

Towards Understanding the Design of Body-Actuated Play

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Bodily games sense players' physiology and provide feedback via screen-based modalities. Alternative I/O loops could extend bodily games to display game results through the player's body. My work addresses this opportunity by using Electrical Muscle Stimulation (EMS). This body-actuating technology can actuate bodily movements by passing electricity via electrodes attached to the player's body, presenting players with opportunities to use their bodies as an input and output modality. To explore this opportunity, I created three "body-actuated play" systems ranging from single-player to social game experiences, further integrating the human body into the I/O loop. Ultimately, by studying the associated experiences of my systems, I will deduce a prescriptive design framework for designing games in which humans can use their bodies as an input and output modality.

CCS CONCEPTS • Human-centered computing • Interaction design

Additional Keywords and Phrases: bodily, movement-based design, electrical muscle stimulation, wearable interaction, integrated motor play, hand games

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1 INTRODUCTION

My PhD's vision is to create bodily games in which the human body is not just used as input but also as an output modality (Fig. 1). I call the act of playing such games as "Body-Actuating Play". I leverage technological advances in what I define Body-Actuating Technologies (BATs), such as Electrical Muscle Stimulation (EMS) [14,18]. EMS works by passing a small amount of electricity via electrodes attached to the skin, which contracts muscles and can actuate involuntary bodily movements [14,18]. HCI researchers used EMS to create novel bodily experiences [1,6] and to make VR experiences immersive [8]. However, EMS has not been used to researched for games in which the body is used as input and output.

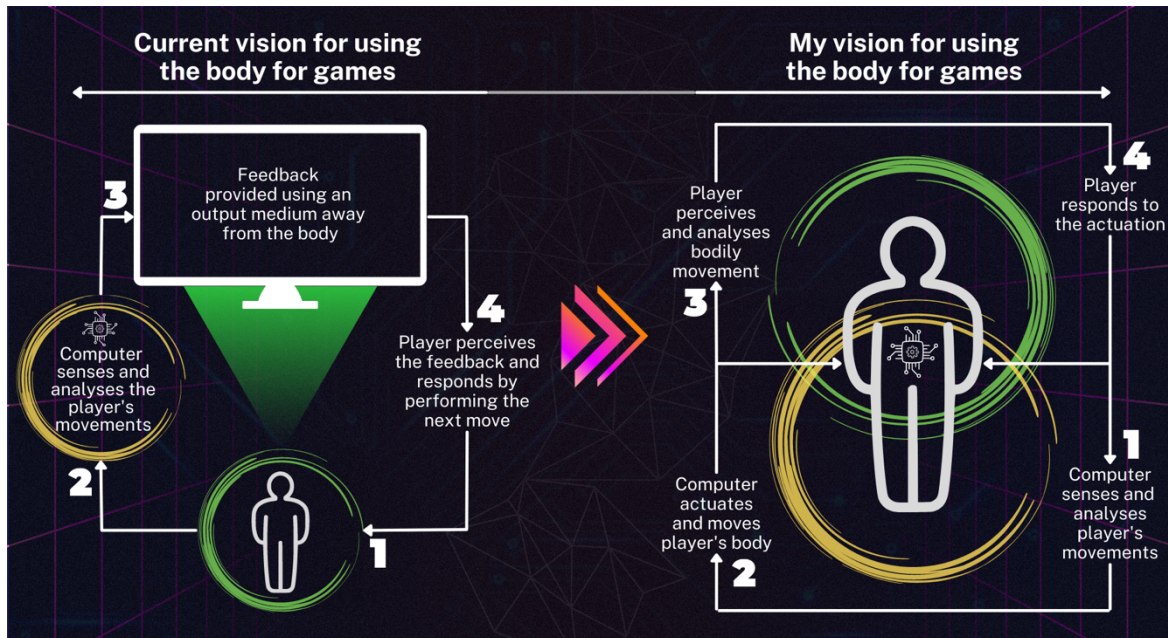


Figure 1. My vision of the body for games.

I utilised EMS to design three body-actuating play systems: (a) Auto-Paízo Games, (b) Theatís Games, and (c) Smínos Games. Through these three design systems, I will answer the research question: *How do we design for body-actuated play in which humans share bodily control with computers?* Overall, my work makes three contributions: 1) extend HCI's collection of novel systems [32] by designing these games, 2) extend our understanding of bodily games [25] by articulating user experience themes derived from studying three systems and 3) by articulating the design of games in which players share bodily control with EMS, I also extend the potential of "human-computer integration" [26] systems, highlighting its potential for play [24].

2 RELATED WORK

Prior work on sharing control in bodily games and EMS works in HCI inspired and informs my work.

2.1 Sharing Control in Bodily Games

The HCI game design community are exploring ways to share control over our actions with computers to create playful bodily experiences [2]. Specifically, researchers proposed that designers should consider how games can offer players the opportunity to "experience the body as play" [21] and suggested limiting player's control over their body as part of play [9]. Loss of control could lead to a significant shift in the player's focus towards their body and facilitate self-awareness [21]. Benford et al. [2] argue that when the computer gains control over the human, humans and computers can enter into a contest when playing bodily games. The authors suggest supporting this contesting of control by keeping the players informed when the computer is about to take control by using feedback.

In summary, playing bodily games promotes self-awareness, and we learn from the strategies provided by game design researchers. Currently, designers are creating novel ways of *sensing* players' bodily movements to create playful bodily experiences games. This means that the body is used as an input but not an output modality. I explore the design of games in which the players' bodies can be used both as an input and *output* modality by using EMS.

2.2 Electrical Muscle Stimulation for Games in HCI

HCI researchers have used EMS to create novel bodily experiences and show that involuntary body movements, although ambiguous, are interpretable by users. This EMS capability can be used to communicate abstract information and create novel game experiences. EMS for games such as "Red-Hands" [36] has previously been explored [18], albeit to explore "proprioceptive interactions" [18]. My work focuses on designing bodily games in which players share control over their bodies with a computer to use it as an input and output modality.

3 RESEARCH METHODOLOGY

My research methodology encompasses four methods: (a) Research through design (RtD) [33] - game design is an iterative and reflective process resulting in design artefacts, which can transform the world from its current state to an idealistic state, (b) in-the-wild [4,28] approach to study systems - to avoid the novelty effect [15,29] and obtain 'ecologically valid' results by studying participants' behaviour in their natural environment, (c) semi-structured interviews [16] - participants can freely articulate their experiences, rather than using pre-meditated questions, and (d) thematic analysis [3] - organise comments of a rich data set to report patterns of player behaviours.

4 DESIGN, STUDY AND RESULTS

I completed the design and development of my first system, which consists of a suite of three "Auto-Paizo" games. Auto-Paizo is Greek for "self-play". The three individual games are 'Elements', 'Numbers' and 'Slap-Me-If-You-Can'. In these games, players share bodily control over one of their hands with EMS enabling them to play hand games against themselves. Insights from related work and my experience using EMS to create involuntary, fine and gross motor-movements [14,18], inform the game design. The three games differ in how players share bodily control with EMS and use previously identified key characteristics of designing bodily games motor-movement [20], game outcome [12] and bodily interference [23]. Testing the game in-the-wild with 12 participants for one week each revealed two interesting observations that informed the designs of my second and third systems.

4.1 Observation 1: Sharing control with the EMS made players forget to play with their body

I noted that the pre-game ritual and dramatic sound immersed participants [30], and some even just watched the EMS hand, forgetting to perform bodily gestures to complete. These experiences playing with the EMS hand indicate that players enjoyed being a spectator, i.e., watching their hands move involuntarily as a "screen". Therefore, my second system, consisting of three games, is called "Theatis Games", Greek for "Spectator Games". Here, players share bodily control over both their hands with the EMS and watch the EMS hands play

against each other. This system's design will help understand what it means to completely share control over one's body parts with the computer and experience the body as a "pure output modality".

4.2 Observation 2: Sharing control over their body socially made players feel surprisingly comfortable

I designed game challenges to engage novel participant interactions over the one-week in-the-wild study. One challenge out of the twelve was to ask their partner/friend to wear the glove with the phone and play with them using their EMS hand. This sharing of bodily control socially means that they were using their friend or partner's body as input and using their EMS hand to play the game against them. Participants enjoyed this form of social and bodily play and were surprised by how comfortable they felt sharing control over their bodies with their partner/friend. Therefore, my third system, consisting of two social games, is called Smínos Games. Here, EMS influences players' control over other players' bodily movements. This system's design will help us understand what it means to share control over our body with other humans mediated by a computer.

5 DISCUSSION

After unpacking the Auto-Paizo games data, I came up with six over-arching UX themes and strategies. I discuss one UX theme and reflect upon prior theory to comply with space.

User Experience Theme	Theoretical Reflection
<p>Sharing bodily control: In this theme, participants described their experience of sharing bodily control with the EMS. Specifically, they reflected on how they <i>had to relax their body to use it as an output modality for play.</i></p>	<p>This theme refers to the “Leib” (body with life) and “Körper” (body as an object) analogy by Mueller et. al [21] when designing to experience the body as play. My work extends this theory and suggests that designers must consider creating features to help players relax their bodies before playing body-actuating games.</p>

6 LIMITATIONS AND FUTURE WORK

My work introduces how to use the body as an input and output modality with the help of BATs and could be a springboard for future designers interesting in creating body-actuating play experiences. However, I use EMS for all three systems, i.e., my work alone is insufficient to understand the broader landscape of using the human body in the I/O loop for digital play. Therefore, future researchers could explore other sensing mechanisms such as Brain-Computer Interfaces and other BATs such as pneumatics and exoskeletons to create novel body-actuated play experiences.

7 CONCLUSION

In conclusion, I show that players can use their body as an input and output modality using BATs and experience body-actuating play. Specifically, I briefly describe my first system's design. Observations from studying this system inspired and informed my two future designs. Ultimately, by studying the associated experiences of my systems, I will deduce a prescriptive design framework for designing games in which humans can use their bodies as an input and output modality.

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