Roaming with a Robot: Analyzing the Experiences and Understanding the Dimensions of Designing Human-Robot Walking Interactions

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Abstract

Walking is an essential aspect of daily life, while walking with companions offers numerous benefits. Recently developed mobile robots, through their ability to navigate challenging terrains, open new possibilities for outdoor walking companionship. Yet, little is known about how such companions shape the human walking experience. In this study, nine participants walked outdoors with a robot and later reflected on their walking experience in semi-structured interviews. Thematic analysis showed that the robot influenced how participants related to it, how they managed proximity, and how their attention, control, and social presence were affected. Building on these insights, we identify five key dimensions of human–robot walking: attunement, awareness mediation, proxemics, social perception, and playful curiosity. These dimensions capture how walking with robots transforms this ordinary activity into a co-experienced practice and additionally offer concrete design implications for designing and creating more meaningful, comfortable, and socially attuned human-robot walking interactions.

CCS Concepts

• **Human-centered computing → HCI design and evaluation methods**.

Keywords

Walking, Companion Robots, Outdoor Walking, Walking with Robots

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1 Introduction

Walking and mobility are integral aspects of human life, offering different experiences depending on context and company. Walking alone can elevate mindfulness, exploration, and creativity [60], while walking with a companion often transforms the activity into a more socially and emotionally enriching experience. Companionship adds enjoyment and socialization [65]; interaction with a friend, family member, or even a pet dog can make walks more stimulating, provide opportunities to share thoughts and experiences, and create deeper connections. Companions may also enhance feelings of safety during walks in unfamiliar or isolated areas [56], and in cases such as walking with a dog, serve as motivation and accountability for maintaining activity goals [61]. In short, companionship can elevate walking from a purely physical activity to a social and emotional one. Yet, a key question remains: how do these effects alter the experience when the companion is neither human nor living? This study seeks to answer that question by qualitatively examining how walking experiences unfold when the companion is a robot, and how such companionship shapes humans' walking experience.

Robots are increasingly being integrated into daily life, supported by advances in their social capabilities, user experience, and companionship functions [18]. Companion robots, through their ability to engage physically, socially, emotionally, and safely with humans, are finding applications across diverse contexts, from daily life assistants and healthcare companions to learning and entertainment partners [3]. Commercial developments illustrate this trend as well: Samsung's home companion robot Ballie provides personalized assistance in daily activities [110], while Sony's Poiq engages users through emotional cues and personalization [92]. Outdoors, robots such as Gita [39] autonomously follow humans while carrying cargo, demonstrating how robotic companions can integrate into pedestrian environments. Beyond commercial devices, research has investigated robots designed to follow people and carry loads [55, 117], assist with photography [84], serve as robotic wheelchairs [40, 102], provide navigation support for blind users [21, 45], or ensure safety while accompanying individuals [56]. Companion robots in these contexts introduce qualities such as social presence [70], empathy [67], contextual adaptation [98], and coexistence [113], which are central to building meaningful relationships between humans and robots [6]. Human-Robot Companionship (HRC) [3] can be defined as the relationship built through the robot's intelligence, usability, and behavioral influence, as well as its capacity to shape human perceptions in ways that support wellbeing and enhance quality of life. Such robots are envisioned not only as tools but as entities capable of coexisting [113] and co-performing [66] with humans, engaging in activities ranging from recreation and exercise to conversation and, in the scope of this study, walking.

Recent work highlights a growing interest in robots that accompany humans during locomotion, from leash-based walking interfaces [118] and guide-dog-style mobility support [119] to studies of proxemics, awareness, and affective cues in virtual or animal-like robotic companions [86, 94, 101]. Research on mindful walking and immersive movement technologies [100] further shows that walking is not only utilitarian but also shapes wellbeing, attention, and social experience. As mobile robots continue to transition into everyday environments, recent studies position them as possible companions in routine activities including walking, including walking [71, 109]. Yet despite these advances, we still know remarkably little about how walking with a real robot outdoors, natural settings influence human experience compared to walking alone. In parallel, human-robot interaction (HRI) research has increasingly been approached through posthumanist perspectives, which challenge traditional human-centered views [34] and highlight the relationality of humans and robots in situated practices [32, 115]. As robots increasingly enter streets and sidewalks for delivery, mobility, and assistance (e.g., delivery robots, autonomous vehicles) [46, 80, 83, 107], walking with robots will likely become more common. On top of that, understanding these experiences appeals to people of all ages, genders, races, and occupations, especially because walking as an activity is an undetachable part of daily human life for able bodied people. While prior work has focused on designing robots that can accompany humans, the human perspective on such companionship and what it entails remains underexplored [5, 88, 89]. Understanding these experiences is essential for envisioning how mobility in daily human-robot companionship (HRC) might potentially affect relationships between humans and robots. Investigating robots as walking companions thus allows us to probe the embodied, relational, and social dimensions of companionship, offering new insights into how HRC might unfold in dynamic, public, and outdoor environments. To enable an informed investigation of the factors that shape human–robot relationships during walking, it is essential to first develop a qualitative, in-depth understanding of the key experiential dimensions involved. Such exploratory work provides the conceptual grounding needed to identify the most influential relational, behavioral, and contextual factors before progressing toward more controlled or comparative studies. Accordingly, as a significant step in this research trajectory, we conducted a qualitative investigation to uncover the prominent elements that structure the human experience of walking with a robot in outdoor environments. Nine participants walked outdoors with a companion robot and were subsequently interviewed about their experiences. Applying thematic analysis [14], we identified four overarching themes, including 12 subthemes that reveal multiple facets of human-robot walking companionship. Through these findings, we explore the subjective and social dimensions of walking with a robot and how walking dynamics, defined here as the coordination of movement and mutual influence between human and robot, are shaped. Specifically, our study addresses the following research questions:

RQ1: How does walking with a robot companion shape the perceived experience of walking?

RQ2: What are the subjective and social facets of human experiences when co-walking with robots, and how do these affect walking dynamics?

Our findings contribute to the growing body of outdoor HRI research by offering new insights into the experiences of human-robot co-walking in everyday contexts. Additionally, we present the dimensions of designing human-robot walking interactions supported by actionable implications. We anticipate that the insights generated by this study will inform subsequent research by guiding more specific, nuanced, and comparative investigations, enabling the development of more actionable and empirically grounded knowledge in this area.

2 Background

2.1 Walking with Companions

Beyond its utilitarian function, walking promotes physical health [63], whereas outdoor walking might create a deeper connection to the environment, allowing individuals to engage with their surroundings and cultivate a sense of belonging [90]. Johansson et al. [60] investigated the impact of time, type of environment (park vs. street), and social context (alone vs. with a friend) on affective states and cognitive performance, where the walking routes varied in greenery, proximity to water, and presence of traffic, buildings, and people. Results show revitalization increased to a greater extent during street walks when with a friend, highlighting the importance of both social context and environmental features, influences the psychological benefits of walking.

Kritz et al. [65] investigated whether engaging in purposeful walking with peers at least once a week yields better behavioral and health outcomes in older adults compared to primarily walking alone. Results showed that those who walked with peers experienced greater improvements in autonomous motivation, walking self-efficacy, functional capacity, body fat, and physical activity compared to those who walked alone.

Pets such as dogs are great companions and walking with dogs has been found to be associated with increased physical activity, especially among older adults, motivating them to be more active and mobile [50]. Curl et al. investigated the relationship between dog ownership, pet bonding, walking behavior, and health outcomes in older adults using data from the Health and Retirement Study [29]. Results showed higher levels of pet bonding correlated with increased likelihood of dog walking and longer duration per walk, suggesting a potential positive influence of the human-dog bond on physical activity [75]. Degeling et al. [33] found that the sense of care in the human-dog relationship can be positively associated with how people use space and how they approach being active in daily life.

Building on these insights, we can assume that walking with companions, be it human or non-human, always has its benefits. However, little is known about how robotic companionship might influence these dynamics. Our study seeks to extend this knowledge by exploring how these experiences are affected, if the companion is not a human or an animal, but a robot.

2.2 Walking with Robots

Investigations into walking with robots can be broadly divided into indoor and outdoor implementations, a distinction grounded in the characteristics of the interaction environment, with the rare exception of virtual environments [86]. These environments significantly shape what kinds of interactions and system capabilities are feasible: indoor settings, being controlled and predictable, commonly support applications such as rehabilitation, entertainment, and playful or experimental experiences. In contrast, outdoor environments are inherently more dynamic and unpredictable, enabling investigations into navigation, mobility support, and other utility-oriented purposes that reflect real-world deployment conditions [97, 120]. Indoor walking with robots is mostly associated with indoor navigation and assisted walking for rehabilitation purposes. Gross et al. [44] developed a mobile robot companion designed to support walking training for stroke patients during clinical rehabilitation, aiming to provide consistent guidance and motivation; their findings show that the robot effectively assisted patients’ gait exercises and was positively received as a supportive partner in therapy. Hesse et al. reviewed robot-assisted rehabilitation technologies for both upper and lower limbs after stroke, demonstrating that robotic systems can improve training intensity and movement quality, ultimately contributing to better functional recovery [54]. Bakracheva et al. investigated companion robotic assistants for people with disabilities, showing that such robots can enhance daily functioning, autonomy, and overall quality of life by providing physical and emotional support in everyday tasks [10].

In terms of outdoor implementations, Clotet et al. [26] developed an outdoor mobile robot companion that leverages a Google Android™ smartphone and GPS guidance to support autonomous navigation and companion behaviors such as “go to location,” “follow me,” and “keep close.” Tested in real outdoor walks, the system demonstrated that GPS-based robotic companions can maintain presence and responsiveness in dynamic, uncontrolled environments. Robotic jogging companions have been explored to some extent using drones where they motivate them to keep up a specific pace as well as following a specific path [43, 81]. The jogging companion robots helped the users keep pace by creating peer pressure and dictating the path. Results showed that the users perceived the robot as a companion and reported having a social connection with it, however, the robots drew a lot of attention from spectators, resulting in awkwardness. Outdoor mobile companion robots have been explored as facilitators of physical activity for older adults [116]. They explored how older adults perceive assistive robots as an outdoor walking guide in a nursing home. The older adults responded positively to the robot and engaged in natural social interactions during robot-assisted physical activities. A Boston Dynamics Spot robot was deployed as a “guide dog” in public spaces for investigating how visually impaired people (VIP) navigate around both stationary and moving pedestrians when being led by a robot [36]. Through video ethnography and multimodal conversation analysis, the study conceptualizes the VIP, the robot, and the human operator as a socio-material assemblage, where trust, agency, and perception are distributed across actors and technology. This work underscores that walking alongside a robot is not just a navigation task, but a deeply social and relational experience in uncontrolled, public environments.

As robots become increasingly integrated into human environments, equipped with advanced capabilities, it is crucial to examine the dynamics of human-robot interactions in everyday activities such as walking. Previous studies explored walking with robots in mostly utilitarian contexts, e.g., navigation and exercising, while the recreational and regular contexts have rarely been explored. Our study offers an in-depth exploration of this underexplored context and seeks to provide foundational insights towards understanding the experiences around it.

2.3 Human-Robot Companionship

Human-robot companionship (HRC) [3] represents the convergence of robotic technical capabilities with their potential to build emotional connections with humans. Robots are increasingly able to perceive and respond to human emotions, preferences, and needs, developing companionship that extends beyond utility, with robots perceived not just as tools but as companions [6]. Humans often reciprocate by forming attachments, anthropomorphizing robots, and attributing human-like qualities to their behaviors [89]. Companion robots have been deployed across diverse roles, such as robotic pets providing comfort to the elderly [64, 72], assistive companions for people with disabilities [10, 53], or social robots engaging in conversation and entertainment [35].

Empirical studies demonstrate the psychosocial impact of robotic companionship. Robinson et al. [96] showed that residents who interacted with a companion robot in a randomized controlled trial experienced significant reductions in loneliness, while also engaging socially around the robot. Heerink et al. [52] found that a robot’s social abilities introduced improved social presence, which enhanced enjoyment and, in turn, acceptance of robotic companions. Similarly, Gross et al. [44] developed a healthcare companion robot for older adults, which supported both instrumental and socio-emotional needs, enabling participants to remain independent while also forming emotional bonds. However, not all perspectives on robotic companionship are favorable. Dautenhahn et al. [30] found that many participants envisioned robots primarily as assistants, machines, or servants, with fewer desiring them as genuine friends.

Research on human–robot relationships shows that people form meaningful social and emotional bonds with robots, and these bonds shape long-term interaction dynamics. For example, long-term cohabitation work by Dziergwa et al. [38] found that users’ attachment styles influence satisfaction and interaction patterns with a domestic social robot, suggesting individual differences shape relational outcomes. De Graaf [31] provides an ethical analysis showing that socially interactive robots invite humans to apply moral and social frameworks to machines, which raises normative concerns as these devices become more embedded in daily life.

Together, these studies highlight the dual nature of HRC, as both functional assistants and emotional companions. Robots' ability to build relationships by combining social presence, instrumental support, and affective engagement position them uniquely as potential companions. Walking, in particular, provides a rich testbed for studying HRC in everyday embodied contexts: it is a fundamental human practice that combines mobility, rhythm, coordination, and social attunement, which has not been explored extensively thus far.

3 Method

This section provides a detailed overview of the study including the participants, procedure, data collection, and analysis.

3.1 Participants

Participant recruitment was conducted through an advertisement posted on the university's intranet. Interested personnel completed a questionnaire via Google Forms, and nine participants were recruited. The final sample comprised five women and four men, with ages ranging from 18 to 30 years. All participants reported engaging in regular walking activities, with a minimum frequency of two walks per week; five participants indicated walking at least four times per week. Regarding their prior experience with robots, all participants had either observed or interacted with robots in some capacity. However, no one had previously walked with a robot, making it a novel experience for all participants in terms of walking with a robotic companion. Table 1 presents a detailed overview of the participants, including their age range, gender, role at the university, and the number of times they usually take a walk per week.

The Boston Dynamics robot, Spot [37], was deployed as the walking companion for this study. Spot is a quadrupedal robot that resembles a canine in form and is equipped with state-of-the-art sensors and cameras. These features enable it to navigate dynamically and adapt to a wide range of terrains, including climbing stairs and traversing uneven or challenging environments. This versatility makes Spot particularly well-suited for accompanying humans in diverse outdoor walking scenarios. To date, no social robot has demonstrated comparable efficiency and adaptability in walking environments, and it was one of the very few robots with such capability during the data collection time, which limited the feasibility of using purpose-built social robots for such studies. Furthermore, Spot's physical resemblance to a four-legged animal, such as a dog, and its ability to perform animal-like gestures create intuitive and relatable interaction dynamics for human participants. While Spot has a specific demeanor which might have certain effect on the interaction, we intentionally did not introduce or compare any other robot as it might have diverted the focus more towards the differences between multiple robots, rather than on the walking interaction itself. Given these considerations, Spot was deemed an ideal choice for exploring human-robot co-walking experiences in this study.

Table 1: Participant demographics and walking frequency

Participant	Age Range	Gender	University Role	Walks / Week
P1	21–25	Woman	Graduate Student	5 or more
P2	26–30	Woman	Faculty Member	3–4
P3	26–30	Man	Post-graduate Student	3–4
P4	26–30	Woman	Post-graduate Student	3–4
P5	18–20	Man	Undergraduate Student	1–2
P6	26–30	Woman	Post-graduate Student	1–2
P7	26–30	Man	Graduate Student	1–2
P8	21–25	Man	Undergraduate Student	3–4
P9	21–25	Woman	Graduate Student	1–2

3.2 Procedure

The participants signed a consent form at the beginning of the study. They were asked to take a 20-minute walk around the university campus, which included walking inside the building corridors, university fields, and roads around the university campus. A walking duration of 20 minutes was chosen as it strikes an optimal balance between providing enough time for participants to engage meaningfully with the robot companion and minimizing fatigue or disengagement. Research suggests that walks lasting 15–30 minutes can provide significant psychological and physical benefits, including improved mood, reduced stress, and enhanced cognitive focus, particularly when conducted in natural outdoor settings [49]. Furthermore, such durations align with findings from Human-Robot Interaction (HRI) studies, where similar intervention lengths have been effective in evaluating first impressions, adaptation, and interaction dynamics without overwhelming participants or compromising data quality [8, 11].

An overall direction was provided for the participants for the walking route. However, we wanted participants to be explorative throughout the walk and allowed them to be flexible so that they can get the experience in their own way of walking. Flexibility was provided to the extent that they could decide their pace, take small detours of the path, and stop at places, still keeping the path same for all the participants. Another layer of flexibility was introduced by the wizard-of-oz process as the robot was simulated to adapt to the participants' interaction choices during the walk. They were asked to finish the walk and go back inside to where they started the walk, creating a closed path, in 20 minutes. The typical flow of the walk would thus be: starting inside the building, going out through the entrance, walking on the field, taking the pedestrian roads around the building, and then coming back inside through the same entrance where the walk started. Fig. 1 provides an overview of the study procedure along with a brief overview of themes.

3.3 Wizard-of-Oz Setup and Interaction Design

A Wizard of Oz method [95] was employed in this case as the robot was controlled by the researcher using a tablet controller, following the participants from a distance of at least 20 feet or six meters. In the briefing of the study, the participants were informed that the researcher had control over the robot through the tablet controller. However, it was not revealed that the whole interaction was simulated. The robot's walking, following, movements, and all other behaviors were simulated using the controller. The participant was exposed to three types of walking behavior of the robot to help them distinguish the authority of the walking intervention. They

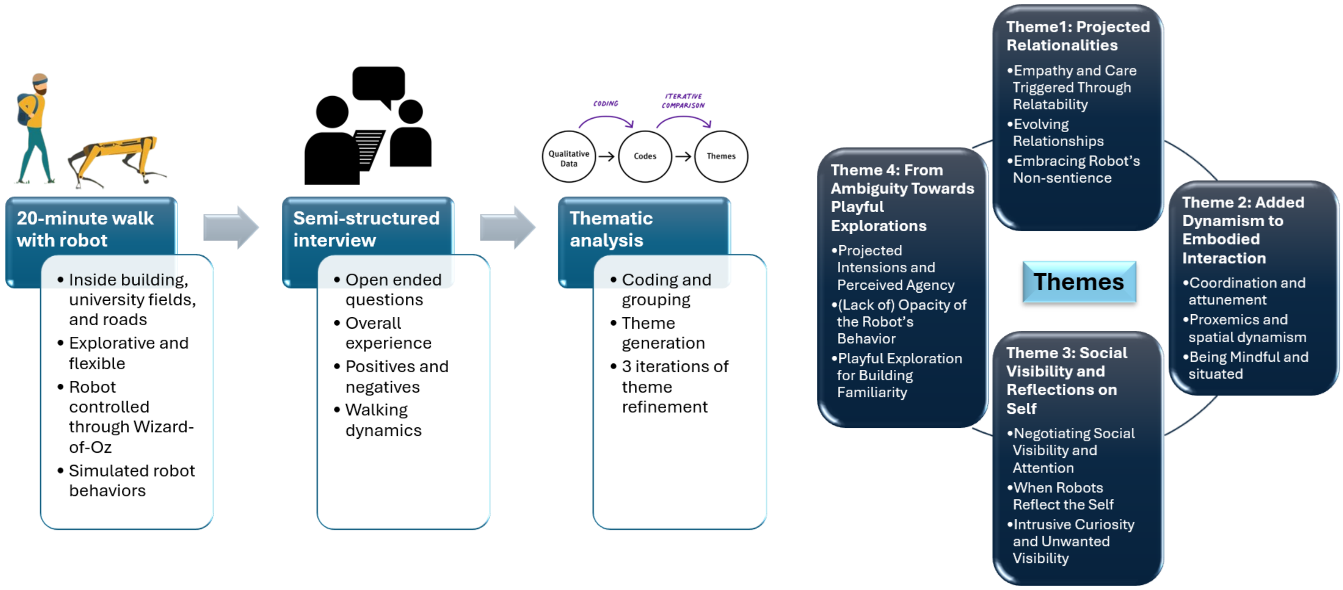

Figure 1: Overview of study procedure including the final themes and subthemes.

were, 1) following the participant, 2) walking side-by-side, and 3) leading the way. These authoritative behaviors were simulated to help participants contextualize different dynamics of walking with a companion, based on the findings from co-design workshops conducted by Ahmed et al. [4]. Two different walking types were also simulated: normal walking and hopping/jogging, which were formulated and influenced by the affordances of the Spot robot as well as the relevance to them in a walking scenario in public spaces [79, 85]. Apart from these, some specific movement behaviors were simulated at specific points of the path, such as the robot would lean forward to observe an object on the path, the robot would lean backward to look at a monument by the path, and it would go and look under a tree and buildings on the sides. Fig. 2 demonstrates the walking path including different walking types, stops, behaviors, and time elapsed between each point.

The robot's interaction behaviors were intentionally informed by both its robot's demeanor as a four-legged animal and established insights from canine behavior in human–animal interaction. Prior work shows that four-legged robots are often spontaneously interpreted through an animal lens, particularly as dog-like, leading users to apply familiar expectations regarding curiosity, attentiveness, and social responsiveness [68]. Moreover, dogs frequently engage in orienting and exploratory behaviors—such as pausing, scanning the environment, altering gaze, sniffing, and visually inspecting objects, which function not only as information-gathering mechanisms [13, 77, 99] but also as social signals that regulate shared attention and joint engagement with humans [93]. Drawing on these findings, we designed the robot's pauses, gaze shifts, and exploratory motions to resemble these canine orienting responses, to leverage well-documented interactional patterns that humans already recognize and respond to. This approach situates the robot's behavior within a familiar socio-behavioral frame, particularly in open and dynamic outdoor environments.

All participants experienced all aforementioned walking and movement behaviors to ensure that the interactions and interventions were consistent. The robot maintained the same pace for walking and jogging/hopping in all interactions. It is important to mention here that the robot (wizard) would comply with any detours or stops caused by the participants, as we attempted to simulate an autonomous walking companion, which was facilitated by the flexibility of the simulations. Fig. 3 shows 3 scenes (a. participant walking side by side with the robot, b. both the robot and participant looking at the surroundings, and c. participant gesturing to the robot to follow them) of a participant walking with the companion robot.

3.4 Data Collection

After walking, participants joined a semi-structured interview [2], where they were asked a series of open-ended questions designed to explore their experiences and perceptions of walking with a robot companion. The questions focused on several key areas, including the participants' overall experience, the differences between walking with and without the robot, and their observations of the robot's behaviors. Participants were asked to describe the dynamics of their interaction with the robot, identifying both positive and negative aspects of the experience. They were also encouraged to reflect on how the robot's behavior influenced their perception of it and any changes in their walking behavior. Finally, participants were asked to suggest modifications to improve the walking experience, providing valuable insights into areas for enhancement. The interviews were audio recorded. The mean interview length was approximately 20:36 minutes, and the standard deviation (SD) was about 8:18 minutes.

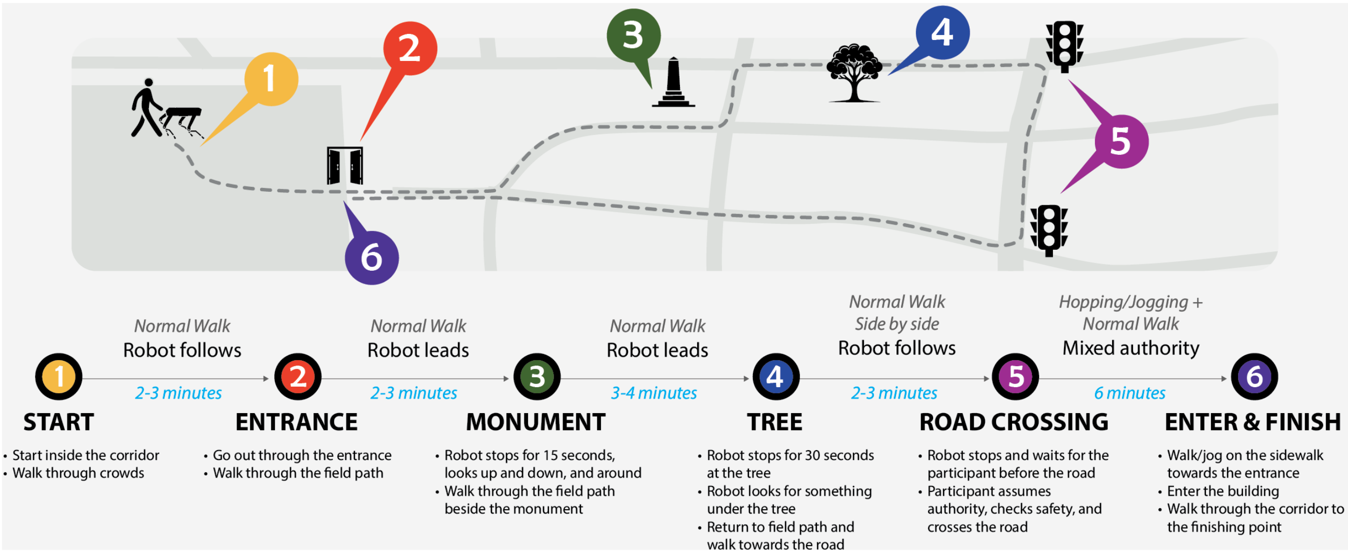

Figure 2: Overview of the walk including path points, flow, walking type, authority, and time consumed.

Figure 3: a. participant walking side by side with the robot (left), b. both the robot and participant looking at the surroundings (middle), and c. participant gesturing to the robot to follow them (right).

3.5 Data Analysis

Recorded semi-structured interviews were transcribed using the MS Word dictation tool which complies with the university policy of data protection so that the data is not shared to any 3rd party. Then all transcription anomalies were corrected by the first author. We applied a reflexive thematic analysis [15, 25] process which included getting familiar with the data, applying codes to each quote, grouping codes to find topics, and then generating topics and themes. Atlas.ti [9] software was used for the coding and topic generation process while Mural [82] was used for grouping and visualizing themes. Initially, the first author conducted the coding process and grouped all the codes into topics through affinity diagramming [73]. The generated topics were then discussed together with the other authors, and this resulted in finding topic groups, which were considered themes. The theme generation process required three iterations of analysis and discussion between all authors. After concrete themes were found, the first author gathered all the data connected to each theme and completed the analysis. Insights were formulated by analyzing the themes.

3.6 Epistemology

This study is grounded in interpretivist epistemology [7, 112], which prioritizes understanding humans lived experiences and the meanings they construct in context. Rather than seeking generalizable truths or statistical relationships, interpretivist approaches aim to produce rich, situated insights into phenomena [22]. In Human–Computer Interaction (HCI), such an orientation is particularly valuable for exploring complex socio-technical interactions that cannot be fully captured through quantitative measures [74], exemplified by works published in prominent venues like CHI [24, 105].

Our research question, how humans experience walking with a robot, centers on subjective, relational, and embodied dimensions of interaction. While quantitative approaches offer generalizable insights and are particularly effective for comparing conditions or identifying broad patterns, they are less suited to capturing the depth, nuance, and interpretive richness of lived experiences in situated contexts [12, 48, 114]. To adequately address the experiential qualities central to this inquiry and to develop an understanding of the subtle, situated, and meaning-laden aspects of human–robot walking interactions, we employed Reflexive Thematic Analysis (RTA) as articulated by Braun and Clarke [14, 15]. RTA is an interpretative, reflexive process where themes are actively constructed by the researcher, which signifies that analysis is shaped by the researcher's theoretical lens, prior knowledge, and engagement with the data. Reflexivity is central to ensuring rigor [20] in RTA, which opposes intercoder agreement (i.e., interpretivist assumptions are not aligned with intercoder agreement) [7] as a marker of quality. Instead, quality is demonstrated through depth of engagement, transparency of analytic decisions, and coherence between data, interpretation, and theoretical positioning [16, 28]. Braun and Clarke [16] argue that applying concepts like "data saturation" or numeric thresholds to thematic analysis is conceptually flawed because the method is not designed for exhaustive coverage or statistical generalization. Reflexive thematic analysis values depth and richness of meaning over breadth, and smaller yet information-rich samples enable the iterative, interpretive engagement that underpins quality.

Our epistemological stance also informs how findings are translated into design implications. These implications are interpretive and generative, not prescriptive "truths." They aim to inspire future work rather than dictate universal solutions. This aligns with design research traditions that value conceptual contributions and sensitizing concepts over standardized guidelines [17]. Moreover, the quality of thematic analysis is evaluated through transparency, coherence, and analytic rigor rather than adherence to a single fixed procedure. Following Braun and Clarke's guidance, we ensure quality by clearly detailing our analytic approach, outlining how codes and themes were developed, positioning ourselves reflexively, and grounding interpretations in rich data excerpts. These quality indicators are demonstrated in our Data Analysis section through explicit methodological reporting and in the Findings section through coherent themes supported by illustrative participant quotes and the researcher's interpretations of them.

4 Thematic Insights

The thematic analysis of the interview data resulted in the generation of four overarching themes, including 12 subthemes. These themes constitute the core empirical findings of the study and are presented in this section, each highlighting distinct dimensions of participants' experiences of walking with a companion robot.

4.1 Theme 1: Projected Relationalities.

4.1.1 Empathy and Care Triggered Through Relatability. Participants appeared to care for the robot and empathized with it as if it was alive and related to them. P9 let the robot be comfortable in what it was doing and did not want it to get hurt in the process, "*I was kind of making sure that it stays safe and just kind of at some point was kind of falling back a bit just to kind of let it, I guess get a sense of the surroundings. Yeah, I think I didn't want it to get hurt*". This reveals a blend of emotional connection, responsibility, and tentative trust in the robot during their walk. Their concern for the robot's safety and use of terms like "hurt" indicate anthropomorphism and a perception of the robot as fragile or vulnerable, triggering caregiving instincts. At the same time, their decision to "fall back a bit" suggests curiosity about the robot's autonomy but also skepticism about its ability to navigate independently, highlighting the need for better communication of the robot's capabilities. P2 said, "*And I think in the crossway, I wasn't too sure whether a pedestrian was allowed to actually cross there. I didn't know if I was supposed to cross there.... So, I felt a bit bad for having it crossed there as well*". This quote suggests that the participant experienced uncertainty and mild discomfort about breaking a social or legal norm (they were legally allowed to cross) while crossing the road. It also highlights the participant's sense of moral responsibility and concern for the robot's well-being, reflecting a projection of human-like qualities onto the robot, as if the robot is also subject to human norms. Despite knowing the robot is a machine and it cannot get hurt, the participant expresses guilt about potentially leading it into an uncertain or unsafe situation. This dynamic, where the participant assumes a caretaker role, is possibly created through relatedness and perceived agency towards the robot, resulting in some scale of emotional engagement.

P9 also mentions that they found similarities with a pet dog and treated the robot the same way they usually treat their pet, "*It was like a dog, I would say it felt more like a dog especially like when I was walking a bit in front of it and we were taking turns, I just had to look, look around the corner like if there's someone, if there are people in the way or objects that it could bump into*". P9's experience of treating the robot like a dog, ensuring its safety and anticipating obstacles, suggests that the robot's movements and interactive features mimic the qualities of a living companion, encouraging protective instincts. P2 mentioned that the robot had features that made it feel real, saying "*It's not a real thing, but it has those features. So, like, I think subconsciously I empathize with that and kind of see it as a little child or a pet*". P2's reflection on the robot's features making it feel "real" highlights the role of design elements in eliciting subconscious emotional responses. Also, finding resemblance with a child or a pet indicates protective instincts through emotionality, which was projected on the robot. The robot, being a mechanical entity after all, does not inherently exhibit lifelike traits or behaviors. Instead, these traits are projected onto the robot by humans, who interpret its movements, actions, and features through the lens of familiarity, often drawing parallels to other living beings such as pets or children.

4.1.2 Evolving Relationship. P8 noticed that the connection with the robot evolved throughout the span of the interaction as they started to walk side by side in a closer proximity, "*One thing I noticed* *that when we were walking towards the exit at first. It was a bit lagging behind and I had to keep checking back, but then when we were after some time of walking, we started actually being a companion like it was right next to me all the time*". These highlight the evolving dynamic between the participant and the robot during their walk, illustrating how the perception of the robot transitioned from being an object to being a companion. This might be the result of transitioning from a follower role to a side-by-side walking role and the varying behaviors of the robot throughout the walk. Initially, the robot's lagging behavior created a sense of detachment, prompting the participant to frequently check on it. However, as the robot adjusted to match the participant's speed and stayed consistently by their side, it began to feel like a reassuring presence, creating a sense of companionship. This scenario mirrors how companionship for humans often develops a process that requires alignment in pace, mutual awareness, and the establishment of trust over time. However, unlike human-human companionship, which is enriched by emotional reciprocity, shared experiences, and complex communication, the companionship here is fundamentally one-sided and shaped by human projections and expectations.

4.1.3 Embracing Robot's Non-sentience. P1 mentioned that they would consider the robot as an extension of friends they can share private thoughts with, "*Sometimes friends have a lot going on in their own lives and you don't want to bother them with your own problems. In that case, I would share some of my private things with the robot*". This reflects an intriguing perspective on the role of robots as non-sentient and nonjudgmental companions and confidants. The participant's sentiment underscores a key advantage of interacting with robots: their lack of emotional complexity or personal burdens, which allows individuals to share private thoughts without fear of judgment, rejection, or imposing on someone else's well-being. This dynamic contrasts with human relationships, where relationality and empathy are essential but can sometimes feel unnatural for the intricacies of personal lives and emotional availability. The robot, being devoid of its own needs and emotions, offers a unique form of companionship, one that is unconditionally present and attentive. This form of companionship, while seemingly comforting, raises important questions about the nature of human-robot relationships and their long-term impact.

4.2 Theme 2: Added Dynamism to Embodied Interaction.

4.2.1 Coordination and Attunement. Participants reported that walking with the robot required them to reduce their walking speed and sometimes they had to move out of their natural walking habit to be with the robot. However, the fact that participants modified their walking behavior for the robot might be a testament of a possible connection (be that an emotional one or just from a responsibility point of view) with the robot, where they felt like they had to take the robot with them. P1, P3, and P4 reported that they walked slowly to match robot's speed. P4 said, "The one thing that I had to change was that I normally walk really fast and with the robot I have to slow down" and they stopped when the robot stopped, "*When it stops, I think that I have to stop*". P6 felt the need to go faster to keep up when the robot increased its own speed, "*Like when he was going faster, like, I feel the need that I need to go with the pace*". P6 felt looking at the directions the robot was looking towards, "*Also like when the robot was stopping, for example, to like look up, look down then I was basically following like OK, what is there?*". These quotes highlight how the robot influenced the participants' walking behaviors. Participants altered their natural walking speed, with some slowing down to match the robot's slower pace and others speeding up when it moved faster, showing a sense of synchronization with the robot. These behaviors suggest that participants might perceive the robot as an active participant in the walk, influencing not only their physical movements but also their situational awareness.

P6 also noticed and applied the interchanging authority in walking, "*I think that I was like both the follower and the guide at some point like if the road was behind me, I was like, then maybe I should choose the path and then if the robot was ahead of me, let's just follow wherever it goes*". P6's experience of alternating roles, acting as both a guide and a follower, demonstrates a sense of shared agency in the interaction. When leading, the participant felt responsible for determining the path, but when the robot took the lead, they willingly adapted and followed its direction. This exchange of roles mirrors human social interactions where leadership might shift based on context and mutual understanding. It suggests that the participant potentially perceived the robot not merely as a tool but as an active collaborator, capable of influencing the shared journey.

P9 reported that they let the robot go ahead when the path was too narrow and then followed it, "*But at times, when the corridor was especially narrow, yeah, I would kind of fall back a bit, just kind of let it go first, just get a sense of the surroundings and kind of like a Snoop around, Sniff the place*". By deliberately falling back and allowing the robot to move ahead, the participant showed characteristics of walking with another human companion, mirroring the social courtesy often extended to human walking partners. This behavior can also be connected with how humans behave when they walk with children or pets as the speed and flow of walking are usually dictated by the child. Such comparisons suggest that the robot was, at times, perceived in a more animated or animal-like way, with behaviors interpreted as curiosity or exploration. This fact speaks volumes about how the robot was generally perceived by the participants. The comparison to "snooping around" or "sniffing the place" reflects how the participant sees the robot as a dog, attributing it with curiosity or an animal-like tendency to investigate its surroundings. These adjustments in pacing and positioning may indicate an attempt to accommodate the robot and maintain a smooth shared walking rhythm.

4.2.2 Proxemics and Spatial Dynamism. P2 needed some time to understand the robot's movement and once they were familiar, it was not a problem for them, "*And I think after a couple of minutes, you realize how close it can get and then you kind of get just get used to that thing and it's not really a problem*". This signifies that, initially, the spatial dynamics between the participant and the robot were not at an optimal level, which is a common challenge in any embodied interaction. The participant's need to "realize how close it can get" indicates that the robot's movements were unfamiliar at first, requiring a period of observation and adjustment.

There were instances where the robot almost or actually bumped into the participants. P2 said, "*I could see that it was following me* *and here and there It kind of felt like, almost like it bumped into me, but it didn't bump into me, but it was about to*". P8 could not really predict the robot's direction and felt like they might walk into the robot, "*There were some times that I was afraid I'd bump into the like, walk into the robot, or that they would walk into me because I couldn't fully predict its next move because it was going not fast, but it changed direction quite quickly, so it was hard to predict and that worries me in a way, like, you can't expect if you can't expect it, you know, how do you maneuver around that?*". These quotes reveal the critical role of proxemics and spatial dynamics in human-robot interaction, highlighting how participants became acutely aware of their personal space and the robot's unpredictable movements. Instances where the robot nearly or actually collided with participants, such as sudden directional changes or abrupt turns, disrupted the expected spatial flow and created discomfort.

These proxemic issues were also shaped by the Wizard-of-Oz setup used in the study. Because the robot's movements were manually controlled by the researcher rather than autonomously generated, slight delays in response, misjudged distances, or imperfect anticipation of participant actions could lead to abrupt turns or near-collisions. This human-in-the-loop control introduced a level of variability and inconsistency, yet similar challenges are commonly observed in autonomous systems as well. Even advanced navigation systems may fail to correctly interpret human motion, predict sudden speed changes, or recognize unstructured terrain, leading to hesitation or awkward repositioning. In more extreme cases, autonomous vehicles have demonstrated misclassification errors and delayed reaction times, resulting in documented accidents. Thus, while our setup contributed to proxemic imperfections, these issues also reflect broader limitations in current real-world robot autonomy, particularly in dynamic, shared environments like walking alongside humans. At the same time, this setup allowed the robot to exhibit more flexible and adaptive behaviors than a fully pre-programmed system might have, giving participants a richer and more dynamic interaction experience. This human-in-the-loop control introduced a level of variability and inconsistency, not typical of a fully autonomous system. At the same time, this setup allowed the robot to exhibit more flexible and adaptive behaviors than a fully pre-programmed system might have, giving participants a richer and more dynamic interaction experience.

P2 and P8 expressed unease due to the robot's inability to maintain consistent movement patterns, leading to concerns about physical contact and the challenge of maneuvering around it. Close proximity with the robot also raised questions about whether participants were standing too close, with some experiencing discomfort due to the potential safety risks posed by the robot's sensor-driven, occasionally erratic behavior. This discomfort is further influenced by cultural and social norms, as practices of proxemics vary widely; what might feel like an acceptable spatial distance in one culture could seem intrusive in another.

4.2.3 *Being Mindful and Situated.*

For some participants, the robot's presence appeared to gently shift their attention toward the surrounding environment, making them more conscious of where they were moving and what was happening around them. Rather than walking on "autopilot," they described moments of noticing the space more intentionally. P1 felt more aware of the surroundings because of the presence of the robot, "*When I'm with the robot, it's as though I'm more present and more aware of the fact that I am here with my body and I'm, you know, someone else is here*". The robot's role as a social entity, although non-human, created a dynamic where P1 felt an enhanced awareness of their surroundings and their embodied interaction within the space. This suggests that the robot acted not merely as a functional companion but also as a stimulus for a situated connection with the walking environment. The heightened awareness might stem from the participant's need to accommodate the robot's movements, navigate shared spaces, and maintain a coordinated moving interaction. This phenomenon reflects the broader implications of social embodiment in human-robot interactions, where the presence of a robot can prompt individuals to engage more attentively with their own physicality and their environment, creating a unique form of mindful presence.

The opposite was also seen by some of the participants as they mostly focused on the robot and the interaction rather than the environment and their surroundings. P1 usually listens to music while walking but this time they did not, "*Usually when I walk, I'm listening to the music and this time I didn't listen*". P6 said that they did not notice the surroundings at all, "*So maybe I was not looking at the surroundings at all, I was mainly focused on the robot. So, if the robot would have taken me, I don't know where, I would have probably just followed*". P9 explained that they were initially aware of the surroundings, but focused on the robot more towards the end, "*I guess, maybe at the beginning, I was more aware of the people, like around me and people reacting to the robots and yeah, but especially towards the end, I'd say I was more just kind of focused on the robots, just look at what it's doing, and just trying to keep up with it*". This shift demonstrates how the robot's presence restructured their priorities, creating a shared focus that altered their relationship with both the robot and the environment. While some participants became more aware of their surroundings initially, others concentrated almost entirely on the robot as the interaction progressed. This suggests that the robot's behavior may have shaped what participants paid attention to during the walk, to some extent influencing their navigation and experience. It points to a possible interplay between human focus, environmental awareness, and social engagement with a non-human walking partner. The insights demonstrate how this shift in attention evolves over time and varies across individuals. Some participants initially maintained awareness of their surroundings but gradually became more engrossed in the robot, while others remained consistently focused on it. This suggests that the presence of a robotic companion can restructure attentional priorities, shaping not only the social aspect of walking but also the degree of engagement with the environment.

Although participants described seemingly contrasting experiences, some becoming more aware of their surroundings because of the robot, others becoming less aware and more focused on the robot, these outcomes are not contradictory but instead reveal the flexible and situated nature of human–robot–environment dynamics. The robot's presence acted as a social and attentional anchor that could either heighten environmental awareness or redirect attention toward the robot, depending on the participant's engagement style, walking habits, and evolving interaction over time. Such duality is common in embodied interaction: the same stimulus can expand one person's sense of place while narrowing another's focus, underscoring the complexity and variability of attentional processes in shared human–robot activity.

4.3 Theme 3: Social Visibility and Reflections on the Self.

4.3.1 Negotiating Social Visibility and Attention. Participants reported mixed feelings regarding the social attention the robot attracted. Some described the feeling that the robot extended their presence in public, which made them more noticeable to others. P1 said, "*I was a little bit confused and embarrassed because people were looking at us all the time*". They also noted feeling comfortable with the robot but less so with the visibility it brought, "*Even if I feel comfortable with the robot, it is a little bit oh My God. Now it's too much attention*". P2 also sensed the attention on them, "*Well, it attracts attention, so if you're an introvert and you were just walking on your own with the robot, you can expect some attention*". While participants generally felt comfortable with the robot itself, the reactions from passersby introduced an element of self-consciousness and, for some, discomfort. The experience deviated from typical solitary walks, where one might blend into the surroundings without attracting any attention. Instead, the presence of the robot seemed to transform them into a focal point, drawing curiosity from people sharing the same walking space. These responses from the participants were possibly generated by the novel nature of human-robot interaction in public settings, where individuals may not only have to navigate their own relationship with the robot but also manage the social perception of having a walking companion that is non-human, and more importantly, non-living.

P8 describes people's attention to be the first thing that comes to their mind when thinking about the whole walking experience, "*The first thing that came to mind was the reactions of others seeing you walking with the companion*". However, they reported liking people's attention, saying, "*That's like a plus for me. So even so, walking with a dog like that still peaks out people and interest people. Smile when they see you or they look surprised or they just pull out their camera and like, Oh my. So that was a.., I was looking forward to that in a way. And I am really interested in seeing how people react to yeah and the differences in reactions in a way*". P9 had a slightly different outlook on how people were reacting and completely ignored them to focus on the robot itself, "*Yeah, I guess, maybe at the beginning, I was more aware of the people, like around me and people reacting to the robots and yeah, but especially towards the end, I'd say I was more just kind of focused on the robots, just look at what it's doing, and just trying to keep up with it*". For P8, the social reactions of others were a key part of the experience, enhancing their enjoyment and curiosity, much like walking with a pet that naturally draws interest. They actively anticipated and welcomed people's smiles, surprise, and engagement, seeing the attention as a positive aspect. In contrast, P9 initially noticed the reactions of bystanders but gradually shifted focus away from them, becoming more immersed in the interaction with the robot itself. This contrast highlights how external social dynamics might influence or fade into the background depending on individual perspectives. While some may view public attention as an integral and enjoyable component of the experience, others may eventually disengage from it, prioritizing their direct interaction with the robot. This variation in perception suggests that human-robot interaction in public spaces might be shaped not only by the robot's behavior but also by the social environment and the participant's own orientation toward public engagement.

Furthermore, our findings indicate that public attention may not be a static factor but rather a dynamic element that can either enhance or fade from a user's perception based on their evolving interaction with the robot. This nuanced perspective raises important design considerations for social robots in public settings: should they be designed to facilitate social engagement with bystanders, or should they encourage deeper one-on-one companionship? As robots become more prevalent in human environments, understanding these differing perspectives can inform how they are introduced, ensuring they complement a wide range of user experiences while accounting for social dynamics in public spaces.

4.3.2 When Robots Reflect the Self. There were questions about social norms and values while trying to make sense of the attention of people. P3 tried to explain why it is not the same type of attention compared to walking with dogs, and how having dogs is a normal thing in the societal context whereas having a robot is unusual. P3 also expects that there is going to be a transition period where these social conflicts will occur, "*I can imagine that if these kinds of robots would be robot companions would become a thing. There would be a transition period where people who get one of those would be looked down on or looked strangely at, let's say for a while because they are. Odd, right?... It stands out. Whereas if you walk around with a dog. It's fine, right? No one. Would look strange to at you for that, yeah*". The participant acknowledges that, much like any emerging technology that disrupts social norms, robotic companions would initially be perceived as unusual or even stigmatized. The comparison to walking with a dog underscore how deeply ingrained certain forms of companionship might be in societal expectations, making human-animal interactions feel natural, while human-robot interactions might still appear novel and unconventional. This reaction stems from the fact that robots, despite their increasing presence, are not yet fully integrated into daily social life. The participant suggests that this initial period of scrutiny and skepticism would eventually subside as robots become more common. The key factor in this transition, as articulated by the participants is repeated exposure over time, as more people adopt robotic companions and their roles become more defined, societal attitudes may shift, reducing the sense of oddity and increasing acceptance.

P1 said that they are not embarrassed by themselves or the robot, but the attention from other people brings the embarrassment which sheds light on how people's self-expressions might be affected, "*Other people, they have their opinions and everything, and it is too much attention... And the embarrassed feeling comes exactly from other people*". This reflects the social pressure and self-consciousness that can arise when engaging with unfamiliar technology in public spaces. The participants' embarrassment does not appear to be rooted in their own feelings about the robot but rather in the attention and judgments of others. This highlights how social norms and collective perceptions shape individual experiences, especially when interacting with something unconventional.

4.3.3 Intrusive Curiosity and Unwanted Visibility. Some of the participants felt that people's attention could result in privacy concerns. P6 shared their previous experience of working with the same robot, "*Even when I was doing my previous work, it's like I just want to take the robot to its place, I just want to reach there and then everyone is like, sorry, can I take a picture because there's people that stops you and ask if they can take a picture or not, or just randomly start taking videos of like it's a little annoying*". P2 also mentioned a possible problematic aspect of people taking photos, "*You know, people will take out their phones and take photos. But that's one thing that I think might be problematic in the long term, like if I had to take it home, it would bother me if people constantly, you know, take photos of it*". The novelty of a walking robot appeared to draw curiosity from bystanders, with some stopping to observe or take photos. Participants expressed varying reactions to this visibility: while the attention could be perceived as a natural response to an unusual sight, several described discomfort with being noticed repeatedly during what would otherwise be a private activity. Drawing on the notion of unwanted visibility, we interpret these accounts as indicating that increased public attention may introduce a sense of reduced personal boundaries. In such moments, individuals may feel unsure about how their image or presence is being perceived or captured by others, raising concerns about privacy or exposure.

This concern highlights an important social challenge in human-robot interaction; while public curiosity is expected, the lack of control over how and when one is recorded can be intrusive. Unlike walking with a pet, where attention may be limited to brief admiration, a robot companion introduces an element of technological spectacle that invites unsolicited engagement. The participants' frustrations suggest that the presence of a robot in public not only reshape their personal experience but also alter how they are perceived and treated by others. This dynamic creates an imbalance in agency: while the robot itself remains indifferent, its human companion must navigate the social consequences of its presence. Additionally, constant public scrutiny could impact long-term user acceptance, as individuals may hesitate to integrate robots into their daily lives if it means sacrificing their sense of autonomy and privacy.

4.4 Theme 4: From Ambiguity Towards Playful Explorations.

4.4.1 Projected Intentions and Perceived Agency. Some participants appeared to interpret the robot's behavior as intentional or communicative, even though the interaction time was brief and explicit feedback mechanisms were limited. This attribution seemed most noticeable in moments of uncertainty, when the robot's actions were not immediately predictable or clearly understood. For instance, P2 speculated whether the robot was trying to communicate something, saying, "*Well, I couldn't put together like it was happening. Why would it have done that.… I would probably think, OK, maybe it was suggesting to me where to go, or maybe trying to get my attention.*" Such reflections point to a natural inclination to anthropomorphize the robot, projecting social or communicative intent onto its behavior. Similarly, P5 described confusion stemming from the robot's unpredictable walking patterns: "*It was sometimes weird when it changed the type of walking in the middle of nothing, all of a sudden.… And I didn't know if it's still following me, or sometimes switch to following something else.*" These experiences highlight how participants attempted to make sense of the robot's actions by assuming underlying motives or goals, even when those actions were not autonomously generated.

This perceived agency may have been amplified by the Wizard-of-Oz methodology used in the study, where the robot's behavior was remotely controlled. The lack of transparency about this control mechanism likely contributed to participants interpreting the robot's movements as purposeful or communicative, rather than externally directed. The resulting ambiguity sometimes led to uncertainty or brief moments of detachment. When participants were left to interpret limited cues, they occasionally considered the robot's actions through a human-like lens, indicating that perceived agency can emerge even with simple behaviors, though its implications require further investigation.

4.4.2 (Lack of) Opacity of the Robot's Behavior. There was a lack of transparency in the robot's behavior as well, which made the participants confused about what to expect from it. The movements of the robot were a black box to participants, and they did not really understand why the robot changed its movement suddenly at times without any prior indication. P2 felt that they did not know how the robot follows them and how it recognizes them, "*Because I don't know how it works. Like. Yeah. Does it latch on to me? or not? Will it then be able to follow me? Will it recognize me? How does it even recognize me?… I didn't know those things, so I was concerned about losing it in the crowds*". P3 also felt similarly, "*Even though sometimes, for example, when we were about to enter the building, it takes a turn and starts heading towards someone who's clearly not me. Then it feels difficult because I have no control over it*". This uncertainty can be partly attributed to the Wizard-of-Oz method used in the study, where the robot's behavior was controlled remotely rather than autonomously by its sensors or algorithms. Since the participants were unaware of this, they likely projected autonomous capabilities onto the robot, assuming it had a clear sense of recognition and intent when it didn't. This misalignment between participants' expectations and the robot's actual behavior might create confusion and anxiety, highlighting the importance of transparency in robotic design and user expectations. Although P6 explained that they were able to follow what the robot was looking at and it added to the experience, most of the participants felt the movements were random and did not mean anything to them. While autonomy and the robot's agency might be preferable, how this will be expressed will affect a companion experience.

4.4.3 Playful Exploration for Building Familiarity. To diminish the ambiguity and build familiarity with the robot, some participants took an active stance to explore the robot's capabilities by pushing its limits. P1 tried to play a "*going-around game" to see if the robot would follow them, "I was able to communicate, and we even had a small game*". P8 tried to see if the robot would respond to changes in speed, "*So I did a bit of an experiment like I ran forward a bit and looked at how it would react to sudden change, in distance and speed*". By engaging in experimental actions, such as testing if the robot would follow them during a "going-around game" or observing how it responded to sudden changes in speed, the participants were actively seeking patterns and seeking to make sense of the robot's responses. This playful approach, often driven by curiosity, allowed them to break free from uncertainty and create a more predictable interaction with the robot. It also highlights the importance of trial-and-error in reducing ambiguity when engaging with new technology.

P4 felt that they could do something crazy with the robot to see its reactions, "*Actually I was curious to do something really weird, for example, just jump into the road to see what it does but then I thought OK why should I put myself in danger and also it in danger to do something*". P4's hesitation to engage in risky behavior, the boundary between playful exploration and safety concerns was also a factor in their decision-making. Overall, playful exploration appeared to support participants in feeling more comfortable and familiar with the robot, offering opportunities to observe how it responded in different situations. Rather than being solely a matter of technical features, aspects such as reducing ambiguity or supporting trust may also develop through continued interaction over time. As with many unfamiliar technologies, shared experience can gradually shape how people understand and relate to a robot's capabilities and limitations.

5 Discussion

In this section, we attempt to answer the research questions we posed at the beginning of the study, by analyzing the thematic findings from the interviews and reflecting on them through the lens of the related research. Additionally, we reflect on the Wizard-of-Oz process to discuss how it might have influenced the study. Finally, we present five dimensions of human-robot walking interactions inspired by the insights generated through this study.

5.1 RQ1: How does walking with a robot companion shape the perceived experience of walking?

Walking with a robot companion introduced new layers of meaning, altering how participants experienced an otherwise ordinary activity. The perceived experience of walking shifted from an individual, habitual activity toward a co-experienced and sometimes co-regulated practice (Theme 1, section 4.1.2). The robot became not just a companion, but a structuring element of the walk. Moreover, this emerging sense of rapport was attributed to the robot's resemblance to familiar and cherished entities, echoing prior findings that appearance and behavior strongly influence early emotional connection with unfamiliar robots [91]. This sense of care can transform the experience from functional to relational, although feeling overly responsible for the robot may introduce cognitive load, stress, or even decreased trust [87], and in some cases elevate anthropomorphism [104].

Initially perceived as a mechanically lagging object that needed supervision; the robot's stabilized pacing eventually shifted its presence toward that of a companion walking in sync. This gradual transition highlights the role of temporal dynamics in human-robot companionship: it was not immediately granted but emerged as the robot's behavior came to match human expectations of synchrony and presence. Such progression mirrors how human companionship itself often develops through repeated alignment, trust-building, and a sense of mutual attunement [47, 111]. Yet, unlike human relationships, the companionship here was not reciprocal but instead hinged on the human interpretations and projections [27]. This asymmetry reinforces earlier critiques that companionship with robots is fundamentally one-sided, shaped by human expectations rather than mutual emotional exchange [27], and possibly creating an illusion of perfect, nonjudgmental companionship due to the robot's endless patience and obedience [59, 78]. While appealing, this lack of true reciprocity can ultimately limit the depth of the relationship, as genuine companionship thrives on disagreement, mutual influence, and shared growth, elements robots cannot yet provide [106, 121].

Walking with the robot also appeared to change the participants' attentional orientation, often enhancing their sense of presence and mindfulness during the activity. Whereas walking alone can sometimes become habitual and backgrounded, the presence of the robot reintroduced a degree of novelty and reflexivity (Theme 2, section 4.2.1). Participants reported being more aware of their surroundings and of their own bodily movements, in part because the robot occasionally disrupted the flow of the walk, by slowing down, shifting position, or attracting their attention. When participants mirrored the robot's stopping, gaze direction, or attentional shifts, they enacted forms of joint attention typical of human-human coordination, aligning with research that links synchrony and shared focus to relational attunement [41, 69]. These interruptions encouraged reflection and made the walk feel more intentional rather than routine. Such heightened awareness echoes findings in human-companion studies, where the presence of another being improves mindfulness and draws individuals into the present moment [60, 65]. In this case, however, the mindfulness was not born of conversation or emotional exchange, but of adapting to the rhythm and movements of a machine whose presence resisted complete predictability. Thus, the robot shaped the walk as a more consciously experienced event, amplifying the meaning of an otherwise mundane activity through subtle disruptions and attentional cues. The heightened attention towards the robot during the walks may also partly reflect a novelty effect common in first-time human–robot encounters. It is a known phenomena that users often exhibit increased curiosity, vigilance, or fascination when interacting with a new robotic system, but this attentional demand typically diminishes as familiarity grows [1, 103]. It is therefore possible that, over repeated interactions, participants would allocate less attention to monitoring the robot and more to the surrounding environment or to the activity itself.

A further transformation in the walking experience was shaped by the redistribution of agency and rhythm between human and robot (Theme 2, section 4.2.2). This ongoing negotiation created a shared rhythm in which the walk became less solitary and more of a joint practice. This reflects patterns of attunement seen in human-human interaction, where individuals calibrate their movements to maintain harmony in shared activities [41]. Participants often described this co-regulation as simultaneously engaging and demanding, since it added a layer of attentional responsibility not present when walking alone. These embodied dynamics parallel the coordination seen in walking with human or animal companions, where synchronization and mutual adjustment are central to the experience [19, 61]. However, in the case of the robot, agency was asymmetrically distributed: while humans could adjust or reinterpret the robot's behavior, the robot's capacity for adaptation remained limited, thereby keeping humans in a position of active monitoring. This adaptation was also compounded by the absence of intuitive spatial norms that usually guide human-human coordination, requiring participants to establish such norms through experiential learning instead [58]. This asymmetry underscores a central tension in human-robot companionship, between experiencing the robot as a co-walker with its own rhythm and recognizing its lack of full agency. Nonetheless, these negotiations transformed the walk into a co-experienced practice, highlighting how companionship can be enacted through embodied coordination even in the absence of mutual intentionality.

5.2 RQ2: What are the subjective and social facets of human experiences when co-walking with robots, and how do these affect walking dynamics?

Co-walking with a robot was shaped not only by participants' personal experiences but also by the broader social environment in which the walks took place (Theme 3, section 4.3.1). The presence of the robot influenced how participants managed public visibility, expressed their identity, and negotiated social interactions, all of which directly shaped the dynamics of walking. This expands earlier work showing that walking with companion robots is still an unfamiliar public sight [23], and that reactions from bystanders can evolve within a single encounter rather than remaining fixed [51, 76].

Walking with a robot companion did not only reshape how participants perceived the act of walking but also brought forward a set of subjective and social facets that influenced the unfolding dynamics of the walk. One of the strongest facets was the awareness of public attention (Theme 3, sections 4.3.1). Walking with the robot positioned individuals in a socially conspicuous role that, much like public attention toward people walking with pets, could be experienced as either enjoyable or uncomfortably self-aware depending on one's sensitivity to bystander curiosity. It resonates with studies showing that pets are often perceived as extensions of their owner's identity [62], a dynamic mirrored here as participants felt that the robot's behavior reflected on them personally. Consequently, public scrutiny of the robot was often internalized as judgment of their own self-expression, illustrating how social norms shape the acceptability of robotic companions in everyday life [108]. This contrast underscores that human-robot walking is embedded not only in dyadic coordination between human and robot but also within the wider social environment, echoing prior findings on how the novelty of robotic companions challenges established social norms [30, 51, 76].

Another subjective facet was the negotiation of self-expression and identity. The robot has been framed as an extension of humans, noting that its presence reflected on how they were perceived by others. In this sense, the robot acted almost as a performative artifact that shaped participants' public self-presentation (Theme 3, sections 4.3.2). Positive or negative attention from others was not directed solely at the robot but was also internalized by participants as judgments about themselves, much like how pets are often seen as extensions of their owner's personality [62]. This again echoes the finding that companion robot behaviors become associated with the user's own identity [108], heightening the emotional stakes of public interaction. This relational entanglement altered the emotional tone of the walk: for some, it created pride and enjoyment, while for others, it created unease and embarrassment. Such findings suggest that robot companionship in public settings cannot be understood in isolation from social norms, as the presence of a robot reconfigures how individuals negotiate belonging, visibility, and self-expression in shared spaces [103, 108].

Privacy and agency also emerged as central concerns (Theme 3, sections 4.3.3). Unlike walking with a dog, where attention tends to remain fleeting, walking with a robot triggered more deliberate and technologically mediated forms of surveillance, such as photos and videos. This dynamic placed participants in a position of reduced agency: while the robot itself remained indifferent to such interactions, its human companion bore the social consequences of its presence. These concerns point to broader questions about autonomy and digital ethics in public HRI, echoing debates around surveillance and the unintended social costs of deploying novel technologies in everyday life [57].

These facets influenced the walking experience in ways that went beyond pace or rhythm. Participants constantly negotiated their attention between the robot, their own embodied coordination, and the reactions of others. Walking with a robot was therefore not simply a dyadic activity but a triangulated one, involving humans, robots, and the wider public. These dynamics highlight the importance of designing walking robots that can flexibly adapt to different orientations, whether by facilitating social engagement with bystanders, shielding users from unwanted attention, or focusing on one-on-one companionship.

5.3 Reflections on the Wizard-of-Oz process.

Conducting this study using the Wizard-of-Oz method allowed for a controlled yet dynamic exploration of human-robot interaction in outdoor walking scenarios. By manually controlling the robot's behaviors, the researcher was able to simulate realistic responses, adapting its actions in real-time to participants' movements and behaviors. This approach provided valuable insights into how people engage with an interactive robot in an unpredictable outdoor setting, but it also introduced certain complexities. Since the researcher was making moment-to-moment decisions about the robot's actions, the interaction was, to some extent, shaped by their own interpretations of how a robot should behave in such a context. This meant that participants were not interacting with a fully autonomous system but rather with the researcher's projection of robotic intelligence, which could have influenced their expectations and perceptions of the robot's capabilities. On the one hand, the robot might have behaved too realistically at times, whereas on the other hand, it might not have been able to meet the expectations of humans in some instances. And these discrepancies fall on the researcher's handling of the robot, rather than on the capabilities of the robot itself. However, it needs to be considered that autonomous technology such as autonomous vehicles are prone to errors and risks [42], which indicates that the experiences influenced possibly because of the Wizard-of-Oz process might also happen with

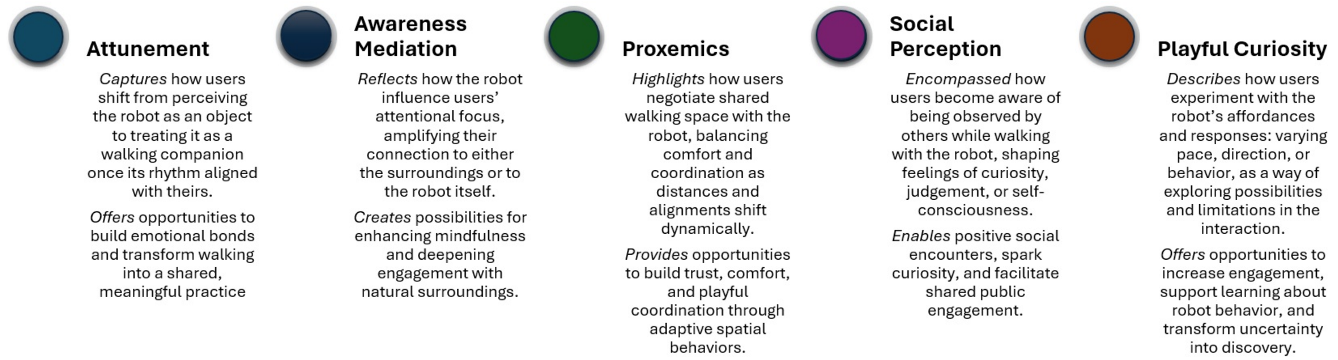

Figure 4: Brief overview of the dimensions of human-robot walking interactions

autonomous technology. Nevertheless, it shaped the participants' perception of the robot and its abilities.

5.4 Dimensions of Human-Robot Walking Interactions

Walking alongside a robot is not merely a technical coordination task but a layered socio-relational experience that intertwines embodiment, environment, and social perception. Our findings suggest that participants' experiences unfolded across multiple overlapping dimensions, each of which shaped the dynamics of companionship, attention, and meaning making during the walks. Below, we outline five key dimensions of human–robot (HR) walking interactions, grounding them in both our empirical data and prior work, followed by concrete and actionable design implications for each dimension. Figure 4 provides a brief overview of the dimensions.

5.4.1 Attunement. *Attunement* captures how users shift from perceiving the robot as a mechanical object to treating it as a walking companion once its rhythm aligned with theirs (Theme 1). *Attunement* offers opportunities to build emotional bonds and transform walking into a shared, meaningful practice. At the same time, it risks over-attribution of agency, unrealistic expectations, and frustration if the robot fails to meet perceived relational roles. Following are the design implications in this dimension:

(1) Design gradual alignment behaviors (e.g., speed matching, side-by-side positioning) to facilitate relational transitions and attunement over time.
(2) Incorporate emotional cues (sounds, gestures, pauses) that invite empathy and build a sense of connection and companionship.
(3) Support users' sense of responsibility by signaling vulnerability (e.g., warnings in uneven terrain) without over-dramatizing dependency.

5.4.2 Awareness Mediation. *Awareness Mediation* reflects how the robot influence users' focus, sometimes amplifying their connection to the surroundings and other times narrowing it toward the robot itself (Theme 2). *Awareness Mediation* creates possibilities for enhancing mindfulness and deepening engagement with natural surroundings. However, it also risks narrowing attention to the robot itself, potentially distracting from the restorative qualities of walking. Design implications for this dimension are as follows:

(1) Incorporate context-sensitive behaviors that direct attention outward (e.g., slowing near landmarks or pausing for scenic views).
(2) Allow adjustable "attention modes" where users can choose whether the robot emphasizes companionship or environmental awareness.
(3) Redirect and manage the focus whenever the users disengage with the environment or over-engage with the robot.

5.4.3 Proxemics. *Proxemics* highlights how users negotiate shared walking space with the robot, balancing comfort and coordination as distances and alignments shift dynamically (Theme 2). *Proxemics* provides opportunities to build trust, comfort, and playful coordination through adaptive spatial behaviors. Yet, mismatches in distance or unexpected movements may lead to discomfort, reduced safety, or loss of trust in the robot. Following are the design implications for this dimension:

(1) Implement real-time distance modulation and speed adaptation to maintain comfort.
(2) Introduce subtle cues (e.g., visual signals, body orientation) to make spatial adjustments legible to the user.
(3) Design for cultural and contextual adaptability, since expectations for personal space vary across cultural backgrounds and social settings.

5.4.4 Social Perception. *Social perception* encompassed how users become aware of being observed by others while walking with the robot, shaping feelings of curiosity, judgement, or self-consciousness (Theme 3). *Social perception* can enable positive social encounters, spark curiosity, and facilitate shared public engagement. Conversely, it risks unwanted attention, social stigma, or user discomfort when external perceptions are negative or intrusive. Following are the design implications for this dimension:

(1) Enable customization of appearance and demeanor so users can control how conspicuous the robot appears.
(2) Provide different modes of social presence that adjust robot expressiveness depending on whether users want to minimize or attract attention.

5.4.5 Playful Curiosity. Playful curiosity describes how users experiment with the robot's affordances and responses: varying pace, direction, or behavior, as a way of exploring possibilities and limitations in interaction (Theme 4). *Playful curiosity* offers opportunities to increase engagement, support learning about robot behavior, and transform uncertainty into discovery. Still, it risks disappointment, confusion, or disillusionment if the robot's responses are inconsistent or fail to meet users' expectations. Design implications for this dimension are as follows:

(1) Integrate subtle interaction opportunities in the form of "micro-challenges" that encourage safe exploration and sustain engagement.
(2) Provide contextual feedback (visual or auditory) to clarify the robot's capabilities and limitations during playful interactions.

6 Limitations and Future Work

All participants were young and connected to a university, likely to make them more familiar and favorable toward technology than other groups. Broader studies with more diverse participants, across age, gender identity, ability, walking habits, and occupations, are needed to address this gap. Additionally, as the study used a Wizard-of-Oz approach, the robot's behavior was controlled by the researcher, which may have shaped participants' perceptions. Autonomous robots could provide richer insights by introducing genuine unpredictability.

The robot used, Boston Dynamics' Spot, resembles and moves like a dog. While chosen for its outdoor mobility, its animal-like appearance likely influenced participants' responses, often inviting comparisons to pets. Future work should examine how different robot forms and appearances shape walking experiences.

Another potential limitation of the study is the lack of information on the perceived differences for indoor vs outdoor as well as different walking behaviors. While such comparisons could yield informative insights, our inductive coding approach focused on themes emerging directly from participants' accounts rather than imposing pre-defined deductive categories. As a result, the data did not provide substantial evidence of condition-specific discrepancies. Future studies designed with these comparisons in mind may further illuminate how environmental and activity contexts shape human–robot walking experiences.

Finally, novelty played a central role: participants walked with the robot only once for 20 minutes, making long-term implications difficult to assess. Longer-term or repeated studies would allow for deeper insights into sustained companionship and into different relational modes (e.g., collaborative, authoritative, or mixed).

7 Conclusion

This qualitative study was designed to answer the broad questions of how co-performance and companionship work between humans and robots in a walking scenario and how it affects humans' overall walking experience. The findings of the study, although not conclusive, shed light on four important aspects of walking companionship between humans and robots. Thematic insights revealed how participants experienced shifts in relationality, negotiated spatial comfort, navigated heightened attention to both the environment and the robot, and grappled with issues of public perception and social attention. Building on these, we articulated five key dimensions of human–robot walking interactions: attunement, awareness mediation, proxemics, social perception, and playful curiosity. Together they illustrate how walking with a robot transforms an ordinary, individual activity into a socially and relationally layered practice. These dimensions provide both a framework for understanding the lived experience of walking with robots and concrete design implications for creating more meaningful, comfortable, and socially attuned walking companions.

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Generative AI Tool (ChatGPT 5) has been used for shortening the following sections: the Rephraser method was used to shorten the text in the Abstract, Limitations and Future Work, and Conclusion. Also, we employed Polisher method for copy-editing the sections 4 (Thematic Insights) and 5 (Discussion). These practices follow the methods outlined in [18]. The final content is thoroughly checked, and authors assume the full responsibility of the core ideas, concepts and articulations in the manuscript.

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