Shared Bodily Fusion: Leveraging Inter-Body Electrical Muscle Stimulation for Social Play

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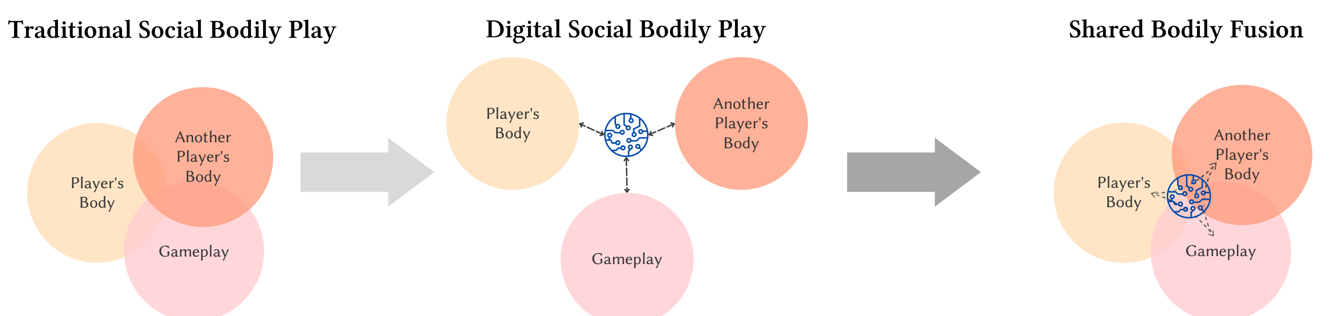

Figure 1: Three forms of Inter-Body Interactions (IBIs) in play: (Left) Traditional social bodily play, where players share control to engage in IBIs intrinsic to gameplay. (Centre) Digital social bodily play, where players use their bodies as input to interact with a computer to share control over virtual avatars, rendering the occurrence of IBIs during gameplay uncertain. (Right) Shared bodily fusion, where players fuse their bodies to engage in IBIs through a computer by creating a shared input and output system, making the occurrence of IBIs intrinsic during gameplay.

ABSTRACT

Traditional games like "Tag" rely on shared control via inter-body interactions (IBIs) – touching, pushing, and pulling – that foster emotional and social connection. Digital games largely limit IBIs, with players using their bodies as input to control virtual avatars instead. Our "Shared Bodily Fusion" approach addresses this by fusing players' bodies through a mediating computer, creating a shared input and output system. We demonstrate this approach with "Hidden Touch", a game where a novel social electrical muscle

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stimulation system transforms touch (input) into muscle actuations (output), facilitating IBIs. Through a study (n=27), we identified three player experience themes. Informed by these findings and our design process, we mapped their trajectories across our three experiential spaces – threshold, tolerance, and precision – which collectively form our design framework. This framework facilitates the creation of future digital games where IBIs are intrinsic, ultimately promoting the many benefits of social play.

CCS CONCEPTS

• **Human-centered computing → Interaction paradigms**.

KEYWORDS

social bodily games, movement-based play, wearable interaction, body-actuating play, electrical muscle stimulation (EMS)

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Figure 2: A group playing Hidden Touch. One Insider (left) looks under the table and decides where to touch, while the other shares a bonding moment with the Decoder (right) during gameplay.

1 INTRODUCTION

While sharing control of our bodies might seem unfamiliar, traditional social games often embrace this concept by encouraging players to engage in inter-body interactions (IBIs) that are intrinsic to the gameplay [128, 152]. Drawing on the concept of inter-corporeality [7, 77], we define IBIs as physical interactions between two or more individuals where players directly influence each other's actions through shared bodily control, creating a core element of the playful experience. In games like "Tag" and "Twister" [86], individual movements become intertwined, demonstrating how gameplay centres on using the body to engage with others' bodies. Research suggests IBIs are essential to traditional play, serving as a form of communication [124], facilitating playful gestures [124], developing camaraderie [46], fostering shared experiences [151], advancing leadership skills [62], and promoting social awareness [62].

Inspired by the benefits of IBIs, both the HCI game design community (e.g., [36, 62, 75, 97, 99, 103]) and the games industry [63, 143] have embraced movement-sensing technologies [1, 40, 148]. While some systems use players' bodies as input, these explorations mostly attempt to emulate IBIs with virtual, screen-based output [76, 103, 119]. Other systems require physical touch and movement of each other's bodies to influence on-screen avatars [26, 60]. However, we find that merely sensing player movements as input limits the direct, reciprocal nature of IBIs found in traditional games, potentially reducing the opportunities for players to profit from the aforementioned benefits.

To address this, we propose the "Shared Bodily Fusion" approach, where players fuse their bodies through a mediating computer to create a shared input and output system, making IBIs intrinsic to gameplay (Figure 1). Our initial focus is on body-actuating technologies (BATs), specifically electrical muscle stimulation (EMS), due to its ability to transform the body into both input and output of the interaction [81, 123]. This approach presents an opportunity to explore IBIs within digital games in a way that closely aligns with the embodied experiences found in traditional play. While our current work focuses on EMS, our approach could inspire future investigations with other BATs, such as exoskeletons [74] or pneumatics [109, 123, 129–131], to facilitate shared bodily control within co-located social play [133]. This could include scenarios like collaborative haptic exploration with exoskeletons, physical redirection with pneumatic actuators, or even the transformation of classic games like tug-of-war or playground activities through BAT-enabled playful mediation, introducing elements of shared control, surprise, and physical collaboration.

We showcase this approach through "Hidden Touch", a three-player game inspired by the traditional "Footsies" game [8, 150] through a novel social electrical muscle stimulation (EMS) system. Deviating from prior HCI work that enables only single-user EMS experiences [64, 81, 82], our game connects two players' bodies via a social EMS system. The game comprises a "Decoder" (wearing the reference electrode on their forearm) and two "Insiders" (wearing active electrodes). An Insider's stealthy touch on the Decoder's barefoot acts as the input, completing the circuit and triggering a muscle contraction in both players' arms as the output, demonstrating how IBIs can be intrinsic to digital gameplay.

Hidden Touch was iteratively designed and playtested [69] using the Research through Design (RtD) [157] approach. The University Ethics Board approved the study, which was conducted with 27 participants divided into nine groups. Given the intimate nature of our game involving skin-to-skin contact (<0.5 meters) between people [55], we recruited participants who were already familiar with each other. We gathered insights through semi-structured interviews [27, 78]. Through thematic analysis [20–22] of our data, we identified three player experience themes. Additionally, we used the trajectories method [16, 17], to map the findings from our themes across three experiential spaces: 1) Threshold, 2) Tolerance, and 3) Precision, which reflect the journeys of players' subjective experiences. These spaces collectively form the framework of our "Shared Bodily Fusion" approach. Our work makes the following contributions:

- **A novel game:** We introduce "Hidden Touch", a novel game, to HCI's growing catalogue of unique systems [155]. Beyond inspiring game developers to utilise body-actuating technologies [123], such as EMS, for creating social, bodily play experiences, this could also motivate non-gaming sectors, such as motor rehabilitation, to investigate playful, immersive EMS applications.
- **Reporting player experiences:** From the analysis of our study data, we articulate three player experience themes [20–22]. They can serve as a resource for interaction design researchers to create systems aimed at crafting social bodily play experiences.
- **Presenting a framework & design implications:** Based on our themes and the craft knowledge of designing our game, we present three experiential spaces that offer a means to anticipate and understand the user experiences of IBIs. Each space is complemented by a design implication, providing concrete guidance for practitioners interested in designing social bodily play experiences.

With our work, we aim to support game designers in creating a broader range of play experiences to facilitate the many benefits of traditional social play.

2 RELATED WORK

Our research was primarily informed by prior work on human touch and social interaction, shared control in traditional games, shared control experiences in HCI, and shared control by using body-actuating technologies.

2.1 Human Touch and Social Interaction

Human touch, a powerful form of inter-body interaction, is a vital part of social connection [146]. It can be philosophically understood through the concept of intercorporeality [7, 77], which involves the sense-making of oneself and others as active participants in creating corporeal interactions that are both visual and tactile [146]. Touch, therefore, holds profound meanings within our social fabric [93], manifesting in various forms [93, 146]. For example, Navarre's [110] and Gentry's [50] research on dance illustrates how physical touch can build positive relationships, empathy, and mutual understanding. Here, touch acts as a language rich in emotional and connective nuances, exemplifying its profound impact on social bonding.

Traditional games like "Footsies" also offer insights, highlighting the personal and intimate aspects of touch [8, 150]. Beyond its experiential dimensions, touch also plays a crucial role in physiological well-being, as evidenced by the comforting impact of gentle physical contact [93]. Informed by the concept of intercorporeality, touch can be understood as a fundamental building block of shared experiences [45, 116]. This highlights its importance in diverse social contexts, from dance to play, as it facilitates connection, communication, and understanding.

2.2 Shared Control Experiences in Traditional Games

Games such as "Tag" [2], "Twister" [39], and "Human Knot" [87] exemplify the practical application of IBIs [128, 152]. These games are important because they foster camaraderie, social awareness [53, 104], and lasting emotional impacts [19, 52, 53]. Cherished across cultures [25, 61, 132], they impart lessons on teamwork, trust, and community [12, 152]. While all IBIs involve social interaction, not all social interactions in games involve IBIs (e.g., text chat, social leaderboards) [132]. This makes traditional games particularly interesting, as prior work highlights the centrality of "shared control" – where players influence each other's bodily actions – in their gameplay [46]. This shared control ranges from verbally instructing another person to move to gently touching to directly moving another person by pushing or pulling (illustrated through a dimensional diagram in Figure 3). Technological advancements have digitised similar experiences; Dance Dance Revolution [15] combined traditional movement with digital on-screen prompts. While such games often focus on individual achievement rather than IBIs [15, 41], this need not be the case. Sicart [139] suggests that digital technology can harness the essence of traditional games to enrich social play [152], as exemplified by games like Bounden [3, 114]. These games are known to potentially foster identity co-creation, group creativity [152], and social dynamics that extend beyond the game itself [137].

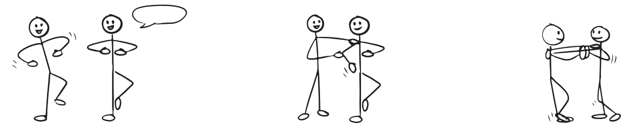

Figure 3: Methods of sharing control for influencing another player's movements, ranging from verbal instruction to direct physical manipulation.

2.3 Shared Control Experiences in HCI

Recognising the significance of shared control through IBIs [146], HCI researchers have explored diverse ways to facilitate these experiences beyond traditional games [101]. Systems like "Physical Telepresence" demonstrate how sharing tactile sensations and video over distance can enhance feelings of closeness [70]. This multisensory approach aligns with previous HCI work on bridging traditional and digital gameplay by using movement-sensing technologies [96], aiming to preserve social elements within digital platforms [132]. However, some games, like "1-2 Switch" [1], while encouraging face-to-face interactions, rely on screen-based output, making shared control indirect. In contrast, "Johann Sebastian Joust" [88, 139] aligns closer with traditional games, using direct player touch to influence opponent movements [156] (centre image - Figure 3). Sykownik et al. [142] suggest that this type of shared control can be categorised under the "Distinct Loci of Manipulation", where players control separate elements that can work together, or where control shifts dynamically between players.

The potential of designing IBIs to foster a sense of connection is further explored in "SocialStools" [57]. This work uses sound, visuals, and physical movement to cultivate togetherness, even between strangers. This kind of collaborative interaction, as suggested by Sykownik et al. [142], can be categorised as a "Mutual Locus of Manipulation" where players simultaneously manipulate shared elements. While such works facilitate playful physical interaction, control can sometimes still feel external to the body. This is seen in games like B.U.T.T.O.N [153], where ambiguity [48, 141] may indirectly encourage some IBIs. A need remains for experiences focused on prolonged, direct human-to-human interaction [29, 60, 104] and exploration of the "proxemics zones" [97], i.e., "the physical distance between people involved in gameplay", influencing gameplay [55].

Prior works like "Musical Embrace" [60], "DubTouch" [24], and touch-based silent disco experiences [59, 85] illustrate how direct touch and shared bodily control can create playful, sometimes even "uncomfortable" interactions [18, 54]. "BioTones" [144] suggests that auditory biofeedback can provide an alternative to the dominant visual feedback in interactive systems. Our work builds on these approaches, employing a face-to-face configuration without screens for deeper player engagement. Another compelling area in HCI is the interplay between shared experiences and self-other perception, as seen in "Morphing Identity" [138], where facial morphing reveals a spectrum of social experiences within communication. Digital versions of games like tug-of-war further endorse the concept of shared control [83] (right image - Figure 3). Similar explorations of gentle touch control can be seen in multiplayer computer games [59, 85]. However, these often treat inputs as external to the body, distinct from the inter-body interactions seen in traditional games.

The nuanced shared control intrinsic to traditional games presents a challenge in HCI, as highlighted by Benford et al. [16, 17]. To address this, we must shift our focus from viewing the body solely as an input medium towards also considering it as a way to produce output. Body-actuating technologies (BATs) [120, 123], such as EMS, offer this unique potential, allowing the body to serve as both input and output of the interaction.

2.4 Shared Control by Using Body-Actuating Technologies

The advancement of BATs has opened new avenues for achieving shared control through IBIs [123]. Systems like BioSync [112] foster collaboration over a distance, using bidirectional muscle communication and movement synchronisation. Similarly, the "Linked-Stick" [108] explores how physical mirroring can enhance tool-based skill learning, while "inTouch" [23] uses touch-based interfaces to facilitate shared experiences remotely. Such designs highlight the unique ability of BATs to foster collaboration and learning through shared physicality and movement.

These explorations contribute to the broader trend of Body-Actuated Play (BAP), where the body itself becomes the core of the play experience. This promotes IBIs by using the body as both input and output [123]. For example, in "Haptic Turk" [30], human actuators manually move a player's body to generate in-game motion. Other BATs, like exoskeletons, have also been explored to control the player's arm and serve as their playmate for playing Pong against a computer [74, 89]. These works demonstrate a shift from screen-based outputs to, bodily-centered experiences [102, 106].

In our work, we focus on EMS for both input and output to facilitate shared bodily control [33, 81, 123]. Unlike movement-sensing, EMS keeps the attention on the body itself [117, 121]. While EMS has been used to simulate touch in VR [38, 82, 127], our research, inspired by prior work on "proxemics play" [97], investigates its potential in human-to-human scenarios.

Prior work also explored using EMS in various bodily play experiences [111, 117, 118, 121], notably in single-player settings where a player shares control of one hand with an EMS system, engaging in a physical contest with it [81, 118]. Here, shared bodily control emerges, but experiences are intra-corporeal, i.e., bodily interactions experienced with one's own self, as they essentially play against a computer attached to their body [117, 121]. While prior work explored an initial multiplayer concept with EMS [111], it was limited to a pilot study with two groups of participants. Building upon the insights from this pilot, we propose the "Shared Bodily Fusion" approach to address the opportunity to create deeper knowledge about designing digital games where IBIs are intrinsic to gameplay. Specifically, this approach aligns with the middle ground between "touch" and "direct player movement" in Figure 3. Our game, "Hidden Touch", serves as a vehicle to answer our research question: *How do we design digital games where IBIs are intrinsic to gameplay?*

3 HIDDEN TOUCH: A GAME SHOWCASING OUR APPROACH

Inspired by prior work highlighting the need for social perspectives within Body Actuated Play (BAP) [117, 121], Hidden Touch incorporates elements from the traditional game "Footsies" [8, 150]. This inspiration stems from two key insights: prior BAP research revealed a willingness to share bodily control, while the discreet touch-based interactions in "Footsies" offered a model for subtle, playful IBIs. These insights led to our creation of a novel social experience.

3.1 Insights from the Research through Design Process

In prior explorations of BAP [117, 121], the hardware setup consisted of only one sensor (accelerometer) and actuator (EMS). This meant that one person controlled the other's body without reciprocal interaction, creating a unidirectional, rather than a mutual, shared bodily control experience. As the goal of our "Shared Bodily Fusion" approach is to facilitate mutual bodily control between two or more participants to encourage IBIs, we invited colleagues to participate in embodied experiments. By drawing inspiration from prior research on control-sharing patterns in multiplayer games [142], three embodied experimental setups were created (Table 1). In each experiment, one participant wore both the sensor and actuator (similar to prior work [117, 121]). The person wearing the sensor controlled the arm of another person wearing the actuator, and vice-versa. Table 1 below illustrates these experimental setups along with the associated learnings.

Through analysis and reflection on these experiences, we discovered that sharing bodily control seemed to foster a unique experience of kinesthetic empathy [32], i.e., "the feeling of sharing another person's movement" [140]. Unlike mere observation, this involved a direct, embodied experience of another player's actions and the resulting sensations, enhancing the ability to anticipate and respond to their intentions. This insight, along with the desire

Table 1: Embodied Experimental Setups and Learnings

Embodied experimental setup	Learning
Setup 1: Both users in the same location (Figure 11 – Appendix A) - An accelerometer on one player's hand-controlled EMS on the other's arm, creating a direct connection between movement and sensation.	Participants could anticipate each other's actions, reducing the element of surprise. Camaraderie seemed possible due to shared physical space.
Setup 2: Same location, but no visual contact - The control mechanics remained the same (accelerometer to EMS), but players were positioned to prevent them from seeing each other's bodily actions.	Bodily actions were unseen, introducing an element of surprise. Communication limitations seemed to lessen the sense of camaraderie.
Setup 3: Different locations, with video call (Figure 12 – Appendix A) - Players interacted via video conferencing, with one player's accelerometer controlling the other's EMS across the distance.	Visual contact partially restored a sense of connection. Internet lag continued to create an element of surprise. Camaraderie seemed possible through voice chat.

to enhance the "surprise" and "camaraderie" found in traditional social games, informed the design of "Hidden Touch". The game aimed to integrate physical touch – a core element of traditional play – while retaining the unique social dynamics that emerged from our embodied experiments.

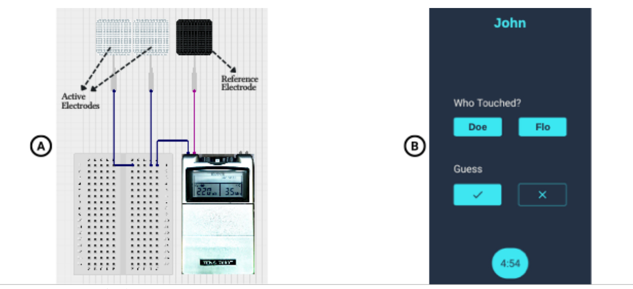

Figure 4: (A) Circuit schematic for converting a single EMS channel into multiple channels with a common reference electrode. (B) The mobile application for game score tracking.

3.2 Hardware for the Social EMS System

In line with safety considerations from previous studies [4], we utilised a standard EMS device, comprising two electrodes (active and reference). In a standard EMS setup, both electrodes from a single EMS channel are typically attached to one user's body [64, 79]. This allows the user to calibrate the EMS for muscle contraction by adjusting parameters such as intensity, pulse rate, and width. However, for our Hidden Touch social EMS system (Figure 4), we modified this standard arrangement. We adapted a single EMS channel to accommodate two active electrodes and one common reference electrode [5]. This system requires the attachment of the electrodes to two separate participants. Consequently, when one participant touches the other's bare skin, the electrical circuit completes, simultaneously contracting both participants' muscles.

3.3 Gameplay

The core gameplay loop of "Hidden Touch" revolves around deception, strategy, and shared bodily control. Here's a breakdown of the loop's central components:

- **Role Assignment:** The game randomly assigns players as a Decoder or Insiders via a mobile app.
- **Calibration:** Before starting, an Insider and Decoder adjust the EMS device to set a shared intensity level through continuous touch to achieve involuntary hand movements.
- **Game flow and goal:** The full game lasts 5 minutes, with timed rounds (15-30 seconds), managed by the mobile app. During each round, Insiders subtly touch the Decoder's foot under an opaque table. The Decoder tries to identify the toucher by feeling the simultaneous, involuntary muscle contractions in their own arm, resulting in deception and detection as the core focus.
- **Scoring and progression:** The players manage the game's scoring system on the mobile app. Correct guesses by the Decoder earn them points, while incorrect guesses benefit the Insiders.
- **Safety:** Besides general EMS safety rules (e.g., using electrodes on unbroken, dry skin) [64], our social EMS system requires specific guidelines to prevent unintended heart stimulation [6]. Insiders must avoid touching the Decoder on the side of their body opposite the active electrode, ensuring stimulation remains localised [6]. Additionally, players should wear full-length trousers to minimise the risk of accidental skin contact.

3.4 Characteristics of the IBIs Facilitated by Hidden Touch

In this section, we discuss three key characteristics of IBIs facilitated by Hidden Touch, which we derived from our design process and internal playtesting sessions [69]. These characteristics, which describe the input and output aspects of the IBIs, offer considerations for game designers exploring options when applying our approach. We utilise them in Section 7 to discuss participants' experiences and their design implications.

3.4.1 Shared Intensity: Extent of mutual comfort with shared control. The "Shared Intensity" characteristic addresses the impact on mutual comfort (output) based on the shared intensity level (input) of EMS-mediated control. Playtesting revealed that finding a universally comfortable intensity is challenging due to individual variations in tolerance. Typically, a middle ground is reached with some discomfort accepted. However, as prior work indicates, minimal discomfort can sometimes enhance the game experience [54, 84, 117].

3.4.2 Control Duration: Extent of bodily awareness with shared control. The "Control Duration" characteristic addresses the impact on bodily awareness (output) based on the duration of shared control (input). Playtesting revealed that sharing control briefly via the EMS creates swift, short involuntary movements, while extended control leads to longer, more exaggerated movements. Playtesting showed players strategically varied the duration to influence their bodily awareness within the game.

3.4.3 Control Deception: Extent of bodily action visibility with shared control. The "Control Deception" characteristic addresses the impact on the visibility of bodily actions (output) based on the extent to which shared control is deceptive (input). Playtesting revealed players used covert (subtle) or overt (exaggerated) movements to create an invisible/stealthy or visible/challenging gameplay experience. Strategies were dynamically adapted based on opponents and evolving gameplay.

The three characteristics of IBIs facilitated by Hidden Touch, in conjunction with our study findings (outlined in Section 5), inform the three experiential spaces, which form our "Shared Bodily Fusion" framework (Section 7).

4 STUDY DESIGN AND DATA ANALYSIS

4.1 Methodology

To understand our game's user experiences, we adopted an in-the-field study approach [56], aligning with prior game research [75, 117, 131, 134, 135]. This approach enables 1) rich data collection while minimising researcher biases; 2) participants to engage with our system in settings and times of their choosing; and 3) participants to adapt the gameplay to their preferences, freeing them from the researchers' preconceived notions [81, 125].

4.2 Participants

Due to the interaction's intimate nature, we recruited groups of three participants who knew each other (such as family or friends). In total, we recruited 27 participants through social media channels and mailing lists. Eight participants identified as female (mean age = 31.7) and 19 as male (mean age = 29.7), with none as non-binary or self-described. Each participant received an explanatory statement detailing the gameplay and a consent form, including reassurance that they could opt-out anytime. Of the 27 participants, nine had EMS experience.

4.3 Study Procedure

Based on prior HCI research [117, 121], we structured our study into three phases: pre-study, in-the-field, and post-study (Figure 9). When using technologies that enable users to share bodily control, like EMS [64], this study structure helps build participants' trust in the system by allowing them to understand its capabilities and limitations [149].

4.3.1 Pre-study phase. Participants were provided with an explanatory statement and a consent form. They were then screened to determine their general suitability for using an EMS device [4]. Exclusion criteria included pregnant women, individuals with pacemakers, and those with skin injuries [64]. After the screening, participants were educated on best practices, including muscle relaxation techniques and focused breathing when using EMS [117, 118, 121], and we provided a hands-on introduction to familiarise participants with the EMS sensations. Participants were then introduced to the social EMS setup and the calibration process by connecting two players' bodies (section 3). Later, participant groups engaged with Hidden Touch. To ensure that the groups understood the game, they played at least seven rounds. This phase lasted 46.5 minutes on average.

4.3.2 In-the-field phase: Study. During this phase, groups played Hidden Touch daily for three days. Participants were asked to record their gameplay and log scores using a provided action camera and smartphone application. Excluding the calibration time, our log data indicated that participants played the game 55 times (average), with each round lasting approximately 30 seconds, totalling an average playtime of 37 minutes over the three days.

4.3.3 Post-study phase: Data collection. After completing the in-the-field phase, participants were interviewed using the semi-structured interviews method [78]. These interviews, which were recorded in audio and video [34], enabled participants to share their experiences, opinions, and queries with the researchers. Despite the group nature of the study, we conducted individual interviews to capture personal insights and reduce the impact of group dynamics, allowing participants to freely express detailed experiences [51]. The average interview time was 60 minutes. Interview topics ranged from participants' engagement with bodily social games to bodily awareness and sharing bodily control.

4.4 Data Analysis

We conducted a thematic analysis using a six-step process [20] with two independent coders working with NVivo software [154]. Each participant's response was treated as a separate data unit. We created a master NVivo project file to facilitate two rounds of coding. The initial coding round resulted in 94 codes from one coder and 85 codes from the other. The coders then discussed these codes and reconciled discrepancies to refine the coding schema in the master file. After this, the schema was used for a second round of coding. Multiple discussions took place to address discrepancies, resulting in a refined coding scheme in the master file with 76 final codes. The coders then crafted six overarching themes after examining and cross-referencing the coded categories with the data units. Our study focuses on three themes derived from 41 of the 76 final codes and encompassing 396 of the 916 data units. Since this paper focuses on qualitative analysis, we do not include other themes related to the quantitative data [9, 90], which might be explored in future publications. Complementing thematic analysis, we used the trajectories method [17] to map player experiences within the experiential spaces defined by our "Shared Bodily Fusion" framework, which consists of Threshold, Tolerance, and Precision. This method, combining interview transcripts, gameplay recordings, and game logs, allowed us to track how experiences evolved across the three core shared control dynamics (shared intensity, control duration, control deception) that directly shape those spaces. While the thematic analysis revealed core aspects of experience, the trajectories method further illuminated their evolution within our framework.

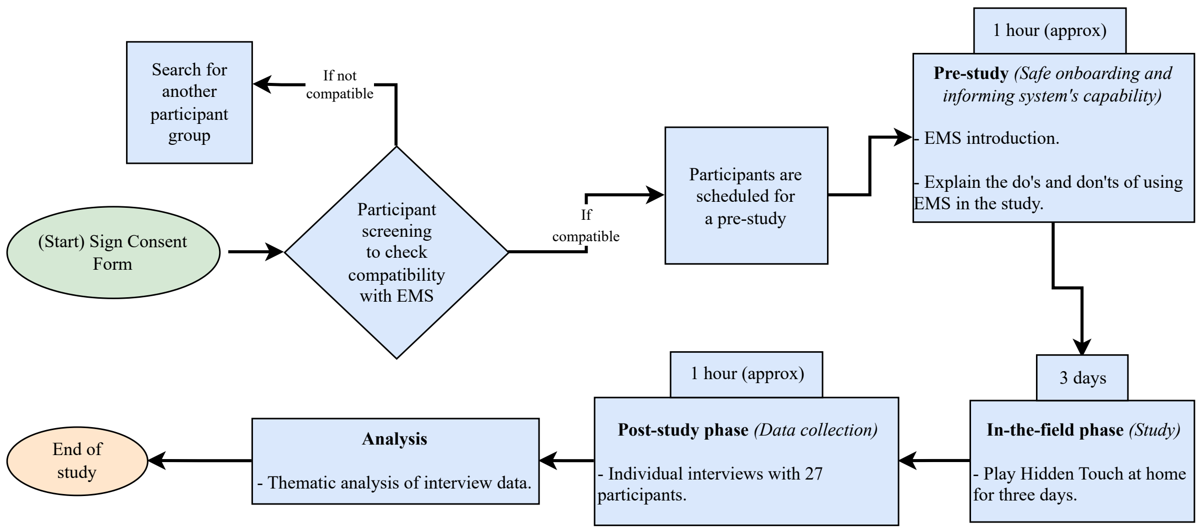

Figure 5: Flowchart of study procedure: Starting with consent acquisition and participant screening for EMS compatibility, followed by an EMS introduction, the study includes a three-day in-home gaming phase, post-study data collection through interviews, and concludes with thematic data analysis.

5 FINDINGS: PLAYER EXPERIENCE THEMES

In this section, we articulate our three themes: 1) embracing the physicality of IBIs (16 codes and 154 data units); 2) developing group bonding through IBIs (13 codes and 125 data units); and 3) cultivating bodily awareness through inter-body gameplay strategies (12 codes and 117 data units).

5.1 Theme 1: Embracing the physicality of IBIs

In this theme, participants explained their experiences of embracing the physicality of the inter-body interactions. Three sub-themes were identified: 1) exploring the unfamiliar sensations of IBIs (60 data units); 2) experiencing an enriched spectrum of emotions (49 data units); and 3) actively engaging with the varied levels of controlling the IBIs intrinsic to gameplay (45 data units).

5.1.1 Exploring the unfamiliar sensations of IBIs. In this sub-theme, participants explained their experiences of exploring the unfamiliar sensations of IBIs. Initially, participants expressed hesitation about intimate bodily interactions. As P1 said: *"I was apprehensive... I wouldn't normally do it."* Over time, they developed strategies for engaging with IBIs and said: *"In Hidden Touch, we could use many strategies to try and fool the person."* The shared sensation of electricity through touch was a particularly novel aspect. P6 commented: *"In Hidden Touch, we are decoding the intention of every touch... which felt amplified."* P7 added: *"It makes you pause and think about the touch as you have granular control over it."* P25 elaborated on this sense of control: *"I changed the duration and location of touch to influence the feeling".* These experiences suggest that the integration of electrical stimulation created a unique tactile experience, prompting participants to actively analyse and learn to control touch interactions.

5.1.2 Experiencing an enriched spectrum of emotions. In this sub-theme, participants described how touch in Hidden Touch evoked a strong emotional connection. P4 noted, *"The touch struck a stronger connection between us"*, while P6 highlighted a shared emotional state: *"Feeling the electricity went beyond physical sensations; we shared psychological emotions from the touch"*. This suggests heightened emotional experiences due to shared electrical sensations. Contrasting game experiences, P5 described touch as a form of dialogue: *"Hidden Touch caused unusual hand sensations, making each touch feel like a dialogue."* P18 and P10 elaborated on this, with P18 noting how touch added narrative depth and P10 finding the unpredictability of shared control enhanced their ability to manipulate expectations: *"Unlike Footsies, this provides us with opportunities to make the opponents' anticipation harder".*

These reflections indicate that while IBIs involved a temporary loss of individual control, participants saw this as enhancing their overall agency and contributing to richer emotional gameplay experiences in contrast to prior work [64, 81].

5.1.3 Actively engaging with the varied levels of controlling the IBIs intrinsic to gameplay. This sub-theme describes participants' varying levels of engagement with the IBIs. Some focused purely on the gameplay aspect: *"Oh, I can shock someone, cool!"* (P9), while others were less preoccupied with the physicality: *"I didn't give too much thought... to the touch aspect"* (P14). However, most became more conscious of the shared touch experience over time: *"...the sensation and the dynamics of touching altered, making me more conscious"* (P12). P16 emphasised this dynamic nature of the touch: *"Each electrical touch needed awareness."* P7 elaborated on the complexity and intrigue: *"The electrical stimulation kept me hooked and guessing".* P9 noted their adaptive strategy: *"We started with low intensity and cranked it up as we got used to it".* These reflections show that groups adjusted the intensity to explore different degrees of shared control during gameplay, demonstrating active engagement with varying levels of control within IBIs.

5.2 Theme 2: Developing group bonding through IBIs

In this theme, participants discussed their experiences of developing group bonding through IBIs. The theme has three sub-themes: 1) fostering camaraderie through harnessing the unique nature of touch (48 data units); 2) enhanced communication due to heightened synchrony of IBIs (41 data units); and 3) exploring cultural differences through non-rigid game rules (36 data units).

5.2.1 Fostering camaraderie through harnessing the unique nature of touch. In this sub-theme, participants described their experiences of how sharing bodily control fostered camaraderie and group cohesion. P2 said, *"Playing the game made the atmosphere around us a lot more comfortable"*, and expressed their enjoyment of playing with close friends: *"I was comfortable touching and allowing others to control my body via EMS because we are very close"*. However, participants also expressed their apprehensiveness towards showing their bare feet. P19 said: *"I am not too comfortable and embarrassed to show, let alone touching with my barefoot. However, repeatedly doing it decreased this uncomfortableness and led to knowing the group better"*. Participants also reflected on the impact of the game after the game session. P21 said: *"It improved the feeling of touch lasted beyond the game"*.

5.2.2 Enhanced communication due to heightened synchronisation of IBIs. In this sub-theme, participants described how their heightened synchronisation of IBIs brought about enhanced communication. P5 described non-verbal cues in their game roles: *"As an Insider, I communicated using gestures under the table to synchronise our actions"* (Figure 6). P19 linked observation of touch with partner communication: *"It was like someone patting your back... we experimented with the foot pressure"*. P27 added: *"We (insiders) touched before touching the decoder to determine how much pressure to apply"*. P12 highlighted the unique language-like quality of the experience: *"Subtlety was key... we were speaking a new tactile language..."* P3 felt shared control fostered teamwork: *"It was about a heightened sense of synchrony"*. P4 and P7 further elaborated on the distinctiveness of the sensation and its potential for connection with others. P7 said: *"...interpreting EMS pulses (duration and intensity) added another layer of communication"*. These experiences suggest that participants found ways to enhance their communication through the required heightened synchronisation within IBIs. The positive experience of this synchronisation might explain their willingness to share bodily control for further IBI engagement.

5.2.3 Exploring cultural differences through non-rigid game rules. In this sub-theme, participants described how Hidden Touch's flexible rules allowed players to create their own communication methods, leading to unexpected insights about cultural differences. P10's confusion over their partner's gestures highlighted how non-verbal cues vary across cultures: *"...head nods mean different things in my culture"*. P15 emphasised how gameplay blended cultural interpretation with the novel touch sensations: *"The gameplay was a blend of recognising cultural cues and technological interpretations"*. P13 added how unexpected touch led to playful confusion and learning: *"The shocks and tingles... made us laugh and question if there was a cultural gesture we misinterpreted or if it was just playful mischief"*. These experiences reveal how augmented IBIs within a playful context can expose the complexities of communication across cultures. The mix of learning, confusion, and amusement highlights how gameplay itself can become a space for exploring cultural differences.

Figure 6: The Decoder (left) is waiting for an Insider (right) to touch them. Meanwhile, the Insiders (right) employ a strategy of moving their bodies simultaneously to deceive the Decoder.

5.3 Theme 3: Cultivating bodily awareness through inter-body gameplay strategies

This theme describes participants' experiences of cultivating bodily awareness due to discovering gameplay strategies. It has three sub-themes: 1) developing bodily awareness due to the multisensory nature of IBIs (46 data units); 2) enabling strategic layers by using synchronous and asynchronous shared bodily control (37 data units); and 3) leveraging bodily characteristics and the physical environment for strategic gameplay (34 data units).

5.3.1 Developing bodily awareness due to the multisensory nature of IBIs. In this sub-theme, participants described developing heightened bodily awareness during gameplay. P12 highlighted how gameplay rules led to analysing touch: *"We created a rule of touching... three times to let decoders experience the touch"*. P26 noted how this repeated exposure changed perception: *"Touching multiple times made us realise things, such as texture and temperature..."*

Expanding on this multisensory focus, P13 explained how sensations were amplified and less localised: *"EMS actuations... made it harder to distinguish foot directions."* P22 elaborated on the altered sensation: *"Insiders tried to touch different parts of the foot... changing how shared actuation felt"*. This, combined with actuated hand movements, made developing spatial awareness a challenge. These experiences suggest that participants seemed to balance hiding the extent of their bodily actuations by manipulating the duration of touch alongside their observations of others.

Adding further complexity, P16 described how multiple factors became crucial strategies: *"...altering the foot's temperature... concentrating on [its] size... the intensity and rhythm of touch also mattered..."* P12 noted the limits of traditional cues: *"It was harder to rely on*

Figure 7: Participants play on a shorter table, giving the Decoder (right) the advantage of easily noticing even small movements.

facial cues because the Insiders were preoccupied..." These insights suggest that multidimensional input mechanisms facilitated by our approach, seemed to enrich communication and also enhance the overall gameplay experience.

5.3.2 Enabling strategic layers by using synchronous and asynchronous IBIs. In this sub-theme, participants described how they developed strategies by using synchronous and asynchronous IBIs. P18 aimed to mimic their partner's touch: *"My strategy was to twitch my hand simultaneously..."* while P21 used distraction techniques: *"I could move my hand a lot to hide who touched..."* Coordination was also key strategy, as P20 noted: *"We had gestures to decide who will touch and who will mirror the outcome of actuated movements"*. These experiences suggest that shared control through inter-body electrical muscle stimulations enabled players to engage in parallel gameplay [104]. P9 highlighted the element of deception: *"The ability to meaningfully bluff before the actual touch... enhanced gameplay"*. These experiences suggest that EMS-enabled IBIs introduce strategic layers of anticipation and misdirection. This highlights how co-located social gameplay could be expanded through synchronous and asynchronous IBIs, adding a new dimension to such experiences.

5.3.3 Leveraging bodily characteristics and physical environment for strategic gameplay. In this sub-theme, participants described how they strategically utilised bodily characteristics and environmental details. For example, table height influenced play, as P4 noted: *"A taller table made reaching harder... a shorter player found this advantageous"*. They continued, *"The short table was also advantageous since even the slightest player movement was visible to them"* (Figure 7).

Hidden Touch heightened awareness of subtle details, as P13 observed: *"I can feel one foot is heavier than the other..."* This suggests how the game made them more aware of the little things about themselves and each other. Moreover, while initially distracting, environmental elements and accessories became tools for misdirection, as in P11's example: *"That clinking sound of my bracelet when my hand moved involuntarily...later, I used it to mislead players."* A group of participants explained that the room they played in gave away the Insider's secrets to the Decoder. P5 pointed out how the space itself could reveal secrets: *"The Decoder caught unintentional glimpses of our gestures under the table, due to the reflections in the playing area's windows"*. These experiences suggest the gameplay fostered "somatic awareness" [42] - heightened attention to subtle bodily cues - which players strategically exploited.

6 DISCUSSION: A FRAMEWORK FOR OUR SHARED BODILY FUSION APPROACH

To address our research question, "How do we design digital games where IBIs are intrinsic to gameplay?", we delve into participant experiences using the trajectories method [17] as a narrative framework. This method allowed us to map how shared bodily interactions evolved over time, revealing patterns and shifts across the three core shared control dynamics (shared intensity, control duration, and control deception) that underpin our experiential spaces. In our study of "Hidden Touch", these trajectories encompass transitions between varying levels of these dynamics. Additionally, the method enabled us to analyse how player roles shifted between Insider and Decoder over the three-day study, offering insights into how role changes in the game shape perceptions and engagement with inter-body interactions.

This mapping spans across three experiential spaces – Threshold, Tolerance, and Precision – that collectively form our overarching "Shared Bodily Fusion" framework. Designed as an analytical tool, this framework helps us examine the complex nature of IBIs within game design, emphasising how they can enrich digital bodily gaming experiences. Our framework highlights the delicate interplay among shared control, emotional consequence, and strategic engagement, all of which are essential to creating compelling and meaningful digital bodily play experiences. Additionally, we offer design implications for each experiential space, providing valuable insights for researchers and designers interested in exploring the design of social bodily games using our approach. While the trajectories illustrate general trends, player experiences were not always strictly sequential. Progression through the experiential spaces could be fluid, with players occasionally revisiting earlier stages or demonstrating aspects of multiple spaces simultaneously. This fluidity reflects players adapting to the technology and the evolving nature of their interactions. By explicating this progression within the spaces, we emphasise the transformative impact of IBIs on social play.

6.1 Threshold: Experiential Space of Negotiating Shared Intensity and Bodily Comfort

The term "Threshold" describes the initial stage of the "Shared Bodily Fusion" experience, marking a transition for players into a space characterised by a focus on the shared intensity of bodily sensations and their negotiation of mutual comfort with involuntary movements. In this space, players cautiously explore the boundaries of shared bodily control, experimenting with varying levels of intensity (input) while navigating a sense of bodily comfort (or lack thereof) in response to their involuntary movements (output), as introduced in Section 3.4.1. Importantly, the threshold is not fixed but rather dynamically negotiated between players. What constitutes the tipping point, the moment where shared intensity and involuntary movements become the central focus of their experience depends on each player's sensitivity, risk tolerance, and their evolving social dynamic within the game. The purpose of the

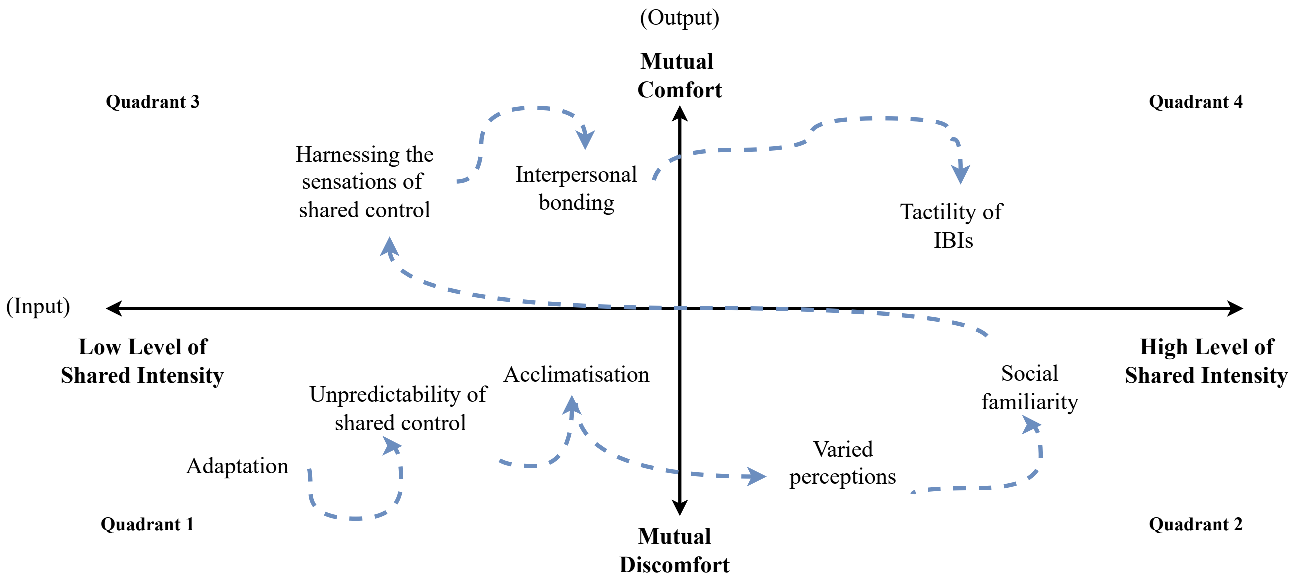

Figure 8: The trajectory of player experiences in the experiential space of "Threshold".

Threshold space is to establish the foundation for the "Shared Bodily Fusion" experience. It is where players begin to calibrate their understanding of shared control, explore what is mutually acceptable, and discover how intensity can be strategically manipulated for gameplay.

In Hidden Touch, this negotiation centres on finding a balance between mutually comfortable and uncomfortable sensations in a shared EMS intensity level, often requiring at least one player to tolerate some discomfort. The Threshold space is presented along two axes: the x-axis represents a continuum from "Low to High Level of Shared Intensity", while the y-axis represents a continuum from "Uncomfortable to Comfortable Mutual Comfort" (Figure 8).

Participants initially found the Shared Intensity experience uncomfortable (Quadrant 1). However, they quickly adapted to the bodily sensations, addressing their initial apprehensions (Theme 1). This aligns with prior work [64, 81, 123], suggesting that players gradually adapt to bodily actuations caused by sharing control. In Hidden Touch, the absence of audio feedback about the timing of involuntary bodily actuations – a feature present in some prior studies [121] – did not hinder this adaptation.

As players continued to engage with shared bodily control through touch, they began to recognise nuanced emotions evoked by interactions, such as "embarrassment" or "comfort" (Themes 1 and 2). These findings highlight the profound nature of amplified touch-based IBIs, enabled by body-actuating technologies, which can elicit deeply personal experiences [84, 93, 117]. Furthermore, our study suggests that thoughtfully introducing discomfort into interactive experiences [146] can enhance gameplay [54, 84, 117].

As the experience transitions to Quadrant 2, players' perceptions of shared control become closely linked with their "familiarity" with co-players (Theme 1). Repeated engagement with the discomfort of touch (Themes 2 and 3) cultivates "Social Familiarity" [31, 35], leading to greater comfort over time (Quadrant 3). These experiences support the idea that repeated exposure to initially uncomfortable IBIs can foster enriching social play experiences by allowing players to adapt [18]. Through this progression, players suggested that they develop interpersonal bonds and laughter during gameplay (Theme 2). These observations align with Sicart's insights, highlighting the potential of mediated computers to amplify play's social dimensions and create long-lasting impact beyond the immediate experience [139].

Upon reaching Quadrant 4, players seemed to attain a mutual level of comfort, having fully adapted to the dynamics of shared intensity. The IBIs, facilitated by the mediating computer, enable players to perceive touch as transcending mere bodily interaction, fostering a "shared psychological position" (Theme 1). This finding echoes prior research [50, 58, 72, 73] on technology-augmented interactions cultivating empathy. However, our "Shared Bodily Fusion" approach uniquely emphasises the direct experience of another player's bodily sensations, potentially deepening the empathetic connection.

6.1.1 Design implication 1: Consider designing systems that allow players to control the level of shared intensity. Prior work [50, 117] highlights the value of gradually easing into shared control scenarios rather than abrupt introductions to new sensations and experiences. Our study emphasises the benefit of allowing participants to control the shared intensity level to calibrate the social EMS system. Participants could start at a comfortable intensity, warming up to the simultaneous and involuntary bodily movements. They gradually increased intensity as they became acclimated to the EMS system during gameplay. Consequently, when developing systems that involve shared bodily control for IBIs, we suggest future designers consider creating design features that give players control over the shared intensity levels. Such functionality not only assists users in gradually warming up to shared control but also ensures a consensual and comfortable exploration space.

6.1.2 Design implication 2: Consider designing systems that distribute input and output across the body. Prior work suggests that integrating discomfort in the design of social bodily games [18, 60] can help foster positive gameplay experiences. Our study supports these findings, but it also indicated that distributing discomfort by using varied input and output locations can also foster deeper interpersonal connections. Specifically, our social EMS system utilised touch at one body location (e.g., foot as input) to actuate muscles at another location (e.g., hand as output), diffusing the focal point of discomfort and engaging the players more holistically. This technique of spreading sensory experiences across the body not only mitigates localised discomfort but also enhances engagement and enjoyment. Therefore, we recommend that designers of shared control systems explore strategies for distributing input and output locations across the body to optimise the user experience.

6.2 Tolerance: Experiential Space of Exploring Control Duration and Bodily Awareness

The term "Tolerance" describes the experiential space where players explore how the duration of shared control (input) and the consequent bodily awareness (output) becomes pivotal to their experience, as introduced in Section 3.4. Within this space, players manipulate the length of touch, ranging from brief to extended, to influence the intensity and visibility of their bodily responses. They strategically communicate through these tactile IBIs, developing a tolerance for varying degrees of bodily discomfort or awkwardness induced by shared control. Individual comfort levels with extended shared control play a significant role in how far players venture into this space. Players collaboratively negotiate the extent to which they are comfortable with prolonged bodily awareness and the strategic benefits it offers within the game. The purpose of the Tolerance space is to allow players to refine their understanding of how shared control translates into bodily experiences over time. It fosters a deeper awareness of their own bodily responses and the ability to interpret nuanced cues from co-players, enhancing their ability to communicate strategically through shared bodily control.

In Hidden Touch, players have direct control over the duration of their shared interactions. The Tolerance space is visualised along two axes: the x-axis represents a continuum from "Brief to Extended Shared Control", while the y-axis represents a continuum from "Low to High Level of Bodily Awareness" (Figure 9).

Initially (Quadrant 1), players discovered a unique form of technology-enhanced bonding through shared bodily control, marked by laughter and close strategising (Theme 2). As they progressed (Quadrant 2), they became attuned to variations in the intensity (Theme 2) associated with different durations of shared control. This finding on becoming aware of the varied sensations caused by the different durations of shared control echoes previous research that suggests engaging in bodily play enhances bodily awareness [95, 105]. This increased awareness facilitated strategic communication among players (Theme 2), highlighting the concept of "bodily intelligence" [49], where an individual is aware of their bodily actions but also knows what to do with this awareness [105].

As participants navigated into Quadrant 3, our findings revealed a refinement in their interpretation of shared control. Players exhibited a mastery over the effects of touch's duration, innovating their gameplay with self-created rules (Theme 3). This behaviour demonstrates players' autonomy and creative agency, embodying "self-effacing play" [47] as they actively deviate from established gameplay paths in favour of experimentation driven by curiosity and exploration.

By Quadrant 4, players had mastered the tactical use of touch duration, communicating through tactile IBIs and interpreting bodily responses as elements of a shared narrative (Themes 1 & 2). This progression aligns with the concept of "Erfahrung" [105], emphasising how active engagement with the diverse sensations of shared control duration shapes players' bodily awareness and connection. This transcends simple gameplay, suggesting narrative potential for meaningful interactive experiences.

6.2.1 Design implication 1: Consider designing systems that give control over the duration of inter-body interactions. Prior work advocates for control over players' bodily actions in digital bodily play [107, 133]. Such control not only fosters "bodily intelligence" [49], but also allows players to explore and understand the nuances of their interactions, encouraging deep engagement and development of personal play strategies [105]. Our findings reveal that participants leveraged shared control to strategically navigate gameplay, adjusting the duration of shared control via the social EMS system to tailor their experience. This flexibility enabled a heightened sense of bodily awareness, allowing players to choose between swift or exaggerated movements as part of their tactical approach. Based on these experiences, we suggest designers consider designing systems that allow users to control the duration of IBIs, to encourage a more personal and immersive gameplay experience.

6.3 Precision: Experiential Space of Visibility and Deception in Shared Bodily Control

The term "Precision" encapsulates the experiential space where players strategically manage the visibility of their bodily actions (output) through IBIs, emphasising control deception (input) as introduced in Section 3.4. Within this space, they can choose between covert (subtle) and overt (exaggerated) movements to create different gameplay dynamics. This ability to manipulate the perceptibility of their bodily actions fosters a nuanced understanding and tactical execution of shared bodily control. How far players venture into the Precision space depends on their ability to deceive and read the bodily cues of their opponents. Players continuously assess their opponent's skill level and adjust their deception strategies, accordingly, creating a dynamic interplay. The purpose of the Precision space is for players to develop a sophisticated understanding of how to exploit their bodily responses for tactical advantage. It encourages deception, social deduction, and the ability to adapt strategies based on their opponent's skill.

In Hidden Touch, players can strategically choose between subtle and exaggerated bodily actions, directly influencing the visibility of their movements to their opponents. The Precision space is visualised along two axes: the x-axis represents a continuum from "Covert to Overt Shared Control", while the y-axis represents a continuum from "Low to High Visibility of Bodily Actions" (Figure 10).

Initially (Quadrant 1), players focused on mastering the physiological sensations of shared bodily control, emphasising strategies

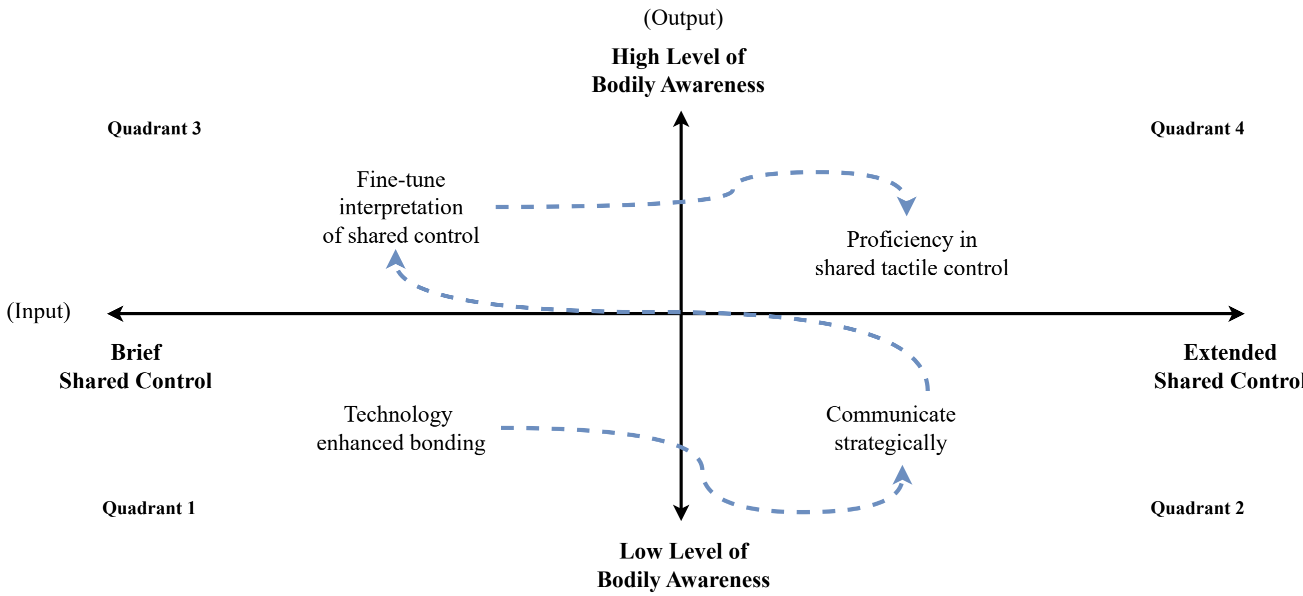

Figure 9: The trajectory of player experiences in the experiential space of "Tolerance".

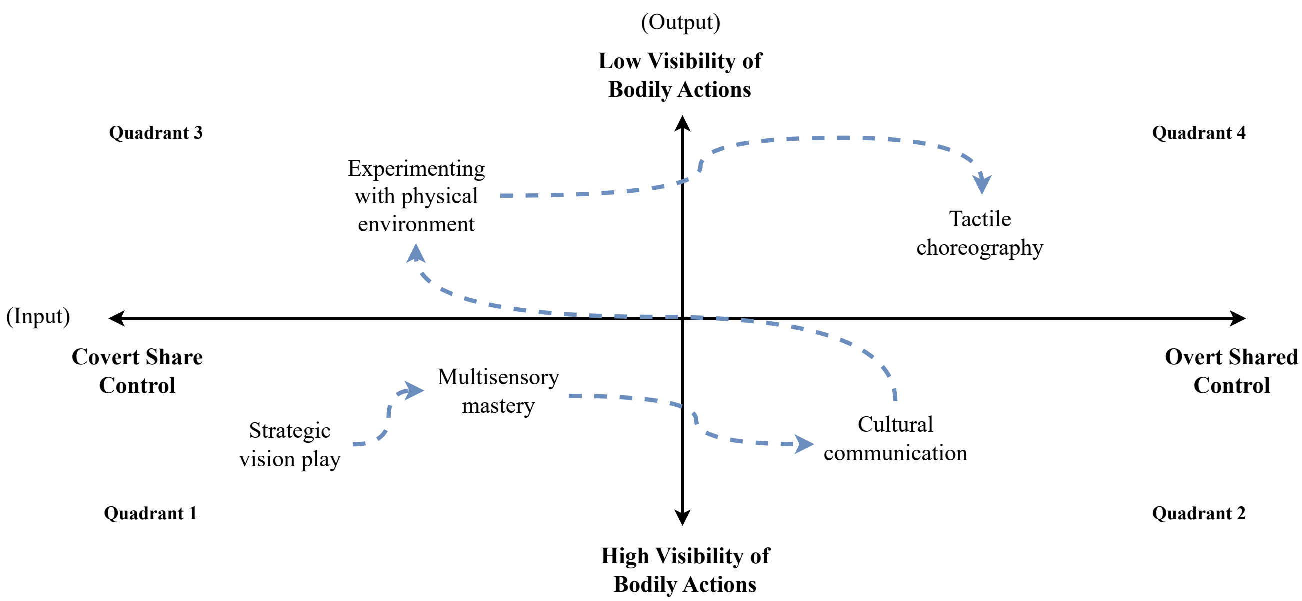

Figure 10: The trajectory of player experiences in the experiential space of "Precision".

linked to vision, direction, and body movement synchronisation (Theme 3). This emphasis on multisensory engagement (Theme 3) enhanced players' ability to predict opponents' actions, which aligns with prior work [67, 118] showcasing the benefits of multisensory experiences for understanding gameplay and overall enjoyment.

Progressing to Quadrant 2, players began using overt gestures that challenged conventional bodily communication. This fostered deeper exploration of each other's cultures and enhanced interpersonal communication (Theme 3). The shared bodily control became a bridge for intercultural connection, appearing to support the notion that digital games can catalyse cross-cultural appreciation [139].

In Quadrant 3, players experimented with the physical environment to optimise covert actions (Theme 3). This highlights how physical and spatial factors can shape shared bodily control, supporting prior theories on environmental influences [62, 139] and extending them within the context of social bodily play.

Advancing to Quadrant 4, players engaged in a rhythmic form of interaction. They approached IBIs with a tactical awareness, carefully balancing overt and covert actions in a manner resembling tactile "choreography" (Theme 3). This phase demonstrates how participants adapted to the dynamics of deception and visibility, developing nuanced shared control and choreographed interaction. This form of embodied communication suggests the potential for technology-mediated play [62, 139] to promote deeper interpersonal understanding, a potential precursor to empathy.

6.3.1 Design implication: Consider designing systems that incorporate synchronous and asynchronous IBIs. Prior research highlighted that bodily actions, undertaken independently or coordinating with each other, can enhance player engagement and interaction [104]. In our study, players engaged in both synchronous (coordinated) and asynchronous (independent) IBIs to enrich their gameplay experiences. This flexibility for engaging in inter-body interactions enhanced players' overall engagement. Consequently, our findings support this prior work [104], and we suggest that designers consider designing systems that incorporate synchronous and asynchronous IBIs to enhance gameplay dynamics and player engagement.

7 POTENTIAL PROSPECTS AND ETHICAL CONSIDERATIONS OF OUR APPROACH

This section delves into the broader implications and future prospects of the "Shared Bodily Fusion" approach. We extend the conversation beyond the immediate context of digital gaming to envisage its potential impact across various domains. Furthermore, we address the ethical implications that accompany the integration of intimate technologies, such as EMS, when designing interactive systems.

7.1 The Future of Shared Bodily Fusion

Our "Shared Bodily Fusion" framework proposes innovative avenues for making Inter-Body Interactions (IBIs) intrinsic in digital games, with potential applications extending beyond mere entertainment. Echoing Mueller et al. [104], our approach aims to broaden the horizons of social bodily interactions mediated by technology. For example, our framework can inspire new forms of athletic training and competition [122, 147] in the fields of SportsHCI [37, 98, 100] and Superhuman sports [68]. This can be done, for example, by blending athletes' physical abilities with subtle technological augmentation using BATs for richer shared control experiences, mirroring those found in contact sports like boxing, martial arts, basketball, and handball [100]. Our framework could also be considered when designing health applications, particularly in therapeutic settings like motor-rehabilitation [91]. Given that traditional therapy often grapples with issues of engagement and adherence and the need for treatment to occur in a co-located setting [44], introducing therapy with playful EMS experiences could shift patients' perception of therapy, and also aid in coming up with creative solutions to treat patients over distance. This shift, albeit subtle, could impact therapy outcomes by aligning physical rehabilitation with an enjoyable and immersive experience [10, 44]. Moreover, our framework has the potential to inspire investigations beyond the immediate context of game design. For instance, it could be adapted to facilitate shared bodily experiences over a distance [94, 97, 142]. Technologies such as haptic feedback systems [23, 127] and remotely controlled actuators [28] might enable a sense of embodied interaction despite geographic separation. Additionally, the framework could find applications in embodied learning, where shared control simulations could help students grasp scientific or historical concepts through direct physical experiences [92].

In contemplating the future of our approach, we also reflected on the limitations of our mediating computer (social EMS system). Our system does not sense when players change their input, for example, when they change location or intensity of touch. Our intention was to retain the authenticity of a traditional gaming experience while giving players options to amplify this experience of shared control using a mediating computer. While this allowed participants to have full control over their experience, incorporating sensing technologies can help create an affective feedback loop (e.g., [26, 60]), perhaps enhancing such shared control experiences. This affective loop can then be used to augment other co-located traditional social games, such as Twister [86] and Three-legged race [136], possibly even allowing players to experience these co-located IBIs over a distance [14]. Moreover, such explorations could also help augment physical games [83], such as arm-wrestling, where technology amplifies physical interactions in the pursuit of balancing such exertion games [11]. However, a challenge lies here: *What is the extent to which technological integration should mirror and/or amplify IBIs while maintaining their authenticity?*

As we look to the future, several other reflective questions arise. *How do we ensure that these experiences remain inclusive and adaptable to diverse user needs? How can we balance the technological complexities with user-friendly interfaces to make these experiences widely accessible? And perhaps most importantly, how do we navigate the ethical landscape that accompanies integrating such intimate technologies into everyday interactions?*

7.2 Ethical Considerations

As we look towards the future of engaging with our approach, we follow Friedman [43] and wish to not only advance the narrative about technology but also to reflect on its corresponding ethical considerations. Our initial steps included developing a study design that received institutional ethics approval. As suggested by prior EMS work [121, 145], we followed three guidelines to conduct our study to balance ethical responsibility alongside our technological exploration. Firstly, "non-maleficence" focuses on minimising risks, which we did by educating our participants on EMS usage and supervising their gameplay during the pre-study phase. Secondly, "beneficence" involves clearly communicating the study's benefits, which we detailed in our explanatory statement. Lastly, "respect for autonomy" was upheld by securing explicit consent for each aspect of our study, including the use of demographic data and adherence to EMS exclusion criteria [64].

In our case, another ethical issue about privacy and consent is the touch's personal nature [71]. To ensure participants' well-being and comfort with mediating computers that can amplify such IBIs [80], we recruited those who are familiar with each other. Additionally, our approach opens several other ethical considerations:

- **Accessibility and inclusivity:** While the production and consumption of BATs like EMS is increasing [115], the ethical imperative is not only to improve accessibility but also to ensure that they are inclusive. This need is highlighted by researchers interested in "Assistive Augmentation" [109], i.e., "integrating technology with all human bodies, regardless

of one's physical abilities, to provide enhanced perceptive capabilities" [109] raises several questions, including: *How can our approach be made adaptable to cater to individuals with diverse physical abilities and sensory experiences? Can technology be adapted to provide equivalent engagement for such individuals?*
- **Acceptability in different settings:** Using our approach in less familiar settings, such as workplaces and educational institutions, would raise questions about social acceptability [66, 113]. *What would be the norms for social acceptance? Does the change in personal boundaries effect the perception of technologically supported IBIs and, by extension, the experience's dynamics?*
- **Cultural sensitivities of IBIs:** Different cultures perceive shared control, such as via touch in varied forms (e.g., conveying emotions [13] or communicating non-verbally [126]). Moreover, what may be considered a casual form of interaction in one culture could be seen as intrusive or even taboo in another [13]. This raises questions such as: *Can our approach be applied to foster cross-cultural empathy? How should it account for variations in personal boundaries when engaging with IBIs in the same cultural context? How do we cater to this intracultural diversity, ensuring comfort and consent?*

Although these ethical perspectives are not exhaustive, we seek to create a starting point for dialogue among researchers, industry, and policymakers. With this dialogue, we hope to shape a technological future that respects human needs, upholds autonomy, and protects the well-being of all.

8 LIMITATIONS AND FUTURE WORK

Our study has some limitations. We did not study the Hidden Touch game with players groups who were unfamiliar with each other. However, even within familiar groups, participants discovered new things about themselves, such as their apprehensiveness about showing their bare feet. Future work could study strangers playing the game. Our study also focused on one game to showcase our approach. While this game helped us to generate new knowledge about IBIs that our approach could facilitate, future work could explore the augmentation of other traditional games to evaluate our work's generalisability. Moreover, the number of players can be scaled using our system, which future work might consider to further understand our work's implications.

A technical limitation of our work was that players had to manually decide who touched and enter their selection to update the score. While our study observations suggested that this manual game engagement promoted camaraderie, future researchers could automate such experiences using touch-sensing mechanisms from prior work [59] to understand how they influence player experiences. We also note the challenge of attaining balanced control (section 3.3.1) between players, which is an ongoing challenge faced by the HCI research community and is being addressed through auto-calibration works [65].

While our safety measures proved effective in our study context, it is important to acknowledge that ensuring the safe use of EMS across multiple individuals remains an area for continuous improvement. Our current approach relies on player awareness and adherence to instructions, but future work could prioritise more robust safeguards. These could include real-time monitoring systems to detect potentially unsafe current levels, circuit designs that intrinsically limit current, and standardised procedural protocols with clear signals to immediately pause the electrical circuits if a player expresses any discomfort. By addressing these safety complexities, the field can ensure the responsible and ethical development of shared bodily control experiences.

9 CONCLUSION

In this work, we proposed the "Shared Bodily Fusion" approach – whereby players fuse their bodies through a mediating computer to create a shared input and output system that facilitates IBIs intrinsic to gameplay. Inspired by our experiments informed by our prior work and traditional social play, we designed "Hidden Touch" to showcase this approach. Through a study with 27 participants (in groups of three), we crafted three player experience themes. Informed by these findings, we mapped their trajectories across our three experiential spaces – Threshold, Tolerance, and Precision – which collectively form our design framework. This framework supports the creation of future digital games with intrinsic IBIs, facilitating both design and anticipation of user experiences, and ultimately promoting the benefits of traditional social play.

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A IMAGES FROM RESEARCH THROUGH DESIGN PROCESS

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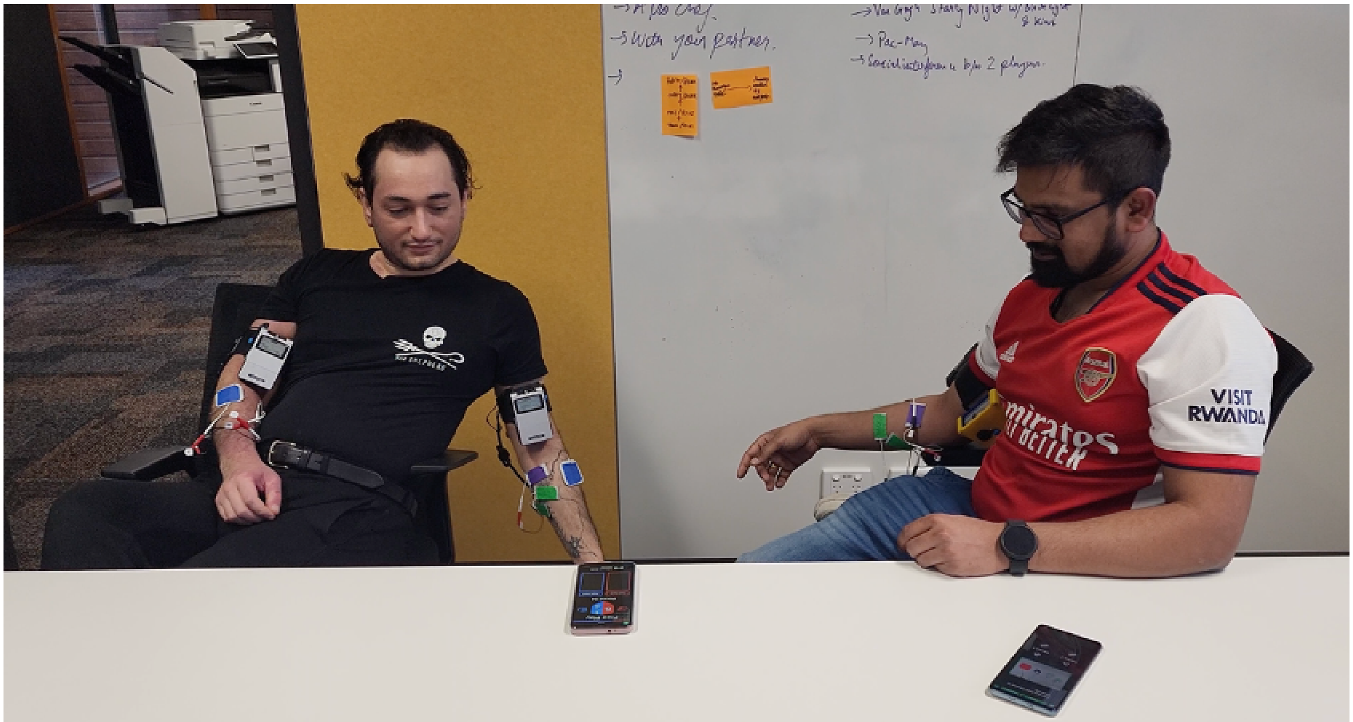

Figure 11: Shared Bodily Control in the same location (setup 1). While this setup seemed to foster camaraderie, the shared space allowed participants to anticipate each other's actions, reducing the element of surprise.

Figure 12: Shared Bodily Control Across Distance (Setup 3). This setup investigates bodily control mediated through video conferencing. Despite the physical distance, this setup allows for surprise due to internet lag, while retaining a sense of camaraderie through voice communication.