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RESEARCH-ARTICLE

The Walking Meditation Mat: Leveraging Targeted Heat Sensation to Guide Attention Inward

TAMAR DUBLIN, Media Innovation Lab (miLAB), Herzlia, Tel Aviv, Israel

OREN ZUCKERMAN, Media Innovation Lab (miLAB), Herzlia, Tel Aviv, Israel

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Tamar Dublin
Media Innovation Lab
Reichman University
Herzliya, Israel
tamar.dublin@milab.idc.ac.il

Oren Zuckerman
Media Innovation Lab
Reichman University
Herzliya, Israel
oren.zuckerman@milab.idc.ac.il



Figure 1: The walking meditation mat, designed to generate feet-focused targeted heat sensation. The mat was evaluated in walking meditation context with two groups, with or without heat, to assess the potential of the heat sensation to guide attention inward.

Abstract

We present the walking meditation mat research, leveraging targeted heat to help meditators focus attention inward. The mat, measuring three meters in length, is designed with 10 visual signifiers and 10 corresponding heater pads arranged in a step-by-step pattern. Walking meditation is challenging, as it requires both inward and outward attention. In a qualitative study we studied the walking meditation experience with or without heat, evaluating the impact of the mat's visual signifiers and the gentle feet-focused targeted heat during the walking experience. Our findings reveal the tension participants experience between external design factors and their internal meditation process. Visual signifiers were more commonly associated with outward attention, dizziness and imbalance, while targeted heat affordances were more commonly associated with attention to bodily sensations, calmness, grounding, and reflection. We conclude with insights regarding the role of targeted heat in balancing inward and outward attention in walking meditation and introspective processes.

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CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI)**.

Keywords

Walking Meditation, Somaesthetic design, Targeted Heat, Introspection, Somatic Awareness, Mind-Body Connection, Well-being

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1 Introduction

Walking, a fundamental human activity, offers more than just a means of transportation. It is a basic movement of our body, a gait, yet it also has deeper aspects related to body and mind, including fostering mindfulness [23], supporting emotional regulation [38, 57], stimulating thought [44], and self-discovery [3, 23, 53]. Walking can be done as a physical exercise or for practical exploration of the physical surroundings, as a relaxing or joyfull activity, but also as a deeper contemplative process of introspection, mentally observing thoughts, feelings, and sensations [53].

In Buddhist tradition, walking holds great significance as a mindful practice that cultivates awareness, concentration, and insight

[49, 57]. It is an important form of Buddhist meditation, included in the four main postures of meditation practice: sitting, standing, walking, and lying [41]. Walking meditation is explained in the Buddha's suttas: "you should fix attention on walking meditation, with the sense-faculties turned inward, and the mind not going out" (Sutta AN 7:58) [6]. There are different traditions and schools of thought with regards to walking meditation. Generally, the practice involves short, back-and-forth walking along a predefined distance, ranging from 2-3 meters to 10-20 meters, but not a long stroll. In this work we chose to focus on the tradition of Mahasi Sayadaw [49], a 20th century Burmese Theravada Buddhist monk and meditation master. We chose Mahasi due to his vast experience introducing Buddhist meditation to westerners, the unique methods he developed to make the ancient tradition more accessible, and the detailed documented instructions he provided on how walking meditation should be introduced. Mahasi's method, known as the "mental noting" or "labeling" method, involves a meditator giving a mental label to any sensation they experience, moment to moment, for example, "pain, pain" when experiencing back pain while sitting, "worried, worried" when experiencing thoughts about a future stressful event, or "pleasant, pleasant" when enjoying a gentle breeze on one's skin. With regards to walking meditation, Mahasi's instructions are to walk at a naturally slow pace, concentrating "on the movement, on the breathing, on the sensations in the feet as they touch and leave the ground, and on the subtle shifts in balance and posture throughout the body" [49]. Mahasi invites practitioners to use the following mental labels while performing walking meditation: "putting down" and "lifting up", or a more detailed version like "lifting, moving forward, putting down, pressing the ground". This structured yet flexible approach actively engages the mind with bodily sensations of the current moment, hence fostering mindfulness [49].

Walking meditation has many potential benefits. It includes the many benefits of regular meditation on health and well-being, attention, mood regulation and stress [30, 56, 57]. The unique aspect of walking meditation is the movement and physical activity. In addition, practicing walking helps cultivate awareness of the body's connection to the external environment, to balance and posture, while encouraging mindfulness [23, 49]. Walking meditation can be a productive pathway into meditation practice for those who find sitting meditation challenging due to vigor or restlessness [29].

In the Buddhists Suttas (discourses), the Buddha listed five benefits of walking meditation (Sutta AN 5:29): improved endurance, overcoming drowsiness, enhanced health, better digestion, and sustained concentration [6]. In some monasteries and retreats, meditation practitioners alternate between sitting and walking meditations to release tension associated with sitting for a long period of time, and to practice sustained concentration [23, 29, 41].

Clearly, Walking meditation has many potential benefits, however it presents several challenges, for experienced or new meditators alike. One key difficulty lies in balancing attention between bodily sensations (inward focus) and external movements or the environment (outward focus) [12]. This delicate balance makes walking meditation more complex than sitting meditation, where the focus is primarily internal. Practitioners need to synchronize their physical movements with their mental state, which can be disrupted by internal distractions (wandering thoughts) and external

factors (such as maintaining balance or reacting to surroundings) [12]. These challenges can lead to difficulties in attentional control and frustration, potentially obscuring the benefits of the practice [35, 45].

The challenges and benefits inherent to walking meditation present a notable opportunity for HCI designers. Existing research involving technology and walking meditation include mobile apps [10, 63], immersive soundscapes [12], and virtual reality experiences [21]. Our approach differs, we believe technology should not contradict the core principles of ancient practices, especially not in contemplative practices that strive to direct attention inward rather than outward. Therefore, inspired by Somaesthetic philosophy, we present a qualitative research of a walking meditation experience on a mat prototype [14] that leverages targeted heat modality to direct attention inwards rather than outwards.

Somaesthetics [50, 51] emphasizes the integral role of bodily awareness and inner sensations. This philosophy challenges the traditional Cartesian dualism, suggesting that the body and mind are not separate entities but rather two aspects of our soma—our integrated body-mind experience. This perspective underscores the notion that improving body awareness is as crucial as nurturing our intellectual faculties [50, 51]. Kristina Höök and others further expand on this concept through the lens of somaesthetic interaction design [25], emphasizing the importance of leveraging habitual everyday activities such as walking, breathing, and standing, to enhance body awareness. Somaesthetic design principles encourage the creation of interactive systems that engage users while guiding their attention inward, enhancing the connection between physical sensations and mental states [25, 28].

Within the context of somaesthetic design, there has been an exploration of various bodily contexts and different sensory stimuli, including touch, sound, as well as targeted heat. The targeted heat modality was explored as a design material in the context of somatic practices such as Feldenkrais [31, 54] and sitting meditation [13, 17], for its unique characteristic of being felt as coming from inside the body, and for promoting positive emotions like comfort and calmness [17, 28, 31, 42]. Of specific interest to our work are the findings that targeted heat can influence direction of attention in a subtle, non-intrusive way, demonstrated in several separate works [13, 17, 31]. Furthermore, targeted heat was shown to be perceived as internal stimuli rather than external one [13, 17, 31, 42], unlike other sensory modalities [13, 42]. This internally perceived quality of targeted heat stimuli positions it as a highly appropriate modality for promoting introspection [13, 17, 31, 42].

In this work we present a deep qualitative analysis of people's feelings, sensations, thoughts, and overall meditation experience while performing a walking meditation practice on a mat with integrated targeted heat elements placed in a step-by-step order. We evaluated participants' qualitative experience in two separate groups, one group walked on the mat without the targeted heat activated i.e. only with visual signifiers, and the other group walked on the mat with the targeted heat activated.

2 Related Work

This work extends our previously published Late Breaking Work, in which we presented the design process of the walking mat in the

context of "introspective walking" [14]. In this work we contextualize the walking experience in the Buddhist tradition and practice of walking meditation, and evaluate the experience with participants of various meditation levels, in two groups of with-heat mat or without-heat mat.

Additional related work includes studies on walking meditation without and with technology, sensory modalities in walking and foot-based interactions, and works that studied the targeted heat modality.

2.1 Walking Meditation Without and With Technology

Several medical and psychological studies have highlighted the benefits of traditional walking meditation in medical and health context, from improvements in physiological and psychological markers in type 2 diabetes patients [19] to enhanced proprioception and balance, particularly in individuals with chronic ankle instability and the elderly [9, 33]. Walking meditation also significantly reduced depression and improved vascular reactivity and functional fitness [46]. A recent comparative study evaluated four different meditation techniques for beginners, Concentrative, Humming, Observing-Thoughts, and Walking Meditation. All techniques improved emotion regulation and body awareness. Walking meditation was least effective in improving decentering and mind-wandering, and the most effective in improving body awareness and emotion regulation. Walking meditation was also found to be particularly beneficial for individuals who prefer more active and engaging forms of meditation [36].

Only a few works have been specifically developed for walking meditation. The Ambient Walk [10] is a design of a mobile app aimed to enhance walking meditation by adjusting visual and sound feedback based on the user's walking pace and breathing pattern. Another design is VR Meditative Walk [21], which incorporates a treadmill mapping the user's walking speed to the navigation of their avatar in a virtual environment, with visual and sonic feedback that changes as the meditator becomes more relaxed. Similarly, the i-m-Walk system [63] utilized pressure sensors in shoes to provide real-time visual feedback on a smartphone, helping users slow down and refine their walking meditation technique. The authors suggest that integrating other feedback modalities could provide additional guidance without requiring users to look at the phone, thus minimizing distractions and better supporting the meditation experience [63].

Cochrane et al. studied how rhythmic sounds, modulated by EEG readings influence the walking meditation practice [12]. The study highlights the complex interplay between internal and external focus during walking meditation practice, suggesting that external rhythmic sounds can provide a focal point that helps synchronize walking and breathing, addressing challenges of balance and stability especially at slower walking speeds. Many novice practitioners struggle to maintain a slow gait while dividing attention between walking and mindfulness. The researchers suggest that for technology-mediated walking meditation, designers should consider how sensory feedback can either support or disrupt this delicate balance [12].

We build on and extend prior work on walking meditation with technology, such as Cochrane et al.'s exploration of how rhythmic sounds can synchronize walking and breathing. While their work highlights the potential of sound to guide attention and support balance, our focus shifts to the targeted heat modality, which we investigate as a means to foster inward attention during walking meditation.

2.2 Sensory Modalities in Walking and Foot-based Interactions

We review works related to sensory modalities (sound, visual, haptic) and their connection to introspective qualities of walking, not in the specific context of walking meditation but in highly related contexts including mindful walking and somatic practices. We then review foot-based interactions, particularly floor-based systems that use sensory cues.

2.2.1 Sensory Modalities in Walking Practices. Sensory modalities were studied as new avenues for introspection in walking context.

Sound was shown to enhance engagement [32] and influence walking speed [39, 42, 58]. The Slow Floor [18], a pressure-sensitive surface that generates sound in response to walking, focused on the impact of sound as a form of sensory feedback on walking, aiming to enhance creative agency and somatic awareness. Participants noted that the sound feedback made them more aware of their feet, pressure, and balance but also led them to explore rhythms, weight distribution, and the relationship between their movements and sound. While it did enhance their awareness of the feet and body, the sound seemed to encourage a more external focus on creative engagement and interaction with the surface, rather than solely on internal somatic awareness [18]. The Mindful Moments work [55] used Head Mounted Displays to offer breath-based audio-visual guidance during routine walks. Participants initially found the visuals helpful for regulating their breathing, but after the rhythm was established, they preferred to rely more on the auditory cues, allowing their attention to shift to their physical surroundings. The findings suggest that while visual cues are effective in establishing a breathing rhythm during walking, they may become distracting over time, and auditory cues consistently maintain focus on the external environment [55].

Haptic, pneumatic-based feedback was studied with a cross-body belt reminiscent of a pouch-strap or a driving safety-belt. Using soft inflatable actuators tactile feedback is provided in varying intensity, frequency, and pattern. It was tested in various everyday scenarios, including outdoor walking, with findings indicating that feedback intensity and frequency are critical to the experience, mentioning mindfulness as a potential application [11]. Our work differs from these prior studies by focusing on the targeted heat modality in the specific context of walking meditation, aiming to gently guide attention inward rather than outward.

2.2.2 Foot-based interactions. In a review paper of foot-based interactions in HCI [59], Velloso et al. highlight the challenge of designing interactions that do not disrupt the user's natural gait or compromise balance and safety, and propose integrating interactions that align with the natural demands of walking, which involve maintaining balance, coordinating movement and ensuring a steady

gait [59]. Foot-based systems often utilize various sensory modalities—visual, auditory, and haptic feedback—to enhance user control and engagement without overwhelming the user’s cognitive load. There are notable examples focused on providing haptic feedback to the feet through floors or shoes. For instance, an ambient haptic floor display using a linear voice coil actuator, exploring applications like pedestrian wayfinding and directing attention toward specific events or locations [60], or “FeetBack”, a shape-changing floor, that demonstrated how directional haptic cues can effectively guide pedestrians with minimal cognitive load, and that sequential actuation patterns enhance the perceivability of these cues [24].

Matthies et al.’s “ShoeSoleSense” explored targeted heat as a sensory modality for the feet, simulating discomfort or changes in temperature to convey environmental hazards or avatar stress in VR environments. Their work demonstrated the potential of thermal feedback for foot-based interactions, focusing on enhancing immersion and conveying information through discomfort, and presents an important perspective on how heat can simulate a sensation of pain[37].

We differ from prior work by exploring the targeted heat modality in a walking meditation context, focusing on the walking itself rather than a separate cognitive task (e.g. navigating). Unlike Matthies et al.’s use of heat to induce discomfort, we aim to evoke introspective sensations, aligning with prior research on targeted heat’s ability to guide attention inward and enhance self-awareness, as discussed in the next section.

2.3 Targeted Heat Modality

Targeted heat has been explored across various HCI contexts, including music, messaging, VR, and interpersonal communication. ThermOn [1] used thermal sensations to alter music perception, and ThermalWear [15] showed thermal stimuli increased positive reception in voice messages. Thermal feedback enhanced emotional engagement in VR [48], and connectedness in remote presentations [22] and parent-child interactions [34]. The most relevant works to our research are somaesthetic or body-focused projects that use targeted heat modality in a meditation context, which we discuss below.

Targeted heat was found to facilitate inward focus, to enhance self-awareness and positive sensations [42]. In WarmMind [13], Daudén Roquet and Sas explored a meditation wearable with integrated targeted heat, they found the heat directed focus of attention inward, enhancing bodily awareness and introspection. The warmth patterns produced by WarmMind were perceived as emanating from within the body during meditation, contrasting with other stimuli like audio feedback, which often led to a sense of isolation [13]. Ezer et al.’s Somaesthetic Meditation Wearable [17] extended the study of targeted heat in meditation contexts. Their findings reveal that the various roles of targeted heat sensation during meditation, guiding participants’ attention inward, grounding their focus on bodily sensations, fostering emotional comfort, and serving as a motivating factor in maintaining their practice. They emphasized the quality of self-exploration in designing for meditation, as participants experimented with placing the targeted heat on various body locations [17]. In contrast to smaller-scale wearables delivering localized targeted heat stimuli [13, 17], the Soma Mat [31, 54] offers a

broader spatial application of targeted heat, controlled by a mobile app with pre-recorded sessions. This work explored how a scripted process of targeted heat during body scan meditations, Feldenkrais sessions, or relaxation exercises, can gently direct participants’ attention to different body parts from underneath while the user lies on the mat. The Soma Mat was evaluated together with the Breathing Light prototype, a large lamp that synchronizes ambient light with a person’s breathing. The exploratory evaluation reported sensations of relaxation and enhanced body awareness, and the authors concluded that the design fosters somatic exploration and awareness [31, 54]. Our work expands the study of targeted heat in the context of introspection and meditation, in the specific context of walking meditation, a movement-based practice that requires a delicate balance between inward and outward attention. Walking meditation has many benefits, but requires both inward and outward attention and is therefore challenging, even for meditators experienced with sitting meditation. Targeted heat has been shown to direct attention inward, and is perceived as an internal feedback rather than external, which makes it highly relevant for meditation. We present a comprehensive qualitative research of the walking meditation mat, evaluating participants’ interpretations of their bodily sensations and meditation experience with or without the targeted heat, analyzing the impact of the visual signifiers and the targeted-heat affordances on the meditation experience.

3 The Walking Meditation Mat

The mat used in this study [14] is a 330cm long cream-colored cotton blend fabric, with 10 integrated Polyimide heating elements placed along the mat in a step-by-step walking pattern. Visual signifiers are embroidered on the fabric at the exact location of each heating element. The Polyimide heaters are regulated by two ToolkitRC P200 power supplies, with an internal safety control based on voltage and current limits of 6V and 2A, to prevent overheating. The heating temperature is set for a constant heat of 45-46°C across all 10 heater pads. The iterative design process of the mat was previously published in our Late Breaking Work [14], and was guided by Somaesthetic Appreciation Design principles and specifically the principle of “turning inwards” [26], a highly relevant principle for the challenge people experience during walking meditation - balancing inward and outward attention. We implemented the Somaesthetic Appreciation Design dimensions [26] to walking meditation context in the following way: *Modality* was centered around targeted heat sensations under the feet, leveraging the known characteristic of targeted heat to enhance inward

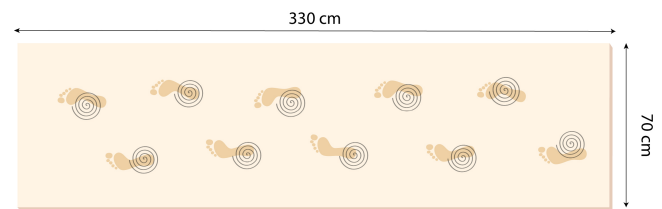


Figure 2: The walking meditation mat. Visual signifiers are embroidered on the fabric at the exact location of each heating element, placed in a step-by-step pattern.

attention, bodily awareness, and calmness [17, 28, 31, 42], making it a highly appropriate modality for meditation [13, 17]; *Timing* of the interaction was designed to align with the rhythm of walking, with the targeted heat stimuli available as part of the walking path, while allowing users the freedom to engage with it in any way they want to; *Intensity* of the heat stimuli was fine-tuned to ensure it was subtle but present, providing a grounding sensation without overwhelming the user.

4 Method

We employed a qualitative approach [4] to explore the walking meditation experiences of participants on the walking mat, both with and without the targeted heat technology. Walking meditation, like other somaesthetic experiences, is highly subjective and introspective experience, and varies significantly from person to person. Through in-depth semi-structured interviews, our research aimed to uncover the nuanced feelings, sensations, emotions, and preferences of participants, providing a deeper understanding of walking meditation in general, and specifically the role of visual signifiers and targeted-heat affordances in the experience. We conducted individual sessions with twenty-four participants, each session lasting about one hour, to gather detailed, personal insights into their experiences. The study was conducted in accordance with the university's ethics committee guidelines, with ethical approval obtained from the Institutional Review Board (IRB).

4.1 Participants

Twenty-four individuals participated in the study (15 females and 9 males), recruited through social media channels, and received a voucher for their participation. Participants completed a questionnaire designed to gather background information on their experience with meditation in general and walking meditation in particular. This included questions about the type of meditation they had practiced, the duration, and general frequency of their practice. The purpose of the questionnaire was to ensure participants had some familiarity with meditation, and ensure a balanced representation of experience levels. The inclusion criteria required active practice of meditation with varying levels of experience, between daily practice to monthly practice, at home or in meditation retreats, without any requirement regarding the specific type of meditation. The experience level was defined as follows: Low (practice once per month), Medium (practice once per week), and High (practice every day).

4.2 Experimental Settings and Measures

Participants were allocated to one of two groups, with heat (WH) or no heat (NH), 12 participants in each, with balanced representation of experience level in each group (with heat group had 3 low, 4 mid, 5 high; no heat group had 4 low, 4 mid, 4 high). In both groups, the participants were invited to walk on the mat for 20 minutes. The decision to use a 20-minute duration for the walking meditation was based on prior research [12], which indicates that this length is sufficient to allow participants to settle into a meditative state. Both groups received the same instructions for the walking meditation activity, based on the teachings of Mahasi Sayadaw, which emphasize mental labeling of sensations, thoughts, and emotions

as they arise [49]. To study was conducted in a quiet room with a large and comfortable space to walk in, with soft lighting. The space also included various items, including a sofa, a large table, and plants. The room temperature was regulated to 25°C to ensure that the experience was consistent for all participants, regardless of external weather conditions. The mat prototype was placed at the center of the room. Before entering the study room, participants engaged in a brief, casual conversation with the researcher to help them relax and smoothly transition from their daily activities to the research environment.

Following the walking session, a semi-structured interview was conducted to gain a deeper understanding of participants' experiences, emotions, and thoughts during the walking meditation. The researcher used a standard interview protocol to ensure consistency across all sessions, while letting the conversation flow naturally. All interviews started with the open-ended question: "Please describe your experience", with follow-up questions were based on the natural flow of the discussion, with focal points around participants sensation, attention, associations, the mat's design and potential uses.

4.3 Procedure

Participants were informed in advance that the study would involve walking meditation without shoes, wearing socks. Upon arrival at the study site, participants were welcomed and given an overview of the study's goals and procedures. For those in the "with heat" mat group, the study began with a standard introduction to the mat (length, material etc.) with an introduction to the mat's embedded targeted heat technology. Safety measures were emphasized, explaining that the mat has a built-in safety mechanism to prevent overheating, that participants can choose whether or not to step on a heating element, and that they can stop their participation at any time. Participants in the "no heat" group received the standard introduction to the walking mat without any specific mention of the mat's heating capability.

Both groups were instructed to remove their shoes and wear the provided socks before beginning the walking meditation. A brief standard definition of mindfulness meditation was presented: "*Meditation is a mindfulness practice. A state of mindfulness is characterized by attentive, non-judgmental awareness of thoughts, emotions, and sensations experienced through the senses in the 'here and now,' without clinging to thoughts of the past or future*" [20].

Instructions based on the teachings of Mahasi Sayadaw [49] were then provided, guiding participants to mentally label every sensation, thought, and emotion, such as "thought," "tension," "sound," "pleasant," or "unpleasant". Participants were then given specific instructions for the walking meditation itself: to walk back and forth on the mat at a pace that suited them, turning around at the end of the mat. Participants were instructed to focus their attention on the lifting and placing of their feet, the physical movement, and the contact with the ground, using the labeling technique "lifting right," "placing right," "lifting left," "placing left." They were encouraged to keep their body relaxed and loose and to keep their eyes open to avoid falling.

The researcher exited the room during the walking meditation and returned after the 20-minute session to conduct the interview.

Participants were reminded that if they felt they had enough of the walking at any point during the session, they could give it one more try, and if they still felt the same, they were free to stop. They were instructed to come to the door and knock if they wished to end the session, at which point the researcher would enter for the interview phase. At the end of the interview, participants were debriefed, and the researcher ensured that the overall experience was positive.



Figure 3: The experiment took place in a quiet room, with the mat placed at the center, and participants walking on it wearing socks.

4.4 Qualitative Analysis

The qualitative analysis of participants' interviews was conducted using thematic coding, specifically the "coding reliability approach" [5]. The process was conducted by two coders and a senior researcher, and consisted of five steps: (1) All interviews were audio-recorded with participants' consent and transcribed using an automated transcription service, with the coders reviewing and correcting any errors in the transcriptions; (2) Four transcripts were selected for initial analysis, during which each coder independently reviewed the data and identified initial emerging themes; (3) These initial themes were then presented and discussed together with the senior researcher, and any inconsistencies were discussed and resolved, until a final set of themes was defined; (4) The coders re-analyzed the initial four interviews using the final themes, along with two additional transcripts, and confirmed inter-rater reliability (Cohen's kappa = 0.86); (5) Once reliability was confirmed, the coders proceeded to analyze the remaining interviews.

5 Findings

The qualitative analysis of the post-experience interviews with 24 participants revealed the meaningful as well as challenging aspects of walking meditation, and specifically the impact of the mat's visual signifiers and targeted heat affordances on the meditation experience. Different people experienced it differently, yet repeating themes were evident. The quotes from both no-heat (NH) and with-heat (WH) experiences were coded as one dataset, using an identical thematic coding process, and each quote is marked with the group it is associated with (NH or WH). The qualitative analysis revealed three high-level themes, eight sub-themes, and seven sub-sub-themes, see the visualization in Figure 4. The three main themes are: the overall walking meditation experience, the direction of attention inward to the body or outward to the environment,

and the impact of the visual signifiers and heat affordances on the meditation experience.

5.1 Theme 1: The Overall Walking Meditation Experience

This theme reflects the diverse emotional states and physical sensations participants experienced during the walking meditation, shaped by their meditation practice and their interactions with the mat, either with heat or without. Participants' comments in this theme varied from deeply calm to dizziness and imbalance. There were clear differences between the two groups. Among the no-heat participants, the most common descriptions about the overall experiences were: Dizziness or Imbalance (7/12), Difficult (2/12), Calm (2/12), and Energetic (1/12). Among the with-heat participants, all participants except one described their experience as Calm (11/12), and one as Difficult (1/12). See Table 1 for details.

Participants who mentioned Dizziness or Imbalance were all in the no-heat group, and mentioned the short distance, the frequent turns, and the challenge of concentrating on several things at once - the walking, the thoughts, the feet, the breathing. Selected quotes include: *"There were stages where I might have felt a bit dizzy because it seemed like a short distance to me"* (P6 NH); *"I think the dizziness is related to everything, focusing on thought while moving back and forth"* (P14 NH); *"I noticed at first there was a gap between my head and my body, like something in my head was in a hurry, and the movement was kind of... clumsy"* (P6 NH); *"I felt that I couldn't maintain balance properly. When I shifted my weight from one foot to the other, there was this moment when one foot was in the air and the other hadn't yet touched the ground"* (P10 NH).

Participants who described their experience as Calm or Pleasant (2 in the no-heat group and 11 in the with-heat) mentioned various aspects, from the obvious quiet atmosphere to deeper levels of concentration, deeper focus on bodily sensations and less on thoughts, better ability to release some control during the walking, to let go, to "clear their mind". Selected quotes include: *"My mind became quiet. Somewhere in the middle, I really felt a relaxation, like everything became sharper. Suddenly, I could notice things. There was that moment of sharpening throughout the walk"* (P2 NH); *"But when I focused more on the feeling of the step, the touch of the foot touching the floor, those were the times I felt calmer"* (P3 WH); *"I was less in my thoughts, even really in a kind of flow of meditation, and I managed to focus my attention and not be distracted by what's around. Feeling a pleasant sensation like that"* (P19 WH).

Participants who described their experience as Difficult (2 in the no-heat group and 1 in the with-heat) discussed the difference between sitting meditation (usually with eyes closed) and walking meditation (eyes open), and that it was hard to direct attention inward towards the body: *"A bit difficult. I think mainly because my eyes were open, and then it's really hard to be without at least the simple sensation of the body, like being inside, yes, all the time. Even if I was just looking at the floor, but still... it made it really hard for me to feel the body"* (P4 NH).

One participant described his experience as Energetic (no-heat group), the experience was a positive experience for him, and connected him more to his body than his mind: *"Feeling great. More*

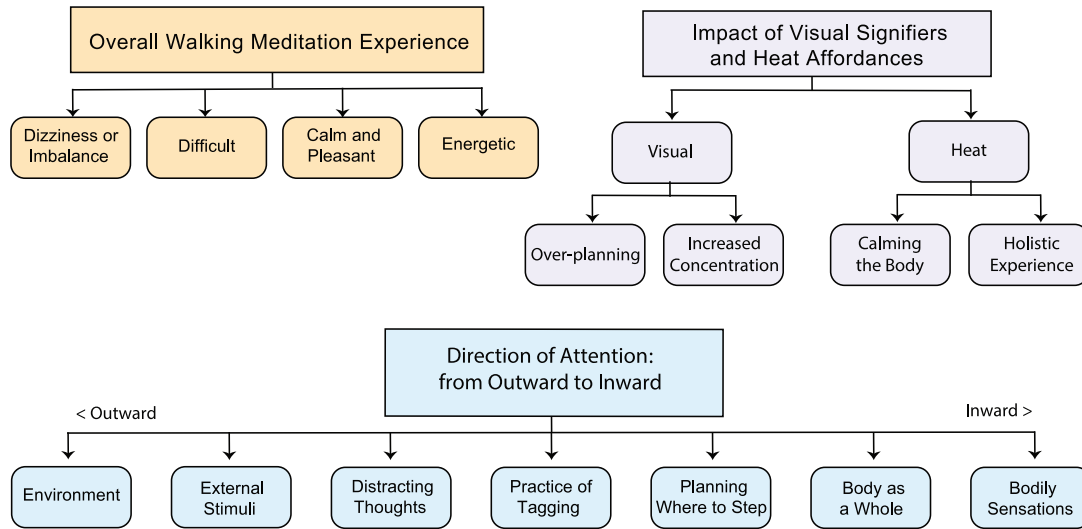


Figure 4: The hierarchy of themes and sub-themes revealed by the qualitative analysis of post-experience interviews, describing the various aspects of participants' walking meditation experience on the mat.

present? Definitely. I don't know if more relaxed, but more alive. I guess it's more connected to the body than to the mind" (P12 NH).

5.2 Theme 2: Direction of Attention Inward to the Body or Outward to the Environment

The direction of attention refers to the way participants describe where they focused their attention or awareness, either inward, towards their bodily sensations and thoughts, or outward, towards the physical environment or external stimuli. Walking meditation includes an inherent tension between inward and outward attention [7,32]. This theme starts with quotes regarding outward attention, and continues with participants' descriptions of the different types of inward attention they experienced, including focusing on distracting thoughts, on thoughts related to the practice of tagging, on thoughts related to planning where to step, on the body as a whole, or on specific bodily sensations.

Many participants experienced outward attention at the beginning of their walking meditation process, and gradually shifted to inward attention. However some found it more challenging than others, and for some the whole experience was impacted by it: "It was a bit harder for me to concentrate on the meditation itself, and I could constantly be distracted by the environment. I feel that it improved over time, but at first, it was harder for me to focus only on meditation with all the things coming up from other senses, not just thoughts" (P21 WH).

When participants were able to focus attention inward, they described it in different ways. It usually started with focus on thoughts: "I realized how open eyes and walking in space cause my thoughts to

run wild [...] I realized that thought has several layers, and tagging is just something I do to serve the purpose, but there are still thoughts on a deeper layer" (P14 NH); "I think I was really not distracted... a lot of thoughts came up, but I wasn't distracted as I was occupied with thoughts about walking" (P19 WH).

Some participants described how they were able to direct attention towards their body, but not necessarily related to the present moment of stepping or walking: "In terms of body sensations, I felt the things that bother me in my body. There was a moment when I really felt my stomach. suddenly I was aware of my nose" (P14 NH); "I noticed that I really felt all my shoulder blades. I work a lot with my body in dance, and I feel it especially these days" (P10 NH).

A deeper inward attention was reflected in what participants defined as attention to sensation. In some cases it did not lead to a deeper experience: "I noticed that in some steps I felt a kind of small 'hill', the sensation was pleasant. I really connect to physical meditations, and the feeling of how things feel under the feet is important to me. But I didn't feel it was something that held me in a deeper way." (P10 NH). In other cases, it did lead to deep experiences: "and then there was a moment where I caught both the rhythm and how I was feeling, and I was walking more freely... the walking became more refined, I didn't have to think about each step, the sensations were easier to feel, and my mind was more open. So I could be more in the walking" (P2 NH); "Something in the feeling of the foot touching the ground is more grounding. It's something very calming regardless. There is a feeling of something beneath me, a feeling we usually don't pay attention to" (P3 WH); "I felt that I managed to reach a reflective place that feels sensations and observes them" (P5 WH); "It's a bit

Table 1: The 24 participants were classified based on their Meditation Experience Level: Low (practice once per month), Medium (practice once per week), and High (practice every day). Participants allocation into the two experience groups (without-heat and with-heat) was balanced based on the classification of experience level. The "Overall Experience" column is derived from the qualitative analysis of post-experience interviews, and represents how participants defined their own overall walking meditation experience.

Group	Meditation Experience Level	Participant n.	Age	Gender	Overall Experience
Without Heat	Low	8	35	F	Dizziness
Without Heat	Low	18	29	F	Difficult
Without Heat	Low	22	30	M	Imbalance
Without Heat	Low	24	29	F	Calm
Without Heat	Mid	2	31	F	Calm
Without Heat	Mid	14	30	F	Dizziness
Without Heat	Mid	16	27	F	Dizziness
Without Heat	Mid	20	37	M	Dizziness
Without Heat	High	4	29	F	Difficult
Without Heat	High	6	33	F	Dizziness
Without Heat	High	10	30	M	Imbalance
Without Heat	High	12	32	F	Energetic
	Low: 4, Mid: 4, High: 4	Total: 12	Mean: 29.33, SD: 3.77	F: 9, M: 3	Dizziness: 5, Difficult: 2, Imbalance: 2, Calm: 2, Energetic: 1
With Heat	Low	1	26	F	Calm
With Heat	Low	3	25	F	Calm
With Heat	Low	15	30	F	Calm
With Heat	Mid	7	28	F	Calm
With Heat	Mid	11	35	F	Calm
With Heat	Mid	13	30	M	Calm
With Heat	Mid	19	31	M	Calm
With Heat	High	9	40	F	Calm
With Heat	High	17	40	F	Calm
With Heat	High	21	43	M	Difficult
With Heat	High	23	26	M	Calm
With Heat	High	5	41	M	Calm
	Low: 3, Mid: 4, High: 5	Total: 12	Mean: 32.08, SD: 7.54	F: 7, M: 5	Calm: 11, Difficult: 1

of living through the feet, not through the head" (P13 WH); "I felt that my body gradually became more present. Like my feet were more connected to each step, feeling what I feel at each stage" (P23 WH).

5.3 Theme 3: The Impact of The Visual Signifiers and Heat Affordances on The Meditation Experience

The heat affordances were the only difference between the two groups, one group with visual signifiers only, and the other with visual signifiers and the additional heat affordances. Participants' descriptions of their meditation experience reveals a clear pattern regarding how each of the different modalities affected various levels of their experience. Both modalities attract attention and invite participants to plan if they wish to physically step on it or not. The targeted heat feedback, which also includes the exact same visual signifier, has an added impact, the warmth, which adds a feeling of comfort, pleasantness, that for many participants triggered deep positive feelings, emotions, and contemplations.

In the visual signifier group (no-heat), most participants mentioned that the "circles", "marks", or "dots" helped them with focus and concentration, but eventually led to over-planning: *"They focus you. It's not exactly that I planned my walk according to the circles, but it did give me a certain focus. It helped me feel the rhythm of*

the walk better" (P8 NH); "I thought about whether to pay attention to these circles or not. To walk through them or not to walk through them" (P18 NH); "At first, I played with the dots on the mat, and it was a bit annoying. In the end, I preferred to ignore them. I had a sense of chaos in my head, you could say" (P22 NH). One participant in this group found it to be interesting: "Actually, the sensation of the mat was interesting, those circles... I liked the sensation of them" (P14 NH).

In the heat affordance group (with heat), participants' experience was deeper. They explained how the "pleasantness", "comfort", "calming" of the heat led them to a more holistic experience, help them direct attention to their bodily sensation: *"I don't know if there's a causal connection to the heat, but in the end, it felt like a holistic experience, like the heat added to it. I feel like it gives a sense of comfort, warmth, a sense of security, like, to lower the tension, the thoughts" (P1 WH); "There's something about the sensation of walking on something warm and calming the body into it" (P3 WH); "I think the temperature changes helped me stay present and feel these nuances each time" (P11 WH). Some shared how it encouraged body and mind investigation processes which are helpful within the meditation: "It triggers an internal sensation within me, but it doesn't come from within. But it doesn't matter to me where it comes from; it doesn't matter to me that there's a mat with wires that trigger*

sensations. *I am in an internal investigation facing myself, touching it, it's pleasant to me, I keep walking, I continue tagging*" (P5 WH). Others shared how it was both guiding their step but not forcing it, allowing them to explore, decide for themselves, or just let it happen by itself: *"Sometimes I planned where I wanted to put my feet, and sometimes I just let my feet walk around"* (P7 WH); *"the moment I lingered with my foot on some of the circles, it felt warmer, and then I kind of wanted to continue more, but then it felt like pleasant surprises"* (P19 WH); One participant gave a deeper analysis of the effect heat has on his meditation process: *"I'm trying to be with this sensation without immediately labeling it as good or bad. It's like letting the heat be part of the meditation and seeing how it affects the body and my presence in the moment without judgment"* (P9 WH).

6 Discussion

In this work, we presented a qualitative research of a walking meditation mat with integrated heat elements and visual signifiers. Our findings uncovered participants' subjective experiences during a walking meditation process, validating the known challenges in balancing inward and outward attention and highlighting the potential in the targeted heat feet-focused sensation. Participants experienced subtle shifts from outward attention to inward attention to bodily sensations. Our findings also highlight the role that the visual signifiers and heat sensation had in their meditation process, specifically the feelings and introspective processes sparked due to the heat sensation, and the motivation it appeared to create for experienced meditators to investigate deeper aspects in their meditation process such as non-attachment to the pleasant aspects of the heat sensation. Taken together, our findings may have a broader potential for HCI designers, within and beyond introspective practices.

6.1 Balancing Outward and Inward Attention

The known challenge of balancing outward and inward attention during walking meditation was evident in our participants' interviews, for example: *"It was hard for me. I tried to make all my steps the same weight and at the same speed, but I couldn't really focus on the steps. It was either on the steps or on the outside noises"* (P18 NH). This challenge was much more dominant in the no-heat group. Some meditators who found it challenging to balance outward and inward attention reported negative feelings during their meditation experience such as dizziness and imbalance. This is in line with existing research in cognitive physiology, demonstrating that divided attention during walking can lead to balance issues [27, 52, 62], and with findings by Cochrane et al., who showed that external sensory feedback can disrupt focus and stability during walking meditation [12]. Meditators that reported they were able to balance outward and inward attention by directing attention inward towards bodily sensations, expressed a more positive meditation experience, for example a common quote from the with-heat group is: *"as I got into it and focused on each sensation and what I was feeling, I began to feel my thoughts clearing up, and my mind became quieter... there was a sense of calm"* (P11 WH). This was also reported by Cochrane et al., in instances where participants successfully managed to shift their attention inward when they got into a certain "flow" while walking [12].

Our findings reveal that the ability to balance outward and inward attention occurred more for participants that walked with the targeted heat enabled. It also happened without the heat, however, it was less common (2 out of 12 vs. 11 out of 12). Beyond the feeling of calmness, most of the participants that walked on the targeted heat mat added deeper aspects about their experience: *"I managed to reach a reflective place"* (P5), *"it's a bit of living through the feet"* (P13), *"my body gradually became more present"* (P23), *"it gives a sense of comfort, warmth, a sense of security"* (P1), *"it felt like pleasant surprises"* (P19), *"my feet were more connected to each step"* (P23).

6.2 Targeted Heat Modality Has Two Inherent Advantages for Walking Meditation

The targeted heat modality appeared to have a positive impact on participants' meditation experience, and our work replicated the known quality of targeted heat in supporting focused attention [17]. The heat sensation seemed to guide attention inward in two meaningful ways: first, attention towards the exact moment in which the foot is touching the ground, inline with the classic instruction of walking meditation [23, 49]; Second, the feet-focused warmth sensation led to positive feelings and a range of bodily sensations beyond the feet itself, positively affecting the overall quality of the meditation process. In contrast, the visual signifiers, the circles/spirals embroidery marks spread along the mat, increased the tension between outward and inward attention. Interestingly, this occurred only in the group that experienced the visual signifiers without the heat, the with-heat group experienced the exact same visual signifiers. Some aspects of the heat sensation reduced or changed the negative impact of the visual signifiers on attention and on the experience in general. One explanation for this finding may be that during walking meditation, people are not occupied with any task, and as a result their attention is naturally shifting between outward and inward attention. In this context, any external stimuli, visual, auditory or other, becomes dominant. The activity instructions were to pay attention to the stepping, so naturally participants directed their attention towards the carpet and the visual signifiers that represent the step-by-step stepping process. Since participants didn't want to direct their attention to other stimuli, they "over-focused" on the visual signifiers. Another possible contributing factor is the body's constant movement, that together with the "over-focus" on the static visual signifiers led to dizziness and imbalance (due to the body movement vs. the external attention on something static).

The heat sensation may have led to an opposite effect; it seemed to help most participants shift their attention inward more easily, and in addition sparked positive feelings in the body, which led to positive subjective interpretations such as calmness, comfort, and security. It is interesting to note that prior research [37] showed how heat can invoke a sensation of pain by inducing discomfort through changes in temperature, this highlights the potential thermal stimuli has to produce a range of feelings, either positive or negative. Regarding the negative effect of the visual signifiers (leading to dizziness), we recommend that future work should look more deeply into their effect and their interaction with heat sensations.

6.3 Non-attachment to Desire (an Advanced Meditation Topic)

Another topic that surfaced during the qualitative analysis among experienced meditators was the advanced meditation concept concerning self-investigation of non-attachment to positive "sensual desire" [61], meaning the instantaneous wish to "have more of a good thing", like beloved food, music, touch, or any positively perceived sensation. In the case of our research, the pleasant sensation was the subtle desire for the pleasant feeling occurring every time the gentle heat sensation touches the feet (relevant only for participants who experienced the targeted heat sensation). The walking activity on the carpet provided an opportunity for experienced meditators to practice non-attachment towards this desire, in a simple, consistent, and repetitive way. The meditator had the ability to make a deliberate choice, to step or not to step (on the heat), to "surrender" to the desire to cling to the pleasantness of the heat sensation, or to physically move the feet away from the pleasant sensation, not surrendering to the sensual desire to cling to the pleasant moment, or, in the case of very experienced meditators, to step on the heat with full awareness to the desire itself. During meditation, this practice is usually done as a thought process without any physical manifestation, directing attention towards or away from a pleasant thought. The opportunity to practice it in a physical way, with a simple movement of the feet, again and again with every step, appealed to advanced meditators as an opportunity to practice. Supporting quotes include: *"here, whenever there was a sensation of warmth, I felt the need to cling to it even more because it was pleasant. And if I could, I would have stood only on it, but I understood by myself that I shouldn't stay on it. I must not cling to it, I can just stand, wait until it leaves, and move on"* (P5 WH).

6.4 Implications of the Design

Our findings suggest potential implications within and beyond meditation. Regarding motivation to perform walking meditation as a regular practice, participants reflected on how the mat created a dedicated space for mindfulness, which helped them foster a sense of readiness and motivation to meditate. One participant compared it to sports gear: *"It's like sports clothes – when you put them on, you get into the mood... It puts you in a mindset of readiness"* (P3 WH). Another participant emphasized its value in creating a ritual for regular practice at home, noting that it could increase the likelihood of engaging in walking meditation: *"If I had such a mat at home, I think there would be a greater chance that I would do walking meditation because it creates a certain space"* (P17 WH).

Beyond formal meditation practice, the mat has potential applications in workplaces and homes promoting relaxation and calm. Several participants envisioned its use at work, for example: *"In workplaces, perhaps a dedicated room for this, like adding some calm to their busy daily routine"* (P23 WH). Participants also shared the mat's potential in a mental health context. They mentioned anxiety, stress reduction, and emotional regulation. Participants noted the sense of grounding it provided during use, suggesting it could be explored in therapeutic settings. For example, one participant shared: *"I have anxiety, and I feel like this could really help. Meditation has helped me a lot, and I like this because I'm a very active person. For someone who finds it hard to sit still, this is a good option"* (P7 WH).

Further research is needed to examine the potential benefits in such a sensitive context.

Beyond meditation or relaxation, the mat may potentially be relevant in physiotherapy context, promoting physical stability and balance. Prior research suggests that divided attention during walking can lead to balance issues [27]. Another research report that challenges in allocating attention may be one factor (among many factors) that contribute to balance constraints during walking [52]. As our findings show targeted heat helps balance outward and inward attention while walking, it may have some potential benefits for people with physical stability and balance challenges. We have not tested the walking mat in such a context, and recommend that future research will look into it with appropriate depth, before any conclusions can be drawn.

7 Limitations

Our study has several limitations. First, walking meditation is practiced in many different ways, and varying techniques can lead to different outcomes. In this study, to maintain consistent guidance, we provided walking meditation instructions based on the well-known Mahasi tradition. However, future research should explore differences between various meditation techniques, including instructions from experienced contemporary teachers, to explore the impact of different instructions. Second, such an introspective process varies significantly from person to person. While our findings are based on a qualitative analysis of 24 participants, our insights are limited in their generalization. Future studies should involve additional qualitative methods that may provide additional perspectives [7, 8], as well as mixed methods research to increase generalization. Third, the involvement of a meditation teacher was outside the scope of this research. Future work could explore how meditation teachers utilize the walking meditation mat in retreats or structured meditation teachings, advocating for an authentic incorporation of teachings and practice [2]. Fourth, our findings are based on a one-time use and might be influenced by the "novelty effect" [16] which may diminish with repeated use. Future research should explore the influence of targeted heat over time, to better understand its long-term effects on regular meditation practice. Fifth, interviewees may have been affected by the "good subject effect" [40, 43], to minimize this risk we followed a detailed protocol. Finally, our research follows a constructivist approach and we recognize that our perspectives as researchers may have influenced both the design and interpretation of the study [47].

8 Conclusion

We presented a qualitative research of a walking meditation mat with integrated heat elements and visual signifiers. Through this work, we have gained a deeper understanding of how targeted heat may support walking meditation by helping participants balance their inward and outward attention, focus on the moment their foot touches the ground, and enhance the overall meditation experience. In contrast, visual signifiers appeared to be less helpful in balancing inward and outward attention. This study points towards the potential of targeted heat as a promising modality for walking meditation. More broadly, it opens up space for further exploration of targeted heat as an interaction modality for HCI designers, in the

context of introspective practices, and potentially also with specific populations that struggle with daily activities that involve physical stability and balance of outward-inward attention, like standing and walking.

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