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Designing Relational Care: Speculative and Participatory Approaches to Movement-Based Human-Robot Interaction through the Performing Arts

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Abstract

Recent developments in health research increasingly frame health as relational and situated—emerging through interactions among bodies, environments, institutions, and technologies. Translating this into the design of robotic care technologies, particularly those involving movement-based Human-Robot Interaction (HRI), remains a challenge. This paper proposes a relational approach to the design of movement-based robotic systems for health and care contexts that integrates the knowledge and expertise of the performing arts, alongside care stakeholders. First, we describe our methodological approach for integrating the performing arts into relational HRI design for health applications, focusing on Fizzy (a minimalistic, robotic ball that supports health promotion and caregiving to older adults) as a design case. Drawing from two interdisciplinary studies, we analyse how Speculative Enactments (SE) and Participatory Design (PD) can inform the design of movement-based HRI from a relational standpoint. Second, we report on three design lessons learned during these studies: (1) take your lead from the materiality of the robotic platform, (2) frame encounters to steer the interpretation in specific ways, (3) attend to emergent movement patterns in situated interactions. Together, these methodological and design insights contribute to a relational approach for designing movement-based robotic technologies that support health and wellbeing through embodied, situated encounters.

CCS Concepts

• **Human-centered computing → User studies**; **Participatory design**; • **Applied computing → Performing arts**; **Consumer health**.

*Both authors contributed equally to this research.

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Speculative enactments, Participatory design, Performing arts, Human-robot interaction, Geriatric care

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1 Introduction

With the growing focus on ethics and personalization of care, conceptualisations of health have shifted from a person's bodily state in isolation to a person's experience emerging from the interaction between themselves and their environment—involving other beings, objects, cultures and values [15]. These new understandings, therefore, position health as a relational and situated phenomenon, transforming the ways in which health can be promoted and care can be delivered. However, when considering the design of care robots, particularly the ones that rely on movement-based interaction, from this relational perspective, several challenges arise: how to pay attention to the social and cultural contexts, institutional systems and environmental surroundings affecting the interaction between care robots and care receivers? How to introduce the person's needs, values and beliefs in the process of designing such technologies?

Fundamentally, a relational approach to movement-based HRI involves paying attention to how movement acquires meaning through its interplay with social, cultural and interactional context, as well as through how encounters are framed. This implies that meaning ceases to be a predetermined, individual quality expressed through movement; instead, it emerges as a collaborative outcome of the act of moving, a co-creation involving the various elements constituting an encounter. Relational HRI thus entails a complex shift in how movement is designed: from predetermined motions and gestures that aim at communicating a specific meaning to designing affordances for interacting. This positions movement as part of larger interactional dynamics while simultaneously underscoring the situatedness of the encounter—examining how diverse elements come together and mutually influence each other to create meaning. In order to approach movement-based HRI relationally, we propose leveraging methodologies from speculative and participatory design practices, including performing art experts alongside care stakeholders. Care stakeholders, as end users, bring experiential and situated expertise about the relational, physical, and organizational dynamics of care settings, grounding the design process in the lived realities of those who will interact with the robot. Performing art professionals, due to their embodied knowledge in creating and sustaining interactions, as well as their sensibilities towards movement qualities and dynamics, are also key when approaching movement-based HRI from a relational angle. Moreover, a performing arts perspective on HRI design encourages us to move beyond what the robot does to pay attention to the broader situation at hand.

To illustrate how such interdisciplinary collaboration can contribute to relational HRI design, we report on a design case with a robotic ball called Fizzy, aimed at promoting health and caregiving to older adults. Firstly, we describe the methodological steps taken in two studies: one involving performing art experts in speculative enactments and another one including future-oriented participatory design workshops with care stakeholders. Secondly, we present three broader lessons that can be applied to the design of movement-based care robots: (1) Take your lead from the materiality of the robotic platform, (2) frame encounters to steer the interpretation in specific ways, and (3) attend to emergent movement patterns in situated encounters. These lessons call for a shift in movement-based HRI, moving from predefining what a robot's movements should mean to creating affordances that allow meaning to emerge through interaction and context, thus fostering a more relational and situated approach to the design of health and care technologies.

2 Related Work

2.1 Designing Care Technologies through a Relational Lens on Health

In their 1948 constitution, the World Health Organisation defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [33]. Although this well-accepted definition places an emphasis on holistic well-being, it framed health as a binary condition, which could be either present or absent, positioning medical practice as the authority in deciding and maintaining an individual's health [15, 25]. In doing so, it treated patients as passive recipients of care and overlooked the influence of the physical environment, social resources, and individual characteristics on health.

Since the bioethical movements of the 1970s that advocated for patient autonomy, understandings of health and approaches to healthcare have undergone a significant shift [27]. Approaches such as person-centred care, evidence-based medicine, and precision medicine have become central to contemporary healthcare, as they view patients not merely as cases of disease but as persons in relation to their own social, cultural, and physical context [18, 21]. From this perspective, health is a dynamic phenomenon that emerges through each person's interactions with their material and immaterial surroundings [15, 26]. Consequently, caregiving or enhancing health must be relational and situated, unfolding through the ongoing exchange between healthcare providers and recipients.

Understanding health and care practices as relational implies a fundamental turn in how robotic care technologies are designed and implemented. Increasingly, some HRI researchers are acknowledging that care practices are defined by an interplay between care receivers, caregivers, their broader networks of social relationships, organisational infrastructures and technologies [2, 9]. Hence, these studies make use of methodologies that attempt to unravel the relational context of robotic care technologies, such as interviews, focus groups or hackathons with care stakeholders, as well as PD practices and Care-Centred Value Sensitive Design (CCVDS) [5, 9, 30, 31].

Moreover, [31] and [22] point at the value of speculative design, especially in combination with PD, to instigate thinking about possible futures, critiquing current care practices and initiate discussions about values in care. These methodologies are concerned with immersing users in plausible yet future situations with technologies, thereby enabling them to experience and reflect on how these technologies align—or do not align—with their needs, values, practices, and ways of living [20]. This consequently helps refine the design of technological devices based on how users perceive and respond to its presence and qualities, as well as how these perceptions are shaped by the circumstances of the encounter.

2.2 Introducing the Performing Arts in the Design of Care Robots

At the intersection of the performing arts and care robots, some studies have used theatre as a testbed [13, 32] or performing arts activities—such as dance exercises, theatre games or plays—to pursue specific aims, like increasing acceptance, enhancing creativity or mitigating loneliness [7, 11]. In these cases, the performing arts are mobilised as predefined activities or frames in the service of external goals, rather than as bodies of knowledge and practice that might shape, from the outset, the design of novel forms of relational human-robot interaction and communication.

Our work follows instead the approach of those HRI studies that employ the performing arts as ways of re-thinking design processes and develop new ways of looking at human-robot interaction. Examples include [19, 22], who employ live theatre and improvisational role-playing in processes of co-design with stakeholders and potential users in the design of care technologies. Moreover, we locate our own work alongside studies such as [4, 10, 24, 28] which point at artworks, methodologies and expert knowledge of the performing arts as productive sites to develop relational HRI design that is embodied and situated.

Specifically, as we will argue in the next sections, we firmly believe that including the expertise of performing art experts in speculative enactments as a first step in the design process, as in [8, 24], opens up possible future HRI scenarios while grounding them in tangible and situated ways due to the embodied knowledge of performers in movement-based interactions. These insights can then be used to further explore the values and needs of care stakeholders in PD practices.

3 A Relational Approach to Designing HRI for Health Applications: Fizzy, the Robotic Ball

As highlighted by [10] and [24], relational approaches to HRI design shift the focus from designing an 'agent' to designing human-machine couplings, emphasising how meaning emerges dynamically through interactions that occur in a particular situation. Furthermore, movement and its potential for meaning-making is positioned at the centre of relational design processes, instead of being added at a later stage as a complement to symbolic interactions or as an afterthought.

Because of this, the performing arts can be extremely useful when approaching the design of movement-based HRI relationally. On the one hand, performing art professionals can be of incalculable value when designing interactions among humans and robots, due to their embodied knowledge in creating and sustaining interactions, as well as their sensibilities towards movement qualities and dynamics. On the other hand, a performing arts perspective on HRI design encourages us to look beyond what the robot does, and to attend to the broader ecology, as highlighted by [17]. In this sense, it pushes designers to attend to how the different elements that compose a situation (such as the staging of the robot, the behavior of the rest of the actors, and the position and interaction of bodies in space) contribute to the creation of meaningful human-robot encounters.

In this section, we present methodological and design insights on how the knowledge and practice of the performing arts can be effectively integrated into relational approaches to HRI design. To illustrate this, we discuss a design case involving two studies that investigated the potential of the robot Fizzy to promote health and support care for older adults. Fizzy [3] is a minimalistic robotic ball equipped with a single motor and an inertial measurement unit (IMU) sensor, which relies only on movement as an interaction modality [29]. Due to its design, Fizzy lacks the ability to detect objects or humans, nor can it determine its absolute position in an environment; it only responds when physically interacted with. This made Fizzy a suitable platform for exploring the possibilities of simple movement-based interactions, harnessing the embodied knowledge of movement experts.

3.1 Methodological Insights on Relational HRI Design

This section outlines a two-step methodological framework for incorporating the performing arts alongside the insights and values of prospective users: first, speculative enactments with performing art professionals, and second, future-oriented participatory design workshops involving potential users. As we will demonstrate, however, the integration of the performing arts in this design case was not linear but iterative, involving a back and forth process between creative exploration and user participation, each informing the other at different stages in the design process.

3.1.1 Study 1: Speculative Enactments. As a first step in our design case, we organised a four-day workshop in a theatre innovation lab, where a home environment was staged by enclosing the space with three walls and placing furniture within (Fig. 1). Over the course of the workshop, we enacted a series of speculative scenarios imagining how Fizzy might function as a care robot designed to support health promotion and caregiving to older adults at home only by means of its movement, minimalistic design and limited sensing capabilities.

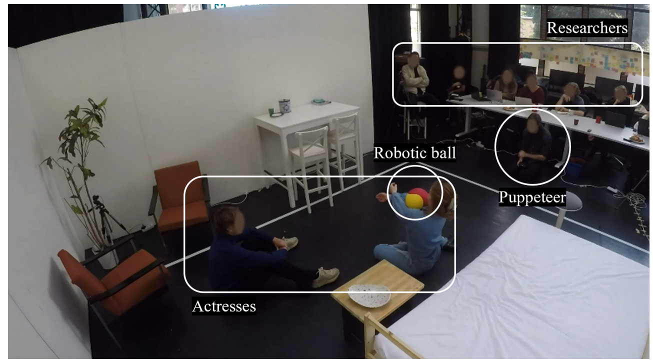

Figure 1: The stage setup

The performing art experts who contributed to this speculative design process included two actresses and a puppeteer. In addition to these experts, eleven researchers specializing in engineering, design, and theatre participated in the workshop. During the workshop, the role of the actresses was to improvise the encounters with the robotic ball by enacting different roles, such as a patient, caregiver, or older individual. The puppeteer was tasked with remotely controlling the robotic ball while being aware of the technical limitations of the robotic prototype; for instance, he controlled Fizzy to respond only to touch, as its sensing capabilities do not allow it to react to verbal commands. The performing art professionals were also invited to share their experiences, thoughts, and insights from the improvisations. In this sense, they functioned as "phenomenological probes" [24], as they provided first-person accounts of their behaviours and the interpretation of the encounters they were part of. The researchers' role was to organize and document the workshop, observe and instruct the experts, and reflect on the enactments through the lens of their disciplines.

In this workshop, we adopted speculative enactments as a design methodology [6]. This approach to speculative design invites the empirical analysis of participants in speculative scenarios. It consists of enacting elements of possible futures with participants, who become part of the research process. Particularly, we included performing art professionals as participating researchers, based on the belief that their embodied expertise can inform HRI more meaningfully when integrated from the outset. Moreover, the use of speculative enactments as a methodological approach proved especially valuable, as it allowed us to explore the kind of embodied insights that arise from situated, context-dependent scenarios.

In the course of the workshop, we harnessed the expertise of performing art professionals in two main ways: first, we conducted open-ended, experimental movement exercises to discover a broader range of possible interactions and movement qualities for Fizzy. Building on these explorations, we then shifted our focus to the enactment of more specific scenarios. Researchers, actresses and puppeteers collaboratively devised and improvised these scenes, carefully considering the factors that could shape how Fizzy's movements were perceived and responded to. Particular attention was given to how the robot was introduced, the movement qualities it evoked in specific scenarios, and how the number and relationships of participants influenced the encounter—especially in terms of whether Fizzy's behaviour invited or discouraged physical activity.

The creativity and openness that came from the performing artists' expertise in improvisation, as well as in creating and sustaining embodied interactions, made space for discovering behaviors and interaction patterns that were not intended by the initial design of the robot or foreseen by the participants, and gave specific insights into how different aspects of an interaction have an effect on how robot behaviour is interpreted. Moreover, the expertise of the puppeteer in animating objects based on their own materiality helped in finding ways of making a minimalistic and non-anthropomorphic robot like Fizzy seem alive, inciting and engaging. As such, the collaboration with performing art professionals facilitated emergent behaviors from actual interactions between humans and robots. Moreover, it encouraged discussions about what is needed to afford the emergence of specific interpretations in concrete situations.

3.1.2 Study 2: Future-Oriented Participatory Design. The second step in our design case involved care stakeholders, whose perspectives and experiences helped refine and reframe our initial creative explorations to better align with the realities of care contexts where Fizzy may operate in the future. These stakeholders were eight healthy older adults aged 68-90 and six healthcare professionals working as a physiotherapist, activity therapist, nurse, occupational therapist, and rehabilitation physician. We organised a one-hour workshop with older adults, followed by two one-hour workshops with healthcare professionals. Between these workshops, two filmmaking sessions with performing art experts were conducted to translate the insights from the first workshop into input for the second.

The methodology we benefited during these activities was future-oriented participatory design, inspired by [14]. As the name suggests, this methodology encourages participants to create and reflect on future situations or designs based on their own needs, values, and experiences. In doing so, it stimulates discussion about the plausibility, desirability, and potential consequences of these future situations or designs. In our design process, future-oriented participatory design was especially useful for exploring the situations and practices in which Fizzy could be integrated, why and how, and what effects it might have on people, their relationships, routines, or living and working contexts.

The first workshop with older adults applied this methodology through improvised interactions with two remote-controlled prototypes and a creative scenario-making activity involving sketching, collaging, and writing. These activities prompted participants to envision how the future of geriatric care might look like with Fizzy, considering how its behaviours might manifest and how interactions could unfold across diverse care contexts with varying socio-physical dynamics. To make the relational and situated aspects of these envisioned scenarios experiential for the subsequent workshops, we then brought in the expertise and knowledge from the performing arts. By building on insights from Study 1 and in collaboration with a filmmaker, these scenarios were translated into scripts for enactments. Seven actors in total and the filmmaker brought these scripts to life, producing four short films that presented Fizzy as a pet-like companion at home, a device in home-based physiotherapy, a plaything stimulating social interaction in a daycare, and an intelligent sports ball used in community center activities [1].

The subsequent workshops with the healthcare professionals involved these films alongside improvised interactions with the prototypes, serving as catalysts for reflection, discussion, and co-design. Particularly, the films invited discussion on how depicted scenarios could align with, challenge, or transform existing modes of (health)care. The participants commented on how Fizzy and its behaviors might be perceived, interpreted, and valued across different care settings, considering its design, the physical characteristics of these settings, and the relational dynamics prompted by them. They also reflected on how Fizzy could be implemented into these settings and what impact it could have on their work practices and relationships. Accordingly, Fizzy's design could be refined in ways that take into account the values, experiences, and expertise of healthcare professionals.

Throughout this study, the workshop with older adults allowed us to identify new robot behaviours and interaction possibilities emerging from the experiences and values of older adults as well as Fizzy's designed qualities. Collaborating with performing art professionals further expanded these possibilities and enabled us to prototype interactions and experiences that did not yet exist. The participation of healthcare professionals helped us explore which behaviors and interaction patterns from Study 1 and early phases of Study 2 aligned with user needs, values, and care setting characteristics. It also clarified how these behaviors would be perceived and interpreted in actual contexts, and why. While Study 1 opened up many possibilities for situated interactions with Fizzy, user participation in this study helped us prioritize these possibilities, revealing which interactions were meaningful, feasible, and contextually appropriate for potential users.

3.2 Design Insights on Relational HRI Design

Through our two-steps methodology of SE and future-oriented PD, we were able to gather valuable information from both performing arts professionals and care stakeholders. These studies helped us in identifying new use contexts and behaviours for Fizzy, reflect on its technological possibilities, and detect enablers and barriers to successful HRI in health applications. Moreover, these studies allowed us to derive three design lessons. We believe that these lessons, although highly situated, are nonetheless useful as broader considerations in the field of relational HRI design. Furthermore, they have the potential to help design care technologies that are in line with a relational perspective on health.

3.2.1 Take Your Lead from the Materiality of the Robotic Platform. This first design lesson addresses the importance of attending to the movement possibilities embedded in the materiality of the specific

[1] Films can be accessed through this link https://shorturl.at/PUs3p

robotic platform. This implies working from the particular embodiment of the robot and the movements that are more appropriate for such embodiment, as well as the interpretations that its motion evokes. This perspective thus prioritises bottom-up rather than top-down design approaches, and is inspired by puppetry practice, as puppetry emphasizes animating objects from their own material affordances rather than imitating human gestures.

This principle was present in the first study, where a puppeteer remotely controlled a Fizzy prototype with a perforated shell and LEGO Mindstorms® drivetrain, a second prototype with a yellow-red covered shell and LEGO Mindstorms® drivetrain, and a third prototype with a green covered shell and a custom-designed drivetrain to assess how their material properties and movement capacities shaped interaction (Fig. 2). Through improvised sessions with actresses, it became clear that the covered prototypes—whose motors were concealed—produced more legible and engaging interactions. The hidden mechanisms reduced distraction and noise, while the simple, covered spherical form encouraged the actresses to touch, pick up, and play with the robot, enabling them to recognize and co-develop movement patterns during interaction.

Figure 2: The three prototypes of Fizzy

The covered prototypes allowed the robot to adopt a more hybrid quality[2]: because their technological components were hidden, Fizzy could simultaneously be perceived as a robot, a companion, and a toy ball. This hybridity encouraged participants to shift fluidly between interpretive frames, enriching the relational dynamics and allowing meaning to emerge collaboratively. Among the prototypes, the green version stood out for its higher-pitched sound, smoother movements, and softer tactile quality, which both the puppeteer and the actresses found more appealing. Its responsiveness and pleasant materiality fostered a sense of liveliness and approachability, demonstrating how subtle variations in material design and sensory feedback can profoundly influence the perceived expressivity and relational potential of a robot.

Because of these insights, we decided to move forward with the closed prototypes for our second study. However, as we experienced during the first study a few instances in which they broke down after being accidentally dropped, we decided to improve the robustness of these prototypes first. Since the second study targeted actual users, who may be more sensitive to technological failures than performing arts professionals, these modifications were made to reduce potential frustration from prototype breakdowns. While the drivetrain of the yellow-red prototype was securely attached to the shell using glue, a complete design iteration was carried out on the green prototype. In this new version, the shell was fabricated from TPU, a material offering greater impact resistance than the previously used PLA [12], and a spoke-like suspension mechanism was introduced to mount the drivetrain onto the shell (Fig 3).

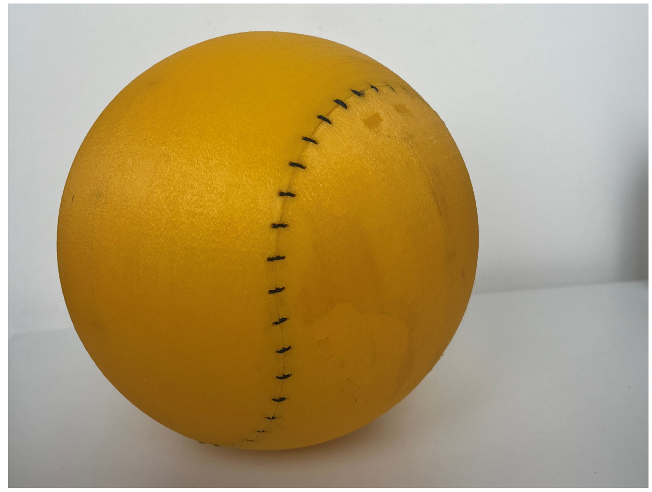

Figure 3: The new prototype that replaced the green prototype

In the second study, the appearances, capacities, and limitations of these prototypes foregrounded certain robot behaviours, ways of interacting and moving with Fizzy, and risks associated with these. Older adults noted no significant differences between the two prototypes, aside from perceiving the yellow-red prototype as more fragile. In the absence of movement, the spherical form and sports ball-like appearance of both prototypes made older adults question what distinguished them from an ordinary ball. Having this comparison in mind, they expected the prototypes to move in familiar, ball-like ways, such as rolling and bouncing. However, when the simple movements of the prototypes, such as rolling and wiggling, were demonstrated, Fizzy was perceived as a more advanced tool. The prototypes' ability to move introduced new interaction possibilities not only for physical activity but also for cognitive and emotional engagement. This was exemplified by scenarios such as a modified Futsal game in which older adults no longer needed to kick the ball, as Fizzy would roll away when approached, or scenarios where Fizzy would perform movements similar to the antics of a clown to evoke reactions from assisted living facility residents.

In contrast to older adults, the healthcare professionals found the yellow-red prototype more cheerful and appropriate for clinical use than the other prototype due to its colours, softer tactile quality, and grippability. At first glance, the ball-likeness of both prototypes suggested potential use on the floor and on tables. Combined with the simple movements, these material qualities also raised concerns about fall risk, as the prototypes could easily move unpredictably or be tripped over. Yet, these same qualities invited the professionals to try Fizzy on different body parts, such as hands, chests, or legs. This bodily experience brought about a new use opportunity

[2] We adopt the notion of hybridity of [16], who defines this concept as an approach to designing robotic embodiments that exists between a functional object and a social being.

for Fizzy: providing physical stimulation to bedridden patients by rolling and wiggling on the body. Additionally, watching the short films, the healthcare professionals were prompted to reflect on how the prototypes' imagined affordances sometimes diverged from their actual material possibilities. One participant captured this tension, noting that "a ball with pet-like behaviors is a strange image to see," thereby highlighting how a robot's embodiment shapes expectations for interaction.

This first design lesson suggests that a relational approach to HRI design benefits from bottom-up approaches in which robotic movement emerges from the materiality and embodiment of the robotic platform. Movement and its potential for meaning-making is central to relational design processes. As such, it is not added as an afterthought or complement to verbal interactions. Instead, it is foregrounded as an initial and fundamental step in exploring the possibilities of the robotic platform, understanding that movement is always deeply interlinked with the embodiment from which it emerges and attending to what it evokes in specific circumstances. By foregrounding the possibilities of movement and meaning-making rather than prescribing certain behaviours, this approach provides space for a broader range of users to interpret and respond flexibly to the possibilities their robotic caregivers or health-promoting devices afford. In this way, health and caregiving emerge through the ongoing, co-constructed negotiation of roles, actions, and meanings between users, caregivers, and the robot.

3.2.2 Frame Encounters to Steer Interpretation in Specific Ways. The second design lesson points at the importance of framing and its impact on how robotic behavior is interpreted and responded to. Our experience with speculative enactments during the first study suggested a distinction between contextuality and framing. Whereas contextuality involves the situatedness of the interaction at hand, framing is a means to actively invite looking at the behavior of a robot in a particular manner. Framing in this sense can be understood as a design strategy that provides a context to steer the interpretation of robotic behavior in certain ways.

The first study explored how different social and functional framings shape human–robot interactions, focusing on two dimensions: interpersonal relationships and the robot's presented purpose. Three improvised scenarios revealed how framing influences interpretation and engagement: (1) a rehabilitation device delivered to a hernia patient by a caregiver, (2) a companion robot given by a granddaughter to her grandmother, and (3) a therapeutic toy provided by a caregiver to mediate the communication between them. When framed as a rehabilitation device, Fizzy's movements were readily perceived as purposeful prompts for exercise, giving the robot an authoritative, guiding role while the caregiver stepped back to assist and interpret its behavior. In contrast, when presented as a companion robot gifted by a granddaughter to her grandmother, Fizzy took on a passive, background role—serving more as a social catalyst than as an interactive agent. The actresses interacted primarily with each other, treating the robot as a domestic presence or pet rather than an entity demanding engagement. The third scenario yielded the most balanced and dynamic exchanges. The defined yet open-ended context encouraged playful and improvisational engagement, with participants incorporating the robot's errors and unpredictability into their interaction rather than seeing them as failures. This responsiveness fostered a reciprocal relationship in which meaning was co-created through mutual adaptation.

Across all scenarios, it became evident that the human introducing the robot—often in a mediating or interpretive role—strongly influenced how the interaction unfolded. The actress in the role of an older adult frequently looked to this figure for guidance and validation, highlighting that social robots operate not merely in dyadic exchanges but within broader networks of human mediation, where the meaning of human-robot encounters is socially coordinated and negotiated among multiple participants.

In the second study, the scenario-making activity enabled the older adults to generate the framings themselves by reflecting on their own experiences, needs, and expectations. The resulting framings showed similarities to the ones explored in Study 1, potentially due to the embodiment of the robot suggesting specific use purposes and participants' prior experiences with or exposure to similar care robots. Due to these similarities, we refined the older adults' framings using the insights that the framings from Study 1 brought about for the creation of short films. These films were then employed as prompts with the healthcare professionals, offering a concrete starting point for a user group who often find the early, ambiguous stages of design (i.e., the "fuzzy front end") challenging to navigate [23].

The films depicted Fizzy as: (1) a pet-like companion at home for a lonely older adult, (2) a home physiotherapy device shown and given by a therapist to a geriatric patient for exercising independently, (3) a plaything used by a caregiver to stimulate social interaction within a daycare group, and (4) an intelligent sports ball used by a coach during group activities in a community center. According to the healthcare professionals, during the first framing, Fizzy's behaviour—rolling towards, hiding from, or running away from someone unprompted —was categorised as strange, unrealistic, and even potentially "freaky" for older adults. This led them to perceive Fizzy's behaviors as childish and unsuitable for older adults, who often have "limited imagination." They also described the robot as uncontrolled and highly autonomous, creating the impression that it might not be possible to turn it off, thereby potentially causing ethical issues for people with cognitive challenges. In contrast, Fizzy's movements, when framed as a home physiotherapy device, were found controlled, legible, and suitable for this care practice. This was mostly due to the fact that this framing depicted the robot as a programmable device combining movements with vocal instructions. This framing prompted the professionals to emphasize the importance of the robot conveying clear, purposeful guidance to patients, particularly in contexts without a caregiver to mediate or interpret its behavior. Similarly, in the third and fourth framings, Fizzy's more unpredictable movements were viewed as acceptable, even enjoyable and playful, because a human mediator was present to frame and guide the interaction.

This second design lesson suggests that, within a relational perspective to HRI, designers need to attend to how meaning is shaped and interpretations are afforded by specific arrangements of behaviours, language, objects, and environments. Movement will not always be unequivocally interpreted. Therefore, attending to framing as a design strategy—considering when to frame and how—helps guide attention and steer the interpretation of robotic behaviour in certain ways, defining a range of meaningful movement-based HRI.

When designing robots for health applications, framing becomes especially crucial, as it raises questions not only about whether a robot's roles and behaviors are appropriate, acceptable, meaningful, and ethical within a care practice, but also about how agency, autonomy, authority, control, and responsibility are negotiated within the complex networks of caregivers, patients, and the robot.

3.2.3 Attend to the Emergence of Meaningful Movement Patterns in Situated Encounters. The third design lesson encourages designers to observe the emergence of meaningful movement patterns in human-robot interactions and utilise those for future design affordances. This has two main implications: firstly, it concerns the design of patterns, instead of specific gestures/movements with a clear communicative intent. This aligns with the concept of design patterns by [1] inasmuch as it looks at patterns that are flexible enough to support different interpretations depending on the situation in which they are enacted but are robust enough to consistently sustain attention and engagement in diverse scenarios. Secondly, this design lesson also encourages observing naturally recurring interactions, deriving meaningful movement patterns from them. The knowledge of performing art professionals became in this respect crucial, as they are experts in creating and sustaining embodied interactions.

In the final sessions of the first study, we examined the types of movement patterns that emerged between Fizzy and the actresses, focusing on how movement contributed to the creation and maintenance of meaningful interactions. To concentrate on emergent movement patterns rather than other elements of the encounter, we used a single improvised scenario in which a hernia patient receives a robot from their caregiver to remain active. In [8], we analysed the empirical data from these final sessions and identified nine basic movement patterns that helped initiate physical interaction between the robot and the human. In that article, we also proposed how these basic patterns could combine into more complex sequences, supported by specific framing strategies to sustain engagement. Importantly, the patterns identified during the workshop did not convey a single, universal meaning; rather, they drew attention to themselves, encouraging human response and allowing for flexible interpretation depending on the context in which they appeared.

In this article, as means of an example, we will focus only on one specific movement pattern that became consistently meaningful in the interaction with the actresses: wiggling, moving, and stopping. The meaning attributed to this movement pattern and the responses it elicited varied based on the situation and diverse interaction elements, such as the interpersonal and functional context or emergent narratives. Regardless of the specific interpretation linked to this movement pattern, it consistently captured the actresses' attention, prompting them to physically interact with the robot—for instance, by picking it up or by following it. The interpretations and responses differed across situations, yet the key point is that this particular pattern invited action and afforded interpretation in situated ways. Rather than being predetermined, it emerged through the interactions between the robot and the actresses, providing affordances that were flexible enough to support diverse meanings while remaining robust enough to sustain attention and engagement.

In the second study, co-designing with the older adults led to the identification of robot movements similar to the patterns found in [8], even though the contexts in which the actual or imagined interactions took place differed between the two studies (for instance, using Fizzy to play games like marbles or jeu de boules). Also aligning with Study 1, the discussions with the healthcare professionals highlighted the importance of situatedness for enacting, responding, and interpreting movement patterns. To exemplify, the activity therapist indicated that Fizzy rolling around unpredictably on a table would be fun, inviting her patients to respond physically by stopping it from falling and cognitively by maintaining attention. However, if any of the patients had a cognitive challenge, the same movement pattern would become confusing. For these patients, as well as for specific situations such as interacting with Fizzy alone or using it in physiotherapy, the movement pattern seemed too ambiguous to invite interaction, limiting Fizzy's potential therapeutic benefits. In these cases, the professionals stressed that Fizzy should move "in a targeted manner" and not behave "like a ball that chooses its own path," emphasizing the importance of controlled, predictable, and directed movements to enhance robot legibility. For designing robots for health applications, these examples indicate that the particular situation in which an encounter takes place does not only influence the interpretation and the resultant human response but also shapes the effectiveness of a movement pattern in yielding a health benefit.

This third design lesson highlights that, within a relational approach to HRI design, it is important to attend to how meaningful movement patterns emerge in specific situations rather than focusing on the performance of predetermined movements or gestures with specific communicative intent. For health applications, this enables users and caregivers to make sense of the robot's actions in their own way, leading to personalized care experiences and catering to different abilities, preferences, and goals. Furthermore, the flexibility of robot behaviors creates multiple opportunities for engagement, which can support sustained participation and adherence to care practices. By fostering personalized interaction and active participation, this approach aligns closely with relational approaches to health.

4 Conclusion

This article proposes a relational approach to movement-based HRI design for health applications, with the design case of the Fizzy—a robotic ball aimed at promoting health and support care for older adults. Fundamentally, our proposed relational approach demonstrates that HRI design should not only pay attention to what the robot does (the movements that the robot enacts), but also what happens around the robot. That is, designing for HRI implies also designing for the situation in which the interaction happens, how the encounters are framed, the role of the human interacting with the robot as well as other humans that might be present.

We argue that introducing the expertise of performing arts professionals as a first step in processes of relational HRI design is key as a means to speculate on how embodied interactions can take shape and unfold within specific situations. This approach allows for the discovery of interaction possibilities between humans and robots in creative, flexible, and innovative ways, paying special attention to how different elements come together to make an encounter meaningful. Moreover, our article argues for the use of participatory design to include the perspectives, values, and needs of potential stakeholders in an iterative HRI design process.

Finally, we propose that a relational perspective on HRI design acknowledges that how movement becomes meaningful is influenced by how users respond and interpret robotic motion depending on the situation in which they encounter the robot. A relational perspective on movement-based HRI therefore focuses on designing affordances for interacting and interpreting behaviour, rather than on designing specific movements that convey a predetermined meaning. By focusing on situatedness and emergence, this perspective may enable robots to be more naturally integrated into a care context with distinct sociophysical dynamics. The patients and caregivers can choose if, when, and how to interact with the robot, having more flexibility in how robotic motion is interpreted and incorporated in their specific care routines, thus allowing for a more relational and situated approach to technological health applications.

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