DOI: 10.61782/fa.2025.0408

FORUM ACUSTICUM EURONOISE 2025

FOOTSTEP SOUNDS RECORDING AND EVALUATION IN OUTDOOR ENVIRONMENTS

Amar D'Adamo[1*] **Karunya Srinivasan**[1] **Daniel de la Prida**[2]
Luis A. Azpicueta-Ruiz[1] **Ana Tajadura-Jiménez**[1,3]
[1] Universidad Carlos III de Madrid, Madrid, Spain
[2] Universidad Politécnica de Madrid, Madrid, Spain
[3] University College London, London, United Kingdom

ABSTRACT

The footstep illusion, based on auditory manipulations of walking sounds, has proven to significantly affect body perception. To study these effects in outdoor settings, we developed a database of recorded footstep sounds. Creating this database involved an iterative design process. Footstep sounds were recorded in an anechoic environment with three participants of different body weights, two binaural microphones sets, variations in walking speed and in walking mode (in place and normally), surface materials and footwear. Participant feedback from structured piloting sessions informed the selection of the most effective recordings. The final sounds were processed into 5-minute tracks with constant walking speed, incorporating background noise recorded in situ. The database was evaluated through an experimental study involving twenty-eight participants and four walking sessions, differing in sound condition, as different frequency filters were applied to study their influence on the walker's body perception. Participants were required to synchronize their movements with the footstep sounds and we assessed the influence of auditory cues on their body perception. The significance of the presented work, evaluated in complex outdoor settings, lies in the methodological framework and decisions that allowed us to create a rich database, which serves as a resource for other applications, such as sound design and virtual reality.

***Corresponding author**: *amar.dadamo@uc3m.es.*

Keywords: *footstep sounds, multisensory body perception, sound interfaces, embodied interaction, wearables*

1. INTRODUCTION

Body perception is a multifaceted phenomenon that encompasses both perceptual elements (such as perceived body size) and attitudinal components (such as emotional responses and thoughts towards body size) [1]. These components impact motor functioning [2], and social interactions [3]. Importantly, body perception is not fixed, but updates continuously in response to different cues. Research has demonstrated that multisensory stimulation, especially sensory feedback related to one's body, can drastically alter perception, thereby influencing emotions, cognition, and behavior [4,5]. Auditory cues, such as musical notes [6], or modifying natural action sounds like tapping [7], have been shown to influence body perception and related attitudes.

Research in [8, 9] built upon the findings of [10], which demonstrated that listeners can make judgments about an unknown walker's body – such as their sex – based on the spectral properties of their walking sounds. Specifically, [10] showed that lowering the spectral mode of pre-recorded footsteps to at least 125 Hz increased the perceived maleness of the walker, while shifting it to higher frequencies (around 1000 Hz) enhanced the perception of femaleness. In [8], a similar setup to that used in [10] was employed. It featured an analog graphic equalizer with a 24-dB dynamic range and nine frequency bands, along with microphones attached to the walker's shoes, a pre-amplifier, and headphones. This system was further advanced in the so-called SoniWeight Shoes device [9]: as described in [11], a digital version was built on

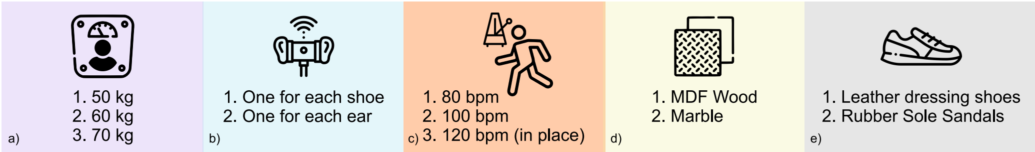

Figure 1. Recording session materials: a) People's body weight; b) Microphones locations; c) Walking speeds; d) Surface materials; e) Footwear types.

the Bela.io platform to mimic the analogue equalizer using 11 cascaded IIR filters. Latency was measured at 1.6 ms, enabling real-time applications. The results indicated that when participants experienced the "High Frequency" (hereafter, HF) condition, they perceived their own bodies as slimmer and lighter. This perception also influenced their walking patterns, leading to more dynamic swings and shorter heel strikes compared to the "Low Frequency" (hereafter, LF) condition.

While earlier studies on this so-called "Footsteps Illusion" – in which participants where asked to walk while listening to real-time alterations of their footstep sounds, while the effects on their body perception, gait and emotional state were measured – in the general population [8] and in populations formed by groups with varying levels of eating disorders and physical activity [9], have primarily focused on controlled environments, understanding how auditory cues, such as footstep sounds, affect body perception in more complex, outdoor settings is crucial. Such environments introduce additional variability, including diverse surfaces, weather conditions, social interaction, which can further modulate the illusion's impact on perception. We aimed to measure the effects on body perception (if any) induced by the use of a minimal experimental setup, consisting of a walking task synchronizing with pre-recorded footstep sounds, filtered using the same frequency manipulations used in [9].

With regards to the synchronization task, we took as reference a previous study [12] investigating how self-other integration and segregation influence coordination and individual awareness during group interactions. In that study participants were instructed to synchronize their steps with a metronome while listening to the footsteps of eight virtual partners. Measures included temporal coordination (step timing regularity and synchrony with the metronome) and gait patterns. This study is particularly relevant for the current work as it demonstrates that individuals can reliably synchronize their movements with auditory cues, and that listening to footstep sounds — even when attributed to others — can influence perceived bodily states.

Regarding the interaction of materials and body perception, previous research [13] examined how participants adjusted synthetic footstep sounds to match their own, using a real-time shoe-based system, to validate sound design choices for different shoe types and ground materials. Their findings show how the relationships between shoe types and ground materials shape footstep sound characteristics, which can be further explored in more naturalistic settings where participants actively walk and synchronize their footsteps.

The work presented in this paper aims to develop and evaluate a footstep sound database for use in both laboratory and real-world contexts, with an emphasis on the auditory manipulation of footstep sounds in outdoor settings. The database was created through a structured process, recording footstep sounds in a variety of footwear, walking speeds, surface materials and participant weights to capture a broad range of auditory cues. These sounds were then selected and processed to obtain soundtracks used in an outdoor experimental setting, specifically using the three sound conditions (i.e., HF, LF and Control) employed in [9], aiming to analyze their influence on body perception. By exploring these effects in naturalistic settings, we aim to extend the ecological validity of the "Footsteps Illusion" and create a versatile resource applicable to various fields, such as sound design, virtual reality, and interactive technologies that rely on auditory feedback to modify bodily experiences.

In the following sections, we describe the technical setup used to capture footstep sounds, the experimental design for evaluating these sounds, and the results of the sound selection procedure and of the study that support the sound dataset validation process. This work serves as a step towards integrating auditory cues into body perception interventions, particularly in settings where portability is key.

2. METHODS

2.1 Recording Hardware Configuration

Recordings were conducted in an anechoic environment at Carlos III University of Madrid. Figure 2 shows the recording location. To record the footstep sounds we used two sets of wired binaural microphones (SOUNDMAN OKM-II), with a frequency response of 20 Hz–20 kHz, a sensitivity of approximately 7 mV/Pa, and an impedance of 2.2 kΩ. Designed for in-ear placement, they support a maximum sound pressure level (SPL) of 120 dB and operate on plug-in power (1.5 V-10 V) via a 3.5 mm TRS stereo mini-jack. We also used a handheld portable recorder (ZOOM h4n), in four-channel configuration. One set of microphones was positioned at the tip of the shoes and the other one in the walker's ears. The files were recorded with a 16-bit resolution and 44100 Hz sampling rate. A mobile application with a flashing-screen metronome functionality was used to provide a synchronized visual tempo cue (80, 100, 120 bpm) during the recordings.

2.2 Materials and Recording Setup

Two different ground materials were used: wood (MDF) planks, positioned on the floor of the anechoic environment to form a runway measuring 480 cm in length and 80 cm in width, and marble tiles (40 x 40 x 4 cm), which were placed on top of the wooden runway (see Figure 2). Further, two types of shoes were used: leather dress shoes (EU sizes 42 and 46) and sandals with hard rubber soles (EU size 42). To simulate increased body weight and create varied weight recording conditions, participants wore a fitness weight set that added 5 kg of extra mass.

The choice to include sandals with hard-rubber soles as footwear and wood (MDF) as the walking surface was made to replicate the materials setup used in [9]. However, in line with the main aim of the experimental study – namely, to explore and test the "Footsteps Illusion" in a more realistic, everyday scenario – we selected an outdoor area on the university campus for conducting the experiment. This area was moderately large (approximately 70 x 90 m), mostly flat, typically not too crowded, and featured a variety of surface materials, including stone and concrete tiles. For this reason, we decided to incorporate marble tiles into the recording session to better reflect this diversity. As for the footwear, we also included leather dress shoes in the recordings, to include other types of shoes commonly worn in daily life.

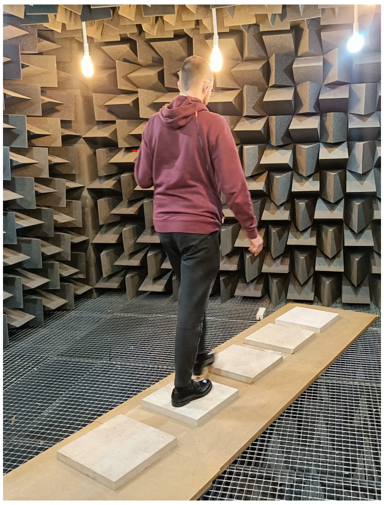

Figure 2. Anechoic environment recording setup, (shoes on marble).

Three people, weighing approximately 50, 60 and 70 kg, participated in the sound recordings. Each of them performed eight recording sessions: four while wearing the 5 kg weights (sandals on marble, sandals on wood, shoes on marble, and shoes on wood), and the same four without the additional weight. This approach allowed us to cover the following weight ranges: 50-55 kg, 55-60 kg, 60-65 kg, 65-70 kg, 70-75 kg and 75-80 kg.

To prevent introducing any additional sound sources into the recordings, participants synchronized their footsteps using a visual metronome on a smartphone, which emitted a screen flash at each beat. The recording consisted of five 1-minute phases: walking in place at 80 bpm, walking normally at 80 bpm, walking in place at 100 bpm, walking normally at 100 bpm, and walking in place at 120 bpm. We only recorded walking in place at 120 bpm due to the limited path length, as walking at this tempo along the short distance would have resulted in unnaturally short steps.

2.3 Sound Selection and Processing

After the recording sessions, we went through all the tracks and selected the candidate sounds for the study. Specifically, we focused on the walking pace and decided to exclude 80 bpm, 120 bpm and walking-in-place recordings. This decision was made considering that, in the study, we wanted participants to walk at a "natural" speed, which we defined as a pace that people typically

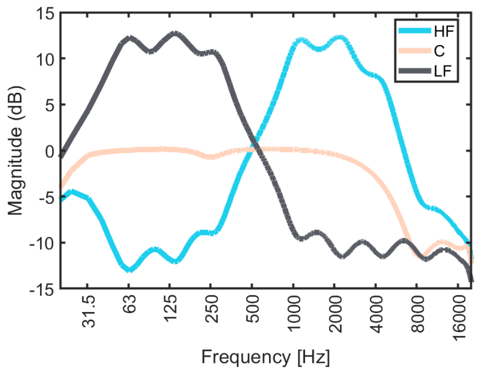

Figure 3. Frequency response of the High Frequency (HF), Low Frequency (LF) and Control (C) filters.

use in everyday walking scenarios. We felt that 80 bpm and 120 bpm might not represent this natural pace, and walking-in-place recordings were excluded to avoid any artificial constraints. Although studies involving similar pre-recorded sounds like [12] have used a 120 bpm walking pace, they only involved the walking-in-place activity, which is different from the walking scenario we aimed to replicate. Once we had preliminarily selected the recordings, we decided to obtain, for each of the six weight-groups, a 5-minute footsteps audio track, that we could later filter to produce the three experimental sound conditions. The strategy we adopted was to extract several "footsteps pairs" and then combine them in random order to obtain 5-minute tracks. For each of the selected recordings, we analyzed the footsteps peaks to extract the time between two adjacent footsteps (T) (e.g., left-right). We then manually cut the footsteps pairs, leaving $\frac{T}{2}$ before the first peak and after the second peak. To automate the process of generating the audio tracks, we developed a MATLAB script that randomly selected and concatenated the footstep pairs. To ensure smooth transitions between the segments, we applied a 10 ms fade-out/fade-in effect at each junction. This approach allowed us to create seamless and randomized 5-minute audio tracks. Furthermore, since the study setup employed passive noise-canceling headphones, we decided to incorporate background noise into the footsteps tracks to make the listening experience more realistic and less frustrating. To do so, we recorded the background noise at the study location and added it to the tracks. Since the recordings were composted of four channels (two for the microphones placed in the ears and two for those placed on the shoes), the footstep pairs extraction involved all four channels, allowing us to generate audio tracks for both microphones locations. We ultimately decided to perform the piloting using only the foot-located microphones for the following reasons. Firstly, in the footsteps recordings with the microphones in the ears, the footstep sound level was lower than with the foot-located microphones, and this, after amplifying the signal, generated a perceivable click at the footstep pairs joints. Secondly, considering the the influence of height differences between the individuals who produced the recorded sounds and the participants in the study. Finally, to remain consistent with previous studies [8, 9] that use the feet as microphone locations.

The same filters developed for the SoniWeight Shoes device [9], as described in [11], were used to equalize the pre-recorded footstep sounds, obtaining: an HF version and a LF version, simulating the acoustic characteristics of a lighter and a heavier body, respectively. In HF, higher frequency bands (1-4 kHz) were amplified by 12 dB, while lower frequencies (83-250 Hz) were attenuated by 12 dB. In contrast, LF inverted this pattern. Figure 3 shows the frequency response of the two filters, along with the Control condition (referred to as C). Both HF and LF filtered versions of the footstep tracks, along with the unmodified footstep soundtrack (C), were mixed with background noise to create four distinct sound sets, each with varying signal-to-noise ratios (SNRs) of 0, 5, 10, and 15 dB. During processing, we also accounted for differences in perceived loudness between the soundtracks by calculating the RMS of each track after applying an A-weighting filter. The resulting gain factors were then used to compensate for these differences and ensure consistent perceived loudness across all soundtracks.

2.4 Piloting Session

We performed a structured piloting session with four participants (here referred to as P1-P4), with the objective of selecting the footsteps soundtracks corresponding to different materials, footwear and levels of SNR. The session was conducted in the experimental study location and focused on assessing the plausibility of the generated footstep sounds. Specifically, we evaluated whether the soundtrack sounded like they were the own person's footsteps (in fact, we played the sound corresponding to the own weight of the participant piloting), and also assessed whether the sound was realistic within the given setting, considering both its acoustic properties and how well it blended with the environmental cues.

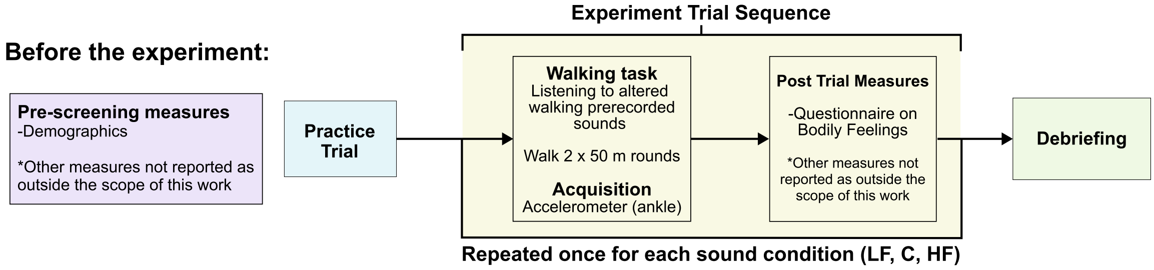

Figure 4. Experiment trial procedure.

During the session, while listening to the *sandals on wood* soundtrack, P1 said: "It has more substance or weight, it's easy to synchronize with, I like it.", P2, "Sounds like stone, I like it", P3, "It's the one I like the most, it sounds like sandals on wood". The *shoes on marble* soundtrack received mixed reactions from participants. P1 found the footsteps somewhat artificial but still identified them as resembling shoes on marble. P2 commented, "It's deep and normal, but it doesn't particularly stand out." P3 perceived the sound as resembling high heels rather than regular shoes and stated, "I wouldn't use it." P4 remarked, "The footsteps don't seem credible." The *sandals on marble* sound also received varied reactions from participants. P1 commented, "The footsteps don't seem believable." P2 had a different perspective, saying, "It's the one I liked the most." P4 found the sound somewhat unconvincing, remarking, "It seems sharper, and it throws me off." The *shoes on wood* sound also elicited mixed responses from participants. P1 was generally unimpressed, stating, "I don't like it overall." P2, however, found it more appealing, saying, "I like this one more than the others." P3 was more critical, commenting, "These footsteps seem unnatural; I wouldn't use them." Overall, the results suggest that, despite the highly subjective nature of participants' perceptions of the footstep soundtracks - with variations significantly influencing participants' impressions of realism and preference - the soundtrack that was most appreciated for its realism was *sandals on wood*, the selected SNR was the 0 dB, which recreated a natural level of background noise and sounded the most realistic in that specific outdoor setting. Most of the participants found it easy to synchronize with and described it as having a natural and immersive quality. For these reasons, the *sandals on wood* soundtracks were selected for carrying out the study.

2.5 Experimental Study

The study included four 2-minute trials, during which participants walked back and forth once along a linear passage approximately 50 meters in length. First, a practice C condition trial, followed by the HF, C, LF sound conditions in randomized order. Figure 4 contains a schematic view of the experiment procedure.

2.5.1 Participants

28 participants (mean age ± SD: 26.21 ± 9.99 years, range: 19-71; Sex: 13 males and 15 females; Gender: 13 masculine and 15 feminine; mean weight ± SD: 66.86 ± 11.44 kg; mean height ± SD: 164.45 ± 32.46 cm), naïve to the study aim, provided the following information during recruitment: demographics, including age, sex (man, woman, non-binary, decline to state), gender (masculine, feminine, non-binary person, decline to state); and anthropometric measurements (height and weight). The latter was used to select the appropriate soundtrack used in the study. The study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments and was approved by the Committee of Ethics in Research of Carlos III University of Madrid. All participants provided informed consent before participating and received a €20 bank transfer as compensation for their time.

2.5.2 Measures

While several measures were used in the study, here we focus on reporting those that allow us to evaluate the suitability of the sounds designed for the study.

Questionnaire on Body Feelings: We used a Likert-type questionnaire, adapted from [8, 9], to assess body feelings. It covered felt walking speed, body weight, strength, posture, perceived femininity/masculinity, vividness of the experience and felt surprise. Importantly, additional items assessed the agreement levels (from strongly disagree to strongly agree) with statements related to the felt agency over the sounds heard [14] and the ability to localize one's feet, which we refer to as "proprioception" [8]. Here we focus on these two items as they allow us to validate the suitability of the soundtracks for the experimental study, as we consider these two sensations (i.e., agency and proprioception) to be prerequisites for the "Footsteps Illusion" to emerge.

Gait Biomechanics: These were used both as a measure of temporal coordination and synchronization [12], with the footsteps soundtracks and as an implicit measure of changes in body perception, following previous studies [8, 9] suggesting that the sound-driven illusion of altered body weight results in people adapting their gait to the prototypical motor pattern of lighter/heavier bodies. Foot acceleration data was collected using a Bitalino device sensor and analyzed in MATLAB. Peaks and valleys in acceleration were used to identify key gait events and assess step timing. While full gait pattern analysis was performed, this paper emphasizes temporal-related measures across sound conditions for statistical analysis. To describe the performance on the synchronization with instructed task, specifically with the soundtrack of pre-recorded foosteps, we measured two temporal coordination measures. The first is the standard deviation (SD) of asynchrony, which assesses interaction performance or coupling between two time series [15]. This metric is calculated by computing the SD of the asynchronies between the participant and the pre-recorded soundtrack for each condition and participant. A lower SD asynchrony indicates stronger coupling with the pre-recorded sounds. We also evaluated the SD of asynchrony with a metronome resembling the same one used during the footsteps sounds recording. The second measure is the SD of inter-step intervals (SD ISI), which reflects step timing regularity (hereafter referred to as coordination). Based on previous research, a lower SD ISI suggests that the participant is performing better in keeping the walking pace regular [16]. For each participant, the time course of each trial (per condition) was analyzed by computing the inter-step intervals and then determining their SD.

3. RESULTS

We present here the results that allowed us to validate that participants could effectively coordinate and synchronize with the heard footstep sounds, as well as feel agency over the sounds heard. We consider these to be prerequisites for the "Footsteps Illusion" to emerge.

3.1 Synchronization and Coordination

To assess synchronization, we evaluated how well participants aligned their footsteps with both the pre-recorded footsteps in the soundtrack and the original metronome used during the recording of those footsteps. This allowed us to determine whether participants were able to synchronize not just with the auditory cues, but also to perform in a way that closely matched the precise timing of the original metronome. With regards to coordination, we calculated an overall SD asynchrony mean(SE) value of 95.9(7.4) ms with the pre-recorded soundtracks and an overall SD asynchrony mean(SE) value of 89.6(9.0) ms synchronizing with the virtual metronome. Therefore, the participants were able to synchronize reasonably well with the auditory cues (having a SD asynchrony lower than 100 ms [17]), especially considering the outdoor varying conditions of the study. The overall SD ISI mean(SE) value was calculated at 87.1(10.2) ms. Participants maintained a relatively consistent walking rhythm, given the experimental setup and the many factors influencing walking activity suggesting that the footstep sounds successfully supported the coordination task.

Additionally, the analyses showed no significant differences across the frequency conditions for the SD asynchrony, $F=0.53$, $p=0.59$, and for SD ISI, $F=1.02$, $p=0.36$. These results inform us that participants' synchronization and coordination didn't differ significantly across the three sound conditions.

3.2 Questionnaire on Body Feelings

Results from the analysis of the questionnaire scores show that, overall, participants felt proprioception (median(range): 5(6) for LF, 5(6) for C and 5(6) for HF; i.e., feeling able to determine exactly where their feet were), with no significant differences across conditions, $F=0.03$, $p=0.96$. Participants also reported agency (median(range): 5(5) for LF, 5(6) for C and 6(5) for HF; i.e., the sensation that the sound the participants were hearing were produced by their own footsteps/body), with no significant differences across conditions, $F=2.98$, $p=0.06$, as shown in Figure 5. Preliminary analysis of the other questionnaire items suggests that these sounds do indeed affect body perception, particularly the perceived body weight, the main target of the "Footsteps Illusion", but reporting these findings is beyond the scope of this paper.

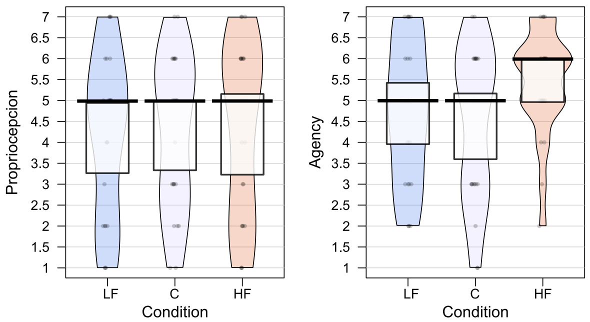

Figure 5. Agency and Proprioception items results. The scale on the y-axis indicates the levels of agreement (from strongly disagree (1) to strongly agree (7)) with statements related to the felt sensation.

4. DISCUSSION

The piloting session presented in this work was crucial for evaluating how the real-world features of the sound, e.g., materials, weights, speeds, footwear and background noise, contribute to creating a realistic auditory experience. This preliminary testing allowed us to make informed choices about the stimuli and ensure a more ecologically valid auditory experience. Our findings offer initial support for the use of our footstep sound database for use in experimental research on body perception. Specifically, we first examined temporal synchronization and coordination, aligning with previous work [12, 17] showing how people can reliably synchronize their movements with auditory cues, even when attributed to others. Secondly, we focused on participants' sense of agency and proprioception, as assessed through the Questionnaire on Body Feelings, since studies have shown that discrepancies between modalities and delays between actions and sensory feedback disrupt agency and diminish the sensory-induced bodily illusions [5, 14] and that sound may interact with proprioception [5].

Our results show that participants consistently reported a moderate-to-high sense of proprioception and agency, indicating that the auditory cues used in the experiment effectively corresponded to their own body movements, and making them a valid resource for further investigations into auditory influences on body perception. The absence of significant differences in synchronization performance across frequency conditions suggests that the auditory manipulation employed in this study did not disrupt participants' ability to coordinate their footsteps.

4.1 Implications and Future Work

Our findings suggest that auditory cues, even within a minimal experimental setup, and relatively uncomplicated trial design, can significantly influence body perception. Importantly, the validation of our footstep sound database is supported by both behavioral data and a rigorous methodology. Sounds were carefully designed, recorded, and selected to closely match real-world walking scenarios, minimizing bias and supporting a robust experimental context. This effort strengthens the reliability of the current results and positions the database as a valuable tool for future applications in fields such as virtual reality, rehabilitation, and psychological interventions, where auditory feedback can be employed to influence perception and behavior. Additionally, evaluating how the footstep sounds perform in dynamic, real-world environments (e.g., personalizing walking speed, surfaces and footwear) could further enhance our understanding of the role of auditory cues in shaping body perception in complex, daily life settings. Prolonged exposure to auditory gait feedback could also be analyzed to understand the impact on body perception and behavior change over time.

5. CONCLUSION

The aim of our work was to create a material capable of supporting experimental designs that can yield unbiased and reproducible findings. Our results confirm the validity of the footstep sound database and demonstrate its potential as a valuable tool for further research into the multisensory influences on body perception. The sound database offers a robust foundation for studying the interaction of auditory cues with body perception in both controlled and real-world settings.

6. ACKNOWLEDGMENTS

We thank Joaku De Sotavento for the technical support during the recordings, piloting and study design. This research was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 101002711; project BODYinTRANSIT)

7. REFERENCES

[1] C. Dijkerman and B. Lenggenhager, "The body and cognition: The relation between body representations

and higher level cognitive and social processes," *Cortex*, vol. 104, pp. 133–139, July 2018.

[2] L. Cardinali, F. Frassinetti, C. Brozzoli, C. Urquizar, A. C. Roy, and A. Farnè, "Tool-use induces morphological updating of the body schema (DOI:10.1016/j.cub.2009.05.009)," *Current Biology*, vol. 19, no. 13, p. 1157, 2009. ISBN: 0960-9822.

[3] S. Clausen, A. Tajadura-Jiménez, C. P. Janssen, and N. Bianchi-Berthouze, "Action sounds informing own body perception influence gender identity and social cognition," *Frontiers in Human Neuroscience*, 2021.

[4] M. Botvinick and J. Cohen, "Rubber hands 'feel' touch that eyes see [8]," *Nature*, vol. 391, no. 6669, p. 756, 1998. ISBN: doi:10.1038/35784.

[5] A. Tajadura-Jiménez, A. Väljamäe, I. Toshima, T. Kimura, M. Tsakiris, and N. Kitagawa, "Action sounds recalibrate perceived tactile distance," *Current Biology*, vol. 22, no. 13, pp. R516–R517, 2012. ISBN: 1879-0445 (Electronic)\r0960-9822 (Linking) Publisher: Elsevier.

[6] A. Singh, A. Klapper, J. Jia, A. Fidalgo, A. Tajadura-Jiménez, N. Kanakam, N. Bianchi-Berthouze, and A. Williams, "Motivating People with Chronic Pain to Do Physical Activity: Opportunities for Technology Design," in *Proceedings of the 32Nd Annual ACM Conference on Human Factors in Computing Systems*, CHI '14, (New York, NY, USA), pp. 2803–2812, ACM, 2014.

[7] A. Tajadura-Jiménez, M. Tsakiris, T. Marquardt, and N. Bianchi-Berthouze, "Action sounds update the mental representation of arm dimension: contributions of kinaesthesia and agency," *Frontiers in Psychology*, vol. 6, 2015.

[8] A. Tajadura-Jiménez, M. Basia, O. Deroy, M. Fairhurst, N. Marquardt, and N. Bianchi-Berthouze, "As Light As Your Footsteps: Altering Walking Sounds to Change Perceived Body Weight, Emotional State and Gait," in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, CHI '15, (New York, NY, USA), pp. 2943–2952, ACM, 2015.

[9] A. D'Adamo, M. Roel, L. Turmo-Vidal, D. M. M., D. De La Prida, J. R. Diaz-Durán, L. A. Azpicueta-Ruiz, A. Väljamäe, and A. Tajadura-Jiménez, "Soniweight shoes: Investigating effects and personalization of a wearable sound device for altering body perception and behavior," in *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*, CHI '24, (New York, NY, USA), Association for Computing Machinery, 2024.

[10] X. Li, R. J. Logan, and R. E. Pastore, "Perception of acoustic source characteristics: Walking sounds," *The Journal of the Acoustical Society of America*, vol. 90, pp. 3036–3049, 12 1991.

[11] D. de la Prida, J. R. D. Durán, L. A. A. Ruiz, and A. T. Jiménez, "As light as your footsteps: design and evaluation of a portable device for changing body perception through a sound illusion," in *Tecniacústica 2022*, Sociedad Española de Acústica (SEA), 2022.

[12] M. T. Fairhurst, A. Tajadura-Jiménez, P. E. Keller, and O. Deroy, "You, me, and us: Maintaining self-other distinction enhances coordination, agency, and affect," *iScience*, vol. 26, no. 12, p. 108253, 2023.

[13] L. Turchet, D. Moffat, A. Tajadura-Jiménez, J. D. Reiss, and T. Stockman, "What do your footsteps sound like? an investigation on interactive footstep sounds adjustment," *Applied Acoustics*, vol. 111, pp. 77–85, 2016.

[14] F. Menzer, A. Brooks, P. Halje, C. Faller, M. Vetterli, and O. Blanke, "Feeling in control of your footsteps: Conscious gait monitoring and the auditory consequences of footsteps," *Cognitive Neuroscience*, vol. 1, pp. 184–192, Aug. 2010. Publisher: Routledge.

[15] M. T. Fairhurst, P. Janata, and P. E. Keller, "Being and feeling in sync with an adaptive virtual partner: Brain mechanisms underlying dynamic cooperativity," *Cerebral Cortex*, vol. 23, pp. 2592–2600, 08 2012.

[16] M. T. Fairhurst, P. Janata, and P. E. Keller, "Leading the follower: An fmri investigation of dynamic cooperativity and leader–follower strategies in synchronization with an adaptive virtual partner," *NeuroImage*, vol. 84, p. 688–697, Jan. 2014.

[17] S. Jordão, N. Cortes, J. Gomes, R. Brandão, P. Santos, P. Pezarat-Correia, R. Oliveira, and J. Vaz, "Synchronization performance affects gait variability measures during cued walking," *Gait & Posture*, vol. 96, pp. 351–356, 2022.