

Towards Understanding the Design of Body-Actuated Play

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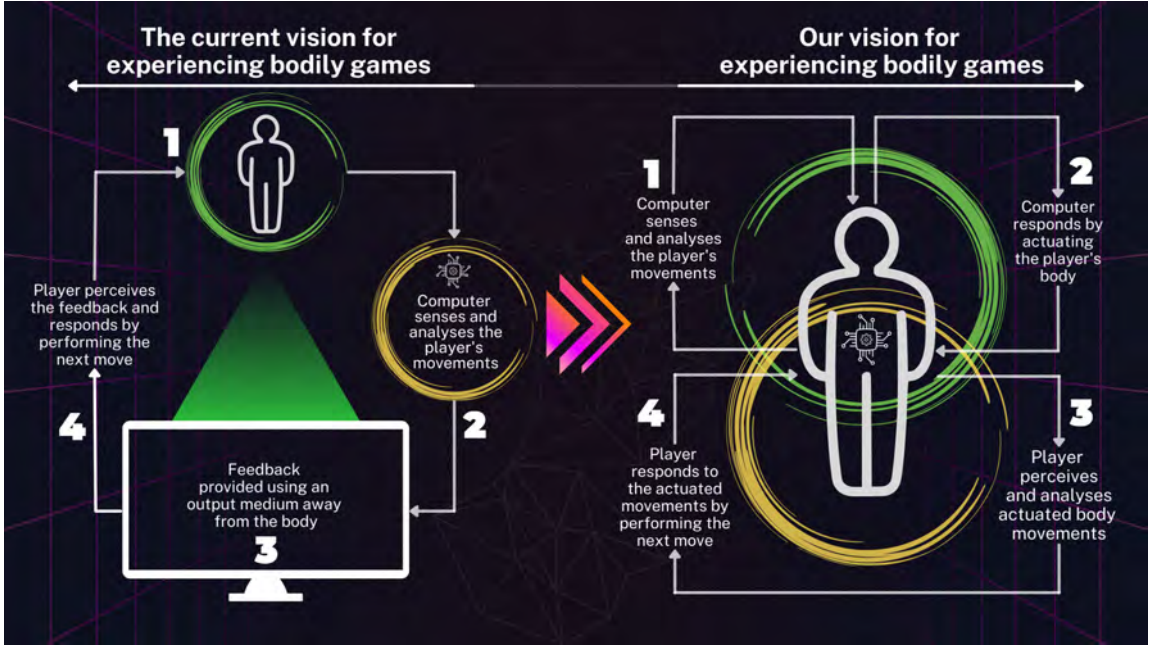


Fig. 1. Our vision of using the body as input and output for designing games.

Bodily games often use players’ physiology as input to provide output via screen-based modalities. Game design researchers could extend the use of the body as input and *output* (I/O) by using body-actuating technologies such as Electrical Muscle Stimulation (EMS). EMS works by passing a small amount of electricity via electrodes attached to the player’s body, contracting their muscles to actuate involuntary body movements. Our work explores this bodily I/O by creating three "body-actuated play" systems ranging from single-player to social game experiences. Ultimately, by studying the associated user experiences of these systems, we will deduce a prescriptive design framework for designing bodily games in which humans can use their bodies as input and output.

CCS Concepts: • **Human-centered computing** → *Human computer interaction (HCI)*; Interaction paradigms;

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1 INTRODUCTION

The PhD's vision is to create bodily games using the human body as input and output (Fig. 1) by leveraging technological advances in what we define Body-Actuating Technologies (BATs), such as Electrical Muscle Stimulation (EMS) [7, 10]. We call the act of playing such games "body-actuated play". EMS works by passing a small amount of electricity via electrodes attached to the body, which contracts muscles and actuates involuntary bodily movements [7, 10]. HCI researchers used EMS to create novel bodily experiences [1, 5] and to make VR experiences immersive [1]. However, bodily games research has not yet fully explored the body as input and output (I/O) using body-actuating technologies like EMS.

To explore this bodily I/O opportunity using EMS, we designed three body-actuated play systems: (a) Auto-Paizo Games, (b) Théa Games, and (c) Mazi Games to answer the research question: *How do we design body-actuated play in which humans share bodily control with computers?* Overall, our work makes three contributions: 1) extend HCI's collection of novel systems [23] by presenting details about the implementation of these games, 2) extend our understanding of bodily games [12] by articulating user experience themes derived from studying three systems, and 3) by articulating the design of our games in which players share bodily control with EMS, we extend previous articulations of the potential of "human-computer integration" [13] for play [16] by enhancing our understanding of the role of 'sharing bodily control' when engaging with our systems.

2 RELATED WORK

Prior work on sharing control in bodily games and EMS works in HCI inspired and informed our 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" [14] and suggested limiting players' control over their body as part of play [17]. Loss of control could lead to a significant shift in the player's focus toward their body and facilitate self-awareness [14]. 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.

Currently, designers are creating novel ways of *sensing* players' bodily movements to create playful bodily experiences games, using the body as input but not output. In contrast, our work explores the design of bodily games using the players' bodies as input and output with the help of EMS. In summary, playing bodily games promotes self-awareness [19], and we learn from the strategies provided by game design researchers.

2.2 Electrical Muscle Stimulation for Games

HCI researchers used EMS to create novel bodily experiences and show that involuntary body movements, although ambiguous [7], are interpretable by users [18]. Therefore, we believe that EMS's ambiguous yet interpretable body movements are useful for communicating abstract information and creating novel game experiences. EMS for games such as "Red-Hands"¹ has previously been designed [10], albeit to explore "proprioceptive interactions" [10]. Our work focuses on using these ambiguous involuntary movements and enable players to experience their body as input and output for playing bodily games [18].

3 RESEARCH METHODOLOGY

Our research methodology encompasses four methods: (a) research through design [24] - 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, 20] approach to study systems - to understand any potential novelty effect [8, 21] and obtain 'ecologically valid' results by studying participants' behaviour in their natural environment, (c) semi-structured interviews [9] - participants can freely articulate their experiences, rather than using pre-meditated questions, and (d) thematic analysis [3] - organising comments of a rich data set to report patterns of player behaviours.

4 DESIGN, STUDY AND RESULTS

We completed the design and development of our first system, which consists of a suite of three "Auto-Paízo" games. Auto-Paízo 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. The three games differ in how players share bodily control with EMS and use previously identified key characteristics of bodily games: 1) motor-movement [11], 2) game outcome [6], and 3) bodily interference [15]. Testing the game in-the-wild with 12 participants for one week each revealed two interesting observations that informed the designs of our second and third systems.

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

We note that the pre-game ritual and dramatic sound immersed participants [22], 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 spectators, i.e., watching their bodies performing as a "screen". Therefore, our second system, consisting of three games, is called "Théa" (Greek for "watching") games. Here, players watch the EMS hands play against each other. This design will help understand what it means to share control over one's body parts with the computer and experience the body as a playful display.

4.2 Observation 2: Sharing control over the body socially felt surprisingly comfortable

We designed game challenges to facilitate novel participant interactions over the one-week study. One challenge out of the twelve was to ask a partner/friend to play with them. This sharing of bodily control socially means they were using their partner/friend's body as input and using their own EMS hand to play the game against them. Participants enjoyed this form of social bodily play and were surprised by how comfortable they felt sharing control over their bodies with their partner/friend. Therefore, our third system, consisting of two social games, is called "Mazi" (Greek for

¹https://en.wikipedia.org/wiki/Red_hands

"social") games. Here, EMS influences players' control over other players' bodily movements. This 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, we derived six over-arching UX themes and strategies. We discuss one UX theme and reflect upon prior theory here in the interest of space.

Table 1. Reflecting on the results of the Auto-Paizo games.

User Experience Theme	Theoretical Reflection
Sharing bodily control: In this theme, participants described their experience of sharing bodily control with the EMS. Specifically, they reflected on <i>how they had to relax their body to use it as an output modality for play.</i>	This theme refers to the "Leib" (body with life) and "Körper" (body as an object) analogy by Mueller et. al [14] when designing to experience the body as play. My work extends this theory by suggesting that designers should consider creating features to help players relax their bodies before playing body-actuating games.

6 LIMITATIONS AND FUTURE WORK

Our work introduces an initial understanding of how to use the body as input and output with the help of body-actuating technologies such as EMS that could be a springboard for designers interested in creating novel bodily play experiences. However, as we use EMS for all three systems, our work alone is insufficient to understand the broader landscape of using the human body in the I/O loop for digital play. Therefore, researchers could explore other body-actuating technologies such as pneumatics and exoskeletons to create novel body-actuated play experiences.

7 CONCLUSION

In conclusion, we show that players can use their bodies as input and output using EMS to experience body-actuated play. Specifically, we briefly describe our first system's design. Observations from studying this system inspire and inform our two future designs. Ultimately, by studying the associated experiences of these systems, we will deduce a framework for designing games in which humans can use their bodies as input and output.

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