confident in using the interactive costumes. If they did not use it regularly and after a longer break from working with the interactive costumes, it happened that they forgot how to handle the technology. For instance, two third of the dancers forgot where to plug in batteries and how to turn on the costume after more than half a year.

Professional Reserve

For some stakeholders, we did not identify familiarization effects as they did not have time with the finished costumes. Those stakeholders behaved dissociated, forming less connection with the costumes. The costume designer and tailoring team were only involved with the wearable technologies while conceptualizing and crafting SW. Beyond short initial explanations, they showed little interest in the integrated e-textile and electronic materials or in the final costumes themselves. All other theatre staff members were curious and kept commenting on the costumes during informal conversations (e.g. the stage manager). Yet stakeholders did not actively reject the costumes and rather behaved very professional. *Professional reserve* thus has a neutral stance and does not constitute negative appropriation. We consider this a complementary type of appropriating technology on a first level.

Professional reserve was displayed by other theatre employees, who reacted positively when asked but developed a professional distance after first contact with the interactive costumes. They seemed to understand the

costumes ‘as just another piece of technology in the theatre environment’, e.g. the stage and lighting technicians.

Functional Dependency

According to Karapanos et al. [24], *functional dependency* is an underlying force of incorporating technology into one’s daily life, resulting in experiences that are connected to the usefulness of the technology. Davis explains that usefulness becomes important when users are familiar with a technology, when it helps to get a job done faster, easier, more efficiently, when performance and productivity increase through the use of a technology [24]. In the case of interactive costing: when a role can be performed more easily and effectively, is more immersive and perceived as more convincing through the wearable technology.

We identified *functional dependency* at an early stage for the director-choreographer, SW dancers and lighting operator. The first depended on the properly working stage technologies, including the costumes, for the overall gestalt of the performance, where every detail has its meaning; the show must touch the audience and the costumes are an essential part that process. The SW dancers relied on the functionality of the costume to ‘perform magic’ through the explicit interaction incorporated into their role. The interaction was designed for a key scene where the little Mermaid was transformed to a real human. If the technology failed, the dancers ability to express ‘magic’ would have been restricted. The lighting operator lowered the ambient stage lighting for the scenes where the illuminated costumes appeared and relied on the correct functioning of the costumes to achieve the overall illumination on the stage. In contrast, JF and SH were not functionally dependent on their costumes because the light effects did not directly influence their performativity. Although the costumes made them feel good and important in the overall production, if the costumes failed, it had no real impact. Concluding, we assume *functional dependency* is higher if the interactive technology is perceived as an essential component for the performance.

Polite Indifference

Dancers who wore an interactive costume but did not show functional dependency or emotional attachment, seemed to become dispassionate after the familiarisation phase. They did not become apathetic – they still spoke positively and seemed fascinated by the interactive costumes when asked for their latest experiences while rehearsing or performing. Nonetheless, they built professional distance to the costumes and did not treat them carefully anymore.

This behaviour differs from professional reserve. Stakeholders who were professionally reserved, were tertiary stakeholders who had not shown familiarization effects. *Polite indifference* only occurs for primary stakeholders (the wearers), after becoming fully familiar with the costume. When asked about the proper functionality and usefulness of the costume, some wearers said that they are aware of the operating status and wow-effect on spectators. Yet, they either did not care when a costume did not work correctly or

did not recognise when light effects failed in any way. Similar to professional reserve, *polite indifference* is not a negative type of appropriation, because stakeholders did not actively avoid the costumes. We consider this a complementary type of appropriating technology on a second level.

Interestingly, *polite indifference* only occurred with wearers of interactive costumes designed for implicit interaction (JF1 and both SH dancers). We know that they were all socially influenced, by family members or friends who saw them dancing in the costume. The brother of JF1 said she looks fat; the family of SH1 said it does not look like a seahorse but rather a hedgehog; and friends of SH2 wondered how she could dance with a hood hiding her beautiful blonde hair. When asked in their final interviews, both SH dancers revealed that they did not really like the black, asymmetric design of their costume – irrespective of the influence of their social environment.

Emotional Attachment

Attachment effects are strongly related to emotional aspects. Karapanos et al. describe *emotional attachment* as identification with the technological device [24]. Emotions affect the interaction [9, 14]. In our case study, only JF2 seemed to love her costume. In her interviews, she was fascinated by the costume, absolutely grateful to wear it onstage, wished to wear it more often. She felt emotionally attached and seemed to identify herself as a performer through that role and costume. She told us during interviews that her family also liked the costume. Based on these findings, we believe the key driver of felt ownership of wearable costuming is *emotional attachment*. It appears when experiences are characterized through big positive emotions, supported by the environment.

Both SW dancers were happy with their role and costume. In particular the SW1, who wore the costume throughout the study, repeatedly expressed that she likes the role very much and the unexpected powerful design of the costume. This response shows a strong tendency to *emotional attachment*. However, SW1 also agreed that ‘professional performers are used to wear any kind of garment’ and that everyone inside a production relies on the given structures. In contrast to JF2, SW1 maintained professional distance to her costume and thus was not fully emotional attached.

DISCUSSION

The *experiencing* and *appropriating* types we described are not static. Rather they should be understood as an ongoing process of experiences and continuous development of appropriating interactive costuming. Appropriation types were partly adopted from Karapanos et al. [24]. According to these authors, the effects occur one after the other for each studied user: first *familiarization*, second *functional dependency*, and lastly *emotional attachment*. Our explorations revealed two new aspects for professionals: when these stakeholders develop a physical (*professional reserve*) or psychological (*polite indifference*) distance to the

interactive costumes. Significantly, participants in our study did not necessarily pass all three levels of appropriation. For some users, only *time-based familiarization* (e.g. theatre dresser) or *professional reserve* (e.g. tailors) occurred, others showed *time-based familiarization* effects and later *polite indifference* (e.g. Seahorse dancers) or *functional dependency* (e.g. director-choreographer). Only one person developed *emotional attachment* (Jellyfish dancer 2). This finding indicates that appropriating technology is different in professional contexts, depending on whether use of the technology is voluntary, the stakeholder’s background, their closeness to the technology, the type of interaction engendered and further contextual influences.

Implications for Introducing Interactive Costuming

Integration into Existing Practices

Our study demonstrates that interactive costuming is perceived by most professional stakeholders as another piece of technology in a technology-loaded environment. The new technology needs to be easily integrable into the existing workflows and practices for stakeholders, although balancing interactive costuming within the overall show sometimes proved a challenge. Production staff need time to get used to interactive technologies [20, 26]. New technology should allow for stress-free and, if possible, fast incorporation into stakeholders’ workflows. We imagine, for instance, preparing a costume manual with clear instruction for handling and maintaining an interactive costume.

In our example, costuming staff had issues integrating the wearable technology into their work routines. Perceived challenges may have been reduced with e-textiles and electronics training, e.g. through a short workshop; or if the interaction designer worked in their lab instead of preparing her contributions externally. Providing such solutions, may help prevent the development of *professional reserve*.

We agree that performers and other costume stakeholders should be involved in the design process [12, 20]. Indeed, prior research finds that early technology introduction has a remarkable impact on choreographic work [26]. We also found that early costume rehearsal was appreciated by the choreographer who needed to balance the costumes against other roles. Further, early fittings and rehearsals can ensure wearability and correct positioning of costume technologies, and lead to a better performance when wearing the costume during main rehearsals and run. Finally, we suggest a participatory design process to support a deeper engagement with interactive costuming, to reduce *polite indifference*, as demonstrated by some performers in our study.

Design for the Show

Karapanos et al. [24] suggest *design for the self* encourages people to become attached to technology. In contrast to their study with laypersons, we found only one performer achieved *emotional attachment*. This suggests that this level of appropriation might not be usual in the performing arts, where the wearer may have little control over the choice of

what technology to wear. Moreover, in professional contexts it seems not essential that stakeholders become emotionally attached to technologies that are basically tools to do a job. Rather, the stakeholders in our example were convinced that the costumes support the overall outcome of the performance and that the audience feels attached to what they see. We thus recommend designing for the show in preference to individual needs.

Significantly, we found explicit interaction provided more improvisational freedom and required more rehearsal time and engagement while performing. As a performer needs to concentrate on presenting their role [20], cognitive load and arousal should remain at minimum for interaction with an interactive costume. The interaction concept must be carefully considered and as little demanding as possible to enable the performer to concentrate on their performance as a whole. If available for the same effect, implicit interaction should be the preferred choice over explicit interaction.

Create Positive Experiences

Familiarization needs time and habituation is normally based on an accumulation of positive experiences. Introducing interactive costuming thus should be designed to provide positive experiences, e.g. costume creators should not conduct technology tests with stakeholders when the technology is not yet ready. Critically, prior research shows that shared tests with functioning technologies remain a risk when stakeholders are not open-minded [20].

A backup plan in case technology fails is important when stakeholders depend on costume functions. Sea Witch dancer 2 repeatedly faced broken costume technologies while rehearsing. This situation made her nervous, in particular during the final dress rehearsal, the day before the premiere. If performers have rehearsed technology fails and have guidance to improvise, they will feel better prepared; more at ease with the technologies; and better able to perform than when nervous, uncertain, or concerned.

Finally, to reduce negative social influence, the interactive costumes could be introduced in a broader context, to prevent misunderstanding of the costume concept. Booklets or a public introduction before the show are typical marketing activities by theatre houses. Introducing interactive costumes through these means could help to prevent negative social influence on stakeholders and peer-pressured *polite indifference*.

Relevance for Other Professional Fields

The study presented here is a first step to understand how professional stakeholders adapt to wearable technologies. We looked at interactive costumes deployed in the performing arts that “have no targeted end users in the commercial sense ... [and that] are cut off from everyday social interactions” [33]. Nevertheless, our insights may be interesting for introducing wearables in other professional environments. For example, for firefighters [37], factory workers [17], or animators of motion sequences [22].

Other professionals experience *time-based familiarization* with specialised workwear, and demonstrate different levels of trust depending on personal backgrounds and closeness to the wearables. Further study is needed to determine if the perceived performative freedom while interacting might be an aspect appreciated by primary users in other fields. Our findings indicate that performers prefer if the interaction allows for improvisational freedom. Nevertheless, performers might (re)act differently than people outside the performing arts, in particular regarding movement and other trained behaviours. Future research should study more cases to validate our findings, and investigate how far the context of the performing arts is generalisable and if behaviour of respective stakeholders is transferrable.

CONCLUSION

We presented the study of a ballet production incorporating three interactive costumes. We focused on appropriation processes of wearers and stakeholders of interactive costuming and how they experienced working with the wearable technologies. Our investigation revealed five aspects important for experiencing interactive costumes. These are: 1) wearability of costumes and feeling disguised, 2) levels of trust in technology differ, 3) performative freedom and mode of interaction matter, 4) perception of special features diverges, and 5) challenging the existing theatre ecology. Based on the experiences of stakeholders when working with interactive costuming, different levels of appropriation emerged. These are: A) *time-based familiarization* or *professional reserve*, shown by all stakeholders in our study; B) *functional dependency* or *polite indifference* shown by some primary and secondary stakeholders; and the strongest but rarest type of appropriation, achieved by one costume wearer in our study: C) *emotional attachment*. Based on these findings we detail three recommendations to consider when introducing interactive costumes: 1) *integration into existing practices*, 2) *design for the show*, and 3) *create positive experiences*. Beyond the performing arts, future research needs to investigate how these findings map to other professional areas deploying wearables.

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