Mutation: Leveraging Performing Arts Practices in Cyborg Transitioning

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ABSTRACT

We present *Mutation*: performing arts based approach that can help decrease the cognitive load associated with cyborg transitioning. Cyborgs are human-machine hybrids with organic and mechatronic body parts that can be implanted or worn. The transition into and out of experiencing additional body parts is not fully understood. Our goal is to draw from performing arts techniques in order to help decrease the cognitive load associated with becoming and unbecoming a cyborg. Actors constantly shift between states, whether from one character to another, or from pre- to post- performance. We contribute a straightforward adaptation of classic performing art practices to cyborg transitioning, and a study where actors used these protocols in order to enter a cyborg state, perform as a cyborg, and then exit the cyborg state. Our work on *Mutation* suggests that classic performing art practices can be useful in cyborg transitioning, as well as in other technology augmented experiences.

Author Keywords

Cyborgs; performing art techniques; interaction design; user experience

CCS Concepts

•**Human-centered computing → Interaction design;**

INTRODUCTION

Humans transition in and out of states throughout their daily lives. These transitions and experiences dictate the way in which we integrate with and detach from non-human objects. For example, a person integrates with their vehicle when they transition into a "driver" state by entering and immersing

Figure 1. *Mutation*: **actors performing in cyborg state, while "wearing" Baxter humanoid supernumerary arms (A1 and A2, right to left)**

themselves in the vehicle's environment by acts such as wearing a seat belt, adjusting the seat and mirrors. The same person also transitions out of that state by leaving the car, thus detaching from their driver selves. Generally, these integration's with objects are made seamless by learned routines over a period of time and a deep understanding of the transition actions. But with the advent of new technology augmented experiences such as virtual reality (VR), mixed reality (MR) and wearables, the experiences of seamless integration and detachment are yet to be perfected [8].

We are interested in physical embodiment's of technological transformations, namely cyborgs. Cyborgs are human-machine hybrids with organic and mechatronic body parts that can be implanted or worn (e.g. [15]). The transition into and out of experiencing additional body parts is not fully understood. Transition experiences can be challenging because not only does the person have to adapt to certain physiological transformations (e.g., wearing additional limbs in the case of cyborgs), they also need to transform cognitively and overcome fear, build trust, and feel in control so as to effectively perform with their machine counterpart. Consider a factory worker who is asked to wear robotic arms, i.e. become a cyborg, to help them complete their tasks with less cognitive load and effort. This factory worker will need to become and unbecome a cyborg repeatedly and stay as a cyborg for long periods. How can a person become and unbecome a

cyborg in a healthy and maintainable way? As humans, we engage in actions and routines to help us with changing states and completing tasks, but how do we support such exercises when technology is involved, and the transition impacted is immense? This overarching question is the focus of our work. In this paper, we present *Mutation* (Figure 1) an exploration of the use of classic performing art techniques in the transitioning into and out of supernumerary arms cyborg state.

We draw from performance art methodologies to help us better understand how we might facilitate people to enter and exit technology augmented experiences. Actors constantly shift between states. Whether from one character to another, or from pre- to post- performance, actors are versed in shifting between psychological states [1, 4, 10, 17, 18]. Their work is measured by their effectiveness in the integrated state, and by their ability to move in and out of states quickly and efficiently over time. The requirements of their work have resulted in the development of a methodical process, warm-up and cool-down, for shifting states and returning to neutral. These methods include various exercises that support deliberate shifting of physical, psychological and emotional states. Motivated by the established strengths of these techniques, our work provides a reflection on how professional performers can use traditional warm-up and cool-down techniques to help them in becoming and unbecoming their cyborg selves.

The current *Mutation* prototype uses a Rethink Robotics Baxter humanoid robot to simulate wearable supernumerary cyborg arms. Padding and a system of comfortable straps were added to the robot, allowing the actor to "wear" Baxter's two arms (see Figure 1 and Video Figure). Over five design phases, we collaboratively worked with professional actors to craft the warm-up and cool-down *Mutation* cyborg protocols, leading to the actors preparing and performing a monologue as cyborgs. We present the effect of these protocols on the actor's integration and acceptance of having become a cyborg.

Overall, our work suggests that performance methods can be used for becoming and unbecoming a cyborg, and have potential in reducing cognitive load and making these transitions more effective. This paper is limited in its scope: stopping short of scaling our proposed approach to the general population or to wider cyborg experiences. *Mutation's* primary contribution is in it being, to the best of our knowledge, the first to detail, propose, and provide a preliminary implementation of traditional performance arts techniques to cyborg transitioning.

RELATED WORK

Cyborg science is an extensively researched and loaded domain. The topic ranges from Haraway's seminal work (e.g. [5, 6]), questioning and redefining the boundaries of being, deeply impacting feminism and post-humanism, through work connecting "everyday cyborgs" and the disabled (e.g. [23]), to provocative cyborg art and installations (e.g. [13, 14, 19]). Our approach in *Mutation* is very narrow and practical: we recognize that cyborgs already exist and are arguably common, and that cyborg technology is deeply impacting more and more people. We try to explore practical

new ways of transitioning into and out of cyborg states, stopping short of discussions related to the deep social and ethical questions and challenges involved in this exploration.

Practical cyborg examples have been discussed and prototyped by the HCI community (e.g. [3, 12, 15, 20, 21]). Projects such as MetaArms [15] examine the use of supernumerary wearable arms. These arms are worn like a backpack and give the user additional limbs allowing them to extend the range of available skills and manipulation possibilities. Other cyborg projects discuss potential uses cases for the technology such as lifting load [12], communication, navigation, [20] and video-logging [21], and are closely aligned with the practical context we set for *Mutation*.

Concerns regarding cognitive overload due to prolonged engagement in cyborg state were raised before, using examples relating to using exoskeletons in construction sites [22], and by Knibbe et al.'s exploration of the experience of exiting VR [8]. Knibbe et al.'s work delves into what they call the moment of exit, and reveals five components related to the exit of VR: space, control, sociality, time and sensory adaptation. Upon the exit of the VR state, users described how they exit, whether it be physically first and mentally second or vice versa.

Our efforts are inspired by these past efforts, and attempt to explore how people may experience both entering and exiting physical technology augmented experiences. *Mutation* adds to the growing body of literature by stepping back and exploring the experience of becoming and unbecoming a cyborg. While past research has proposed prototypes to aid people to become cyborgs by wearing additional limbs, how people transition into and out of that experience is not fully understood. *Mutation* turns to classic acting techniques, with their demonstrated success in helping performers become and unbecome characters, and proposes mapping these techniques to ease the cognitive load while transitioning into and out of cyborg states.

OBSERVATIONAL STUDY

Artistic research has well established methodologies that blend practical technique with various forms of data gathering and analysis. Given the nature of our project we have focused on performance-based research and practice as research models [7, 11], in conjunction with participatory design methods [2, 9] used in HCI to capture, analyze and disseminate results.

The methodology for *Mutation* consisted of collaboratively working with two professional actors (A1 and A2, Figure 1) who are very familiar with the performing techniques traditionally used for becoming and unbecoming a character. Over a period of two weeks we conducted seven sessions with the performers, consisting of the five phases described in this paper: introduction, rehearsal and design, integration, performance and debrief.

In our *Mutation* study, the actors prepared to become cyborgs using the warm up protocol, performed a monologue as a cyborg with two additional arms, and transitioned out of the cyborg state using the cool down protocol. The methods

used for the warm-up and cool-down protocols (explained in the next section) were selected based on their ubiquity in the world of performing arts. The "To Be or Not To Be" [16] monologue was chosen for this study. The selection of this monologue was done in consultation with the actors and research team. The reasons for its selection were popularity and content. As one of the best-known speeches in English, we felt it would be suitable for research designed for a global audience. Furthermore, the message of the speech, which is about choosing whether or not to accept a new way of being, seemed thematically relevant to the choices we make when we find ourselves working in an environment that calls for a change of state.

For the *Mutation* study, qualitative data was sought to better understand the evolution of the actors' into and out of the cyborg state. Actors have extensive training in state-change, and in the articulation of the process of becoming and unbecoming. In order to develop their craft their process entails the development of a rich vocabulary of experiential observation that promised a specialized form of reporting that is not common with non-actor participants, thus making them a rich source of qualitative data. This data was collected in the form of written journals, which the actors carried with them through every session, from video recordings of the study sessions and interviews, as well as constant observation from the researchers throughout the sessions.

Warm-Up and Cool-Down Protocol

The actors used a three-step protocol, for both the warm-up and cool-down, based on common performance practice. These exercises are conducted before attaching to and after detaching from *Mutation's* supernumerary robotic arms. Furthermore, the actors performed a warm-up exercise immediately upon attaching to their wearable (described below). These techniques support the actor in the transition processes by targeting physical, mental and emotional transformations (see also Figures 5,6 and Video Figure). The techniques used were:

1. Instrument: actors place feet in parallel, align their posture and close their eyes. This exercise allows the actors to conduct a "mind and body scan" to "tune up". Focused breathing is a key part of this routine. This exercise targets both the mental and physical aspects of transformation.

2. State: the actors use a "sense-memory exercise" to bring their psychological state to neutral. The actors close their eyes and use visualization techniques, which bring emotional and mental states to neutral. This exercise is used to restore the actor to a neutral state after state changes. By focusing on a singular image, the actors can regain their composure and calm regardless of their previous state.

3. Roll downs: Here, the actor slowly reaches for their toes, and go back up to a natural position. The actors integrate core muscles, the spine and the breath to create an integrated body-state. This releases tension and warms up the breath and body.

4. Cyborg Warm-Up: Upon attaching to their *Mutation* supernumerary wearable arms, the actors execute a series of

Figure 2. Checking the limits: experimenting with different cyborg attachment positions; A1 stands on Baxter's base.

gestures in tandem with their wearable. This gives the actor the chance to "synchronize" with their wearable's movements. This exercise emerged as a result of a demo routine of the gestures that the researchers created. This demo, and the gestures, are described below.

Introduction and Familiarization

The goal of this phase was to introduce the research topic to the actors, and to familiarize them with cyborg interaction. This phase was conducted in one session lasting four hours.

To solidify the actors' understanding of the targeted cyborg concepts, images and videos were shown of cyborgs with wearable technologies in popular media. The actors were also exposed to hypothetical "end-goal" cyborg interactions such as a factory worker who needs to wear a set of arms and become a cyborg. This was followed by an explanation of the research goal and the breakdown of what tasks need to be accomplished, namely:

1. define a warm-up and cool-down protocol based on traditional performance art techniques

2. design and implement a gesture language to be used during the performance

3. practice the performance of the monologue before the final performance in which the warm-up and cool-down protocol will be executed before and after the performance piece

The actors were then introduced to the Baxter robot, which served as *Mutation's* study wearable. After going through
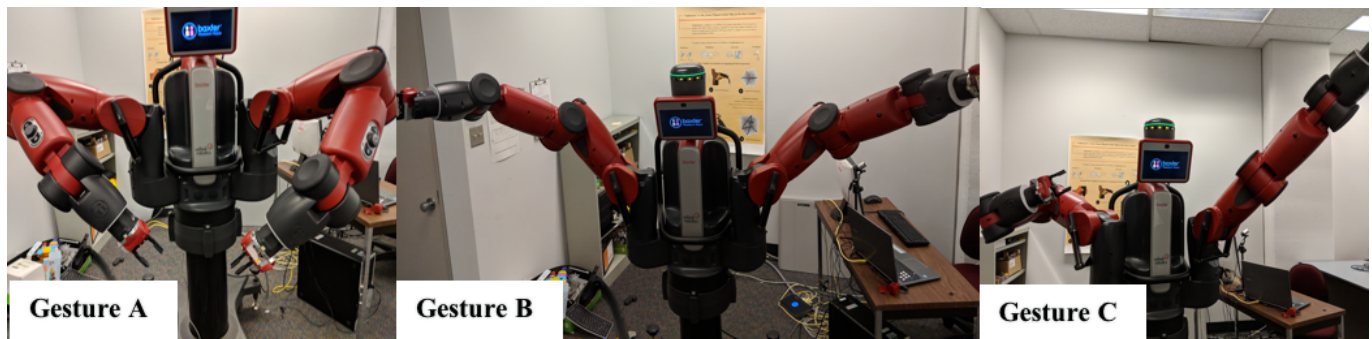
Figure 3. Baxter demonstrating the three fundamental cyborg gestures designed by the actors and researchers(from left to right: A,B and C).

safety instructions, a short demo highlighting Baxter's movements was shown. The actors were then given time to familiarize themselves with Baxter's capabilities and limitations (Figure 2). This provided the actors with the context in which their monologue will be performed, and the limitations in which Baxter can move during the performance.

We observed that in this phase, the actors were already experimenting with different ways to enter the cyborg state based on the physical integration with their wearable. Different positions and straps were used before the actors found their ideal position to wear *Mutation's* cyborg arms.

The actors then began experimenting with the range of motion of the Baxter robot's arms. While doing this, the actors were discovering the gestures and positions their wearable arms could be placed in during the performance, as well as gaining insight into their cyborg selves' capabilities.

The actors began writing in their journals during the first session, and continued to do so in every phase of the *Mutation* study. The actors were asked to document their thought process during the phases. Throughout this session, the actors highlighted their initial thoughts on their cyborg selves and what they think of Baxter's capabilities.

Rehearsal and Design
The purpose of this phase was to allow the actors to rehearse the performance piece, warm-up and cool-down techniques, and, in collaboration with the researchers, to design gestures for *Mutation's* wearable arms. Furthermore, the researchers developed a demo routine to test the gesture combinations on the wearable. This phase took place over three, three-hour sessions. These sessions were conducted on multiple days so that the researchers had time to design and implement the gestures. In the first session of this phase the actors began by analyzing and practicing the Hamlet monologue without any props. This was necessary to allow the actors to understand the performance piece before attempting to perform it as cyborg entities.

Also in the first session, the actors and researchers discussed which warm-up and cool-down techniques will be used in the protocol. The protocol was designed to be two minutes in length, and the actors practiced the protocol to familiarize themselves with this length.

In the second session of this phase, the actors and researchers collaborated to create three unique gestures to be executed by *Mutation's* additional wearable arms. This was done to give the actors a "gesture language" to follow when performing. These gestures are referred to as gesture A, B and C (see Figures 3, 6). The researchers then implemented these gestures on Baxter and created a Wizard of Oz algorithm controlling the transitions using an administrator's keyboard presses. This was followed by the implementation of a demo routine in which *Mutation's* wearable arms executes combinations of the three gestures. This demo was presented to the actors in the integration phase.

In the third session of this phase, the actors first spent time rehearsing the gestures without their wearable arms. This process included human-human interaction between the actors, where each actor spent time as the other actor's cyborg arms (Figure 4). This provided the actors with a basis on which they can form contextual understanding of how the gestures can fit into the monologue, as well as determine gesture comfort, before the gestures were fully implemented. This process also helped illicit further data for use in the implementation of *Mutation's* gestures, as using another human's arms aided in the visualization of where the actors wanted the arms to be for each gesture.

Integration
In this phase, the actors explored integrating with their additional cyborg arms and performing using the pre-determined gestures. This phase included filming of the actors in the cyborg state, which was used to illicit feedback on how the gestures are functioning. Actors provided feedback on the gestures including: The cyborg arms' exact position for each gesture and the speed of transition between each gesture. *Mutation's* implementation was then iterated based on the feedback collected. This phase took place over two four-hour sessions.

With the *Mutation* gestures now fully implemented, the actors spent time experimenting with how each gesture feels. Following this, the actors created a "gesture score". that structures the gesture transitions in the manner that the actor feels will support their performance. In this gesture score, the actors specified the exact location in the monologue script where they want that gesture to begin executing. Each actor created their gesture score based on what emotion they

Figure 4. Human-human supernumerary arms session: A2 mimicking A1's cyborg arms in gesture C.

Figure 5. A1 performing the instrument exercise before entering cyborg state.

wanted their cyborg self to elicit in that particular moment. For example, one actor wanted the starting position of the cyborg arms to be in gesture B, and have them transition to gesture A when the second line of the monologue is read.

This phase concluded with a "dress rehearsal". Traditionally, a dress rehearsal for a performance is used to smooth out any wrinkles, and to test out the technology before the real show. Similarly, the dress rehearsal at the end of this phase helped the actors and researchers finalize the warm-up and cool-down protocol, debug the gestural implementation as well as finalize physical integration ideas such as the strapping techniques.

Performance
The goal of the performance phase was to record the final performance of the actors using *Mutation*. This included executing the warm-up protocol, performing the monologue and executing the cool-down protocol. First, the initial warm-up protocol was conducted before entering the cyborg state (Figure 5). Then, upon strapping into Baxter, the cyborg warm-up was executed (Figure 6). The monologue performance was then completed, followed by unstrapping and executing the cool-down protocol.

The performance process was repeated six times for each actor. In each iteration, the actors explored a new approach to conveying a different mood than the one before. For example, one actor explored their cyborg selves being angry at a former partner in one iteration, and then explored a more
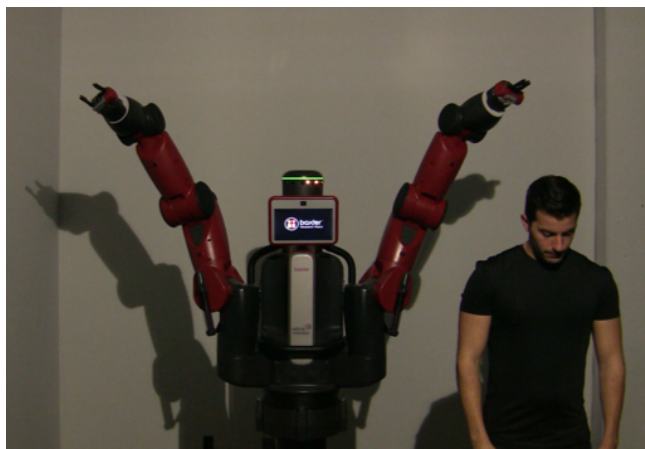
somber mood in the next. Between each performance, the actors wrote in their journals about their experience of entering and exiting the cyborg state. Researchers also recorded data based on observation of the performances.

Debrief
In conclusion, we conducted a semi-structured interview session with the actors. The questions were grouped into categories that were aimed at the various stages of the becoming and unbecoming process. First, the actors were asked a set of questions concerning the experience of entering the cyborg state. These questions focused on physical as well as mental integration, and how the warm-up protocol improved the experience of entering the cyborg state. The next set of questions concerned the cool-down protocol and its effect on the unbecoming experience.

RESULTS AND DISCUSSION
The Experience of Entering
The way in which the actors were physically strapped into Baxter played a role in their integration process: *"I felt I really needed the straps. The fact that I can give my body weight to Baxter and relax and feel (the robot) totally helped my immersion"* [A1]. Furthermore, A2 stated that getting comfortable with the straps felt like the *"first step towards becoming a cyborg"* [A2]. The actors' feelings toward their physical attachment to Baxter highlights that the way we physically wear the technology plays a role in the integration process.

We also learned that the simple exercises included in the protocols were also helpful for the actors to feel integrated with *Mutation's* cyborg arms. For example, A2 described how the instrument exercise helped: *"finding my center helped me because when standing on his base, it forced me to move forward..."* [A2]. Similarly, the state exercises were also found to be useful: *"(having) to go back to a centered, neutral spot is a jump off point, it really helped because (the cyborg state) is a different state, it is a different me"* [A2]. Lastly, the roll-down was also helpful: *"being able to breathe deeply helped me feel more relaxed. It helped me to be in such a state to connect to Baxter"* [A2].
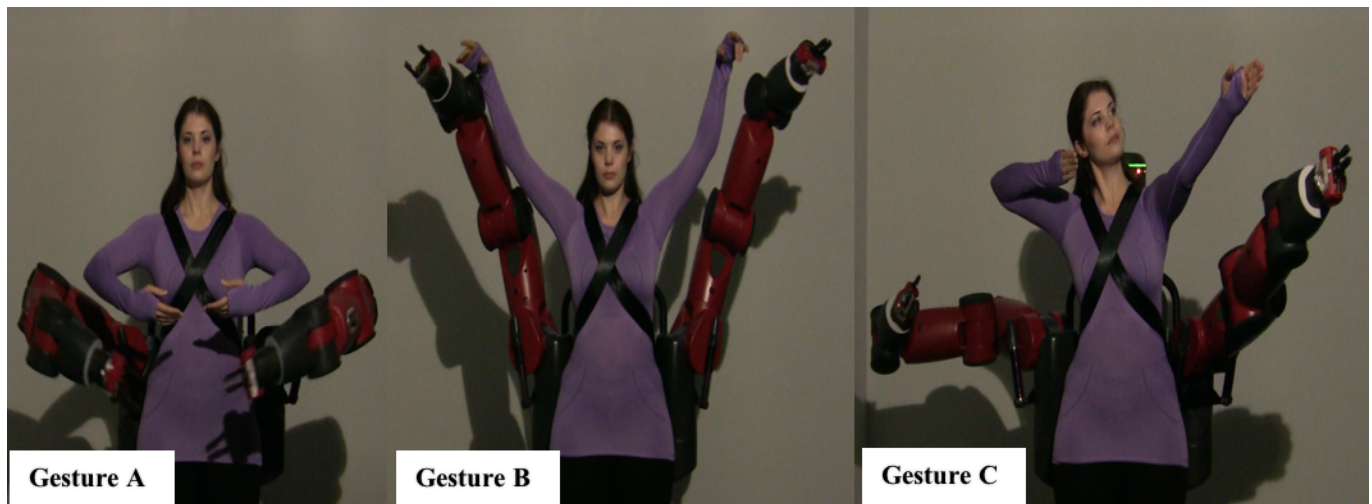
Figure 6. A2 preforming the cyborg warm-up gestures A, B and C (from left to right).

From our study, we learned that practicing with the wearable arms in the cyborg warm-up was found to be extremely useful by the actors. Recalling the human-human session in the design and rehearsal phase, A1 noted that compared to a human, *"Baxter was on a five second delay... (practicing) made me familiar with how Baxter moves the way he does and how long he takes to move the way he does"* [A1].

The Experience of Exiting
Both actors discussed what they felt immediately after detaching from *Mutation's* wearable, before performing the cool-down, and expressed a feeling of vulnerability: *"I felt vulnerable after detaching. (Baxter) is literally protecting your back. You step out of it, you lose this big comfort right behind you, so subconsciously you feel more vulnerable. Cool-down offers safety and addresses the vulnerability"* [A1].

A1 further expressed that *"once you're in sync with Baxter, you come out with a gigantic exhale. Having the physical reset of the centering (the instrument exercise) and roll-downs, and then the (state) exercise, I felt that it was a very gentle transition into the real world"* [A1]. In both the becoming and unbecoming process, A2 noted the importance of the state exercises and getting to the neutral state, which highlights its importance in helping with the mental and emotional transition between states.

Both actors expressed physical strain from their performances, particularly on their lower legs. A2 expressed that this is a result of *"constantly pushing back with my legs and leaning forward"* [A2]. While this is a specific physical ramification of working with Baxter, it implies that the cool-down should be tailored to the wearable's physical integration to reduce the physical strain, thus improving the unbecoming process.

The cyborg warm-up was extremely popular among the actors, to the point where they expressed a desire for a corresponding cyborg cool-down: *"A cyborg cool-down would really help. When I finish my monologue, I picture the transition would be less harsh if I get to shut-down with Baxter. If you could follow Baxter in this scenario, where you're not detaching from this still active machine, if you can shut down with it, if you share that moment, it's almost like sharing exhalation with Baxter"* [A1].

CONCLUSION AND FUTURE WORK
In this work, we motivated the the application of performance techniques in helping people transition into and out of technology augmented experiences. We prototyped an early prototype of a functional supernumerary cyborg arms system, *Mutation*, and then borrowed from and applied commonly used performing arts techniques, warm up and cool down, to observe how actors can transition into and out of cyborg states. The design of *Mutation* was done in close collaboration with two professional actors spanning a two-week design and study process wherein we designed warm-up and cool-down protocols and learned about their impact on the experience of becoming and unbecoming a cyborg. Actors used these protocols in multiple iterations of their monologue performances as cyborgs. Our results suggest that the actors found that these protocols helped the experience of entering and exiting cyborg states.

This being the first project in this space, has opened up several avenues for further exploration in the future. Some next steps include: conducting additional studies to identify further refinements to the warm up and cool down protocol, applying these protocols to other applications and in interaction scenarios involving non-actors, and scaling our *Mutation's* acting techniques transitioning approach to other technology augmented experiences such as VR, MR and computer games.

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