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Proceedings Paper:

Kapsali, M. (Accepted: 2026) Echome (and) in mature company: movement sonification in dementia care homes. In: UNSPECIFIED The 31st International Conference on Auditory Display (ICAD 2026), 28-31 Jul 2026, Bielefeld, Barcelona, Troy/NY. (In Press)

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ECHOME (AND) IN MATURE COMPANY: MOVEMENT SONIFICATION IN DEMENTIA CARE HOMES

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ABSTRACT

This paper explores a real-world application of echome, a wearable technology that sonifies movement, in a care home environment. The use of movement sonification is premised on the user's ability to establish a meaningful relationship between the source data and the sonic output. What has been explored less is how the link between sound and movement may be perceived by people who live with cognitive and mobility impairments, such as the ones caused by dementia. If a user cannot interpret the sound as a form of feedback related to their movement, can movement sonification still have an impact, along the lines suggested by the relevant literature? The paper addresses this question in relation to a project that involved the use of echome in dementia care homes as part of creative sessions delivered by dance artists. It applies the theory of Mimetic Motor Imagery (MMI) to illuminate the way the dance artists' input facilitated the residents' access to the technology and enabled them to establish or enrich a relationship between their movement and the resulting sound. The paper contributes an example of the use of movement sonification within a practice-based, participatory context, emphasizing a facilitator-mediated, embodied and relational interaction.

1. INTRODUCTION

Over 30 years of research has evidenced that movement sonification can facilitate sensorimotor learning and enhance physical performance. Following findings in laboratory experiments, arguments have been made for the development of systems that will allow users to work with movement sonification at home and presumably extend or consolidate the benefits [1]. However, apart from a handful of systems that have been medically certified and commercialized, such as the Music Glove, movement sonification technologies have not yet reached a wide market. The development of real-world solutions is hindered by the lack of technical infrastructure, the high costs associated with their procurement [1] as well as the need for individualization. As Kantan elaborates, within a rehabilitative context, users have different needs, different movement ranges and different aesthetic tastes [2]. A system would have to be flexible enough to accommodate differences between users as well as within the progress trajectory of the same person. Apart from infrastructure, cost and accessibility, an additional reason that stymies the wider dissemination of movement sonification technologies may also be the absence of cultures of use, within domestic, creative or social care contexts. The term 'cultures of use' refers to the set of activities that can be done with a system as well as the ways in which a system becomes integrated into daily routines and therapeutic

or creative practices. Arguably, cultures of use can embed these technologies within the lifeworld of the user in a way that is meaningful and context specific as well as motivate investment in the development of these technologies for a wider audience.

Created between 2019-2020 by an interdisciplinary team of researchers led by the author, echome is a wearable technology that enables the creation of sound through movement and can be used in different settings with basic technical proficiency [3]. It is also a participatory pedagogy that can facilitate user access and acceptance across diverse demographics for creative and wellbeing purposes. Comprising Arduino sensors and an interface built on Max/MSP by sonification technologist Kingsley Ash, the echome interface includes a sound library as well as the functionality to input new recordings; a sensitivity slider; and the option to de-select one or more of the data streams (tilt, roll, spin). The application can run on a laptop through a visual interface that allows the user to access the functionalities mentioned above (Figure 1) or a wooden box fitted with speakers and a Raspberry Pi, also created by Ash (Figure 2). The sensors are Arduino Inertial Measurement Units, custom fitted with a re-chargeable battery and a set of buttons, which allow the user to go through the sounds of the echome library. This includes six MIDI sounds, 20 buffers, i.e. electro-acoustic compositions created by Nikos Stavropoulos, and a list of field recordings of environmental sounds. The system can accommodate multiple sensors at a time, making it appropriate for both individual and group settings.

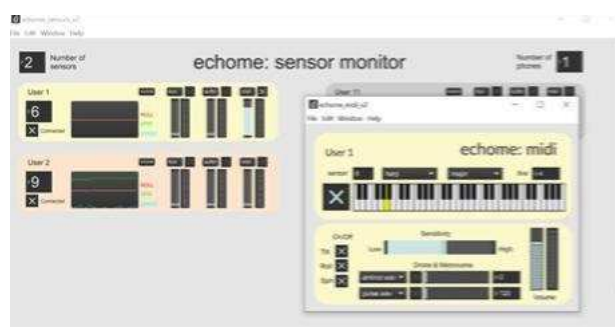


Figure 1: screen grab of echome visual interface





Figure 2: the echome box and sensor

This paper discusses the project ‘echome (and) in mature company’ (ethical approval AHC FREC - 2025 2396-4613), led by the author in collaboration with Yorkshire Dance, a charity dedicated to professional development and inclusion. Between April and July 2025, the author worked with six dance artists associated with the In Mature Company, a programme managed by Yorkshire Dance for providing dance and music sessions in care homes. The aim was to train the dance artists to use echome with care home residents who live with dementia and equip Yorkshire Dance with the echome equipment as well as the know-how for using the technology for creative and wellbeing purposes. The ‘echome (and) in mature company’ project did not set out to measure the impact of movement sonification on the residents in terms of patient health outcomes. Rather the focus was on developing working methods that would enable the dance artists to use the technology in care homes and address their core mission: encourage physical activity, promote social interaction and enhance wellbeing.

The project was informed by an acknowledgment that the inclusion of art activities in social care settings can support the flourishing of the whole person [4], [5], [6]. As discussed in [4] and [5], dance interventions for dementia should not be limited to managing symptoms but consider the ways in which an activity acquires meaning for the participants and allows them to express aspects of the self which a medicalized framework can often neglect. As such, ‘echome (and) in mature company’ aimed to use movement sonification in a dementia context as part of an overall commitment to support personal growth. On the one hand, the specificities of dementia raised a set of questions regarding the cognitive capacity required for the establishment of an interpretative relationship between sound and movement. Is the use of a movement sonification technology premised on the user’s ability to cognitively grasp the parametric relations between sound and movement? Can movement sonification still be a useful and suitable intervention, even when this ability has been compromised by cognitive impairment? On the other hand, a person-centered approach foregrounded the social and interpersonal dimension of the experience. What kind of social and expressive interactions might the use of movement sonification in a group context enable? What is the role of the facilitator in establishing a relationship between user and technology?

2. RESEARCH CONTEXT

Overall, the purpose of movement sonification is to use sonically augmented feedback towards enhancing movement

awareness and facilitating sensorimotor learning. The benefits of movement sonification have been reported across several research projects, focusing on physical activity [7]; dance training [8]; sports training [9] and rehabilitation [9], [10], [11]. A scoping review on the use of movement sonification for rehabilitation [12] lists the following benefits:

Improvement in motor control and/or movement quality, encouraged movement, improved body awareness in space, increased performance executing complex movements when compared with no audio [...]; decreased energy expenditure; supported postural control; improved range of movement; increased self-efficacy [...].

Movement sonification has also been approached as a means for influencing creativity. Discussing a project that explored the use of movement sonification technology in a PE class, Oppici and colleagues argue that the increase in movement range that can be accomplished through movement sonification can also entail an increase in the affordances the mover perceives in their environment [13]. One basic premise of movement sonification is the operation of a cause-and-effect relationship between the movement and the sound at the level of the user’s phenomenal experience. This necessitates the establishment of a set of meaningful co-ordinates that allows the user to interpret the sound in terms of their movement. For example, Guerra and colleagues report that the sound is used as a corrective mechanism or as a reward for the execution of a movement within the desired parameters [12]. Oppici and colleagues similarly point out that the sound can ‘readily “tell” and reward a performer when a new movement is created’ [13]. As such, movement sonification relies on the user’s ability to grasp and follow in time a set of interpretative relations, which, in laboratory settings, are often communicated by the researchers to the research participants.

Dementia has been associated with hearing loss [14], [15] and a link has been established between auditory processing disorder and cognitive impairment [16]. Motor decline is also a core clinical component of dementia and includes symptoms such as gait disturbances, impaired balance and muscle weakness, which can precede the cognitive impairment and can therefore serve as predictive markers [17], [18]. Despite the important role of motor function and auditory processing in dementia, the condition has not been addressed by movement sonification research. One could argue that the fundamental requirement of movement sonification—that users must be able to interpret the sound as feedback about their movement [2]—may limit its applicability for individuals with cognitive impairments. Even if a user’s movement creates sound, even if the sound is perceived, and even if a cause-and-effect relationship between sound and movement is established, it would still be difficult for users with cognitive impairment to interpret the sound in terms of reward or correction related to specific aspects of their movement. It entails therefore that it would be difficult to apply movement sonification to address the symptoms associated with dementia.

Nonetheless, the use of the creative arts in dementia is moving away from an approach focusing on the alleviation of symptoms and instead prioritizes the wellbeing of the person. Central to this approach is a shift away from cognitive-based understanding of the self, which equates memory loss with a loss of self, and towards a conceptualization of selfhood as embodied [5], [6], [19]. As Fleetwood-Smith and colleagues explain: ‘embodied selfhood involves recognizing the role of the body in the construction and manifestation of the self, meaning that a person is their body and that their wishes and desires are experienced and communicated through their

body'[6]. Most importantly, scholars argue that the bodily patterns and kinesthetic dynamics that organise daily action continue to be operative even in late stages of dementia [5], [19]. As such, engagement with the person at an embodied level becomes the main means for communication and relating. Accordingly, scholars working within HCI and music interactive technology advocate for 'approaches that put a whole self at the centre, a self that is agentic, embodied and relational' [20].

Drawing on movement sonification literature, the 'echome (and) in mature company' project assumed that sound would encourage the residents' movement and increase physical activity within a session. Drawing on scholarship in music and dance for dementia [5], [21] as well as on research in the application of interactive music technology in care homes [22], it hypothesized that movement sonification could support movement not only in terms of sensorimotor function but also as a means for interpersonal engagement. Building on this research context, an analysis of the 'echome (and) in mature company' project aims to propose an explanation on the way the relationship between movement and sound becomes established at an embodied level and consider the role of the facilitators in this process.

3. CASE STUDY DESCRIPTION

The project involved three day-long training sessions, which introduced the dance artists to the echome technology and pedagogy; covered relevant literature in movement sonification and dementia respectively; and familiarized them with the functionalities of the echome devices. The dance artists had not worked with interactive technologies before. They were experienced in delivering music and dance sessions in dementia care homes and espoused a person-centered and holistic approach, along the lines discussed in the previous section. As such, the training foregrounded the intersensory and embodied dimension of movement sonification and focused on the use and development of improvisation scores that could facilitate creative and non-verbal forms of interaction within a group setting. The first two sessions of the training centered on the development of the artists' experiential understanding of movement sonification and their ability to use the echome technology smoothly. The last session was dedicated to the planning of activities for the use of echome in care homes. The training was dovetailed by two anonymous questionnaires, the first fielding the dance artists' previous experience and interests, and the second soliciting their feedback on the training.

After the completion of the training, the dance artists worked in pairs and each pair delivered three group sessions in the same care home (nine sessions altogether in three care homes). Each session lasted 60 minutes, included six to eight residents, and in some care homes it was attended by members of staff. The author and the Older People's Producer from Yorkshire Dance attended all sessions and the author kept field notes throughout. The project concluded with a focus group, where the dance artists shared their observations of the sessions, and one-to-one interviews with the author, where they reflected on the project in relation to their previous experience and their ongoing professional development. A filmmaker documented one training session, two group sessions in the same care home, the focus group and evaluation interviews, and a film was made with this material [23]. The audiovisual footage and the interviews were coded and analyzed by the author taking into consideration the ethnographic notes and relevant literature.

3.1 Activities

The care home sessions were based on workshop plans developed by the dance artists during the training phase. Each plan included time for opening and closing the session, through verbal and non-verbal social interactions, movement warm-ups and cool downs, and a set of activities with echome. The echome sensors are usually worn through a custom-made harness, which can be attached to different parts of the body. This increases the possibilities of movement and encourages the motion of other body parts. However, the use of harness presupposes that users can give their explicit consent to wearing the sensor, following a period of familiarization with the device. For these reasons, the initial activities were done with the sensors held rather than worn, and the harnesses were used after the introductory activity and only when residents gave consent. In order to introduce the technology, a different sound was assigned to a different sensor, three to four sensors were laid on a tray and the dance artists went to each resident in turn and encouraged them to pick up the different sensors and listen to the sound that was triggered (Figure 3). This initial exploration offered residents an opportunity to experience the echome sound library and the materiality of the handheld sensor. Because the sensor was held rather than worn, residents were free to place it back on the tray, if they found the sound unpleasant or wished to end the interaction.

The introduction was followed by a group activity where one resident would make a sound and the rest would copy the movement or move to the sound that was created by the person holding the sensor. This was then progressed by setting up duets between two residents and finally an orchestra, where each resident would hold a sensor, creating a distinctive sound. As the orchestra produced a loud and layered sonic environment, it was followed by a final group activity which included only one sensor and sound. For this one, the residents took hold of the edges of a blanket that was spread between them. A sensor was placed in the middle of the blanket, and the sound was created by tugging, lifting and swaying the fabric (Figure 4).

As noted in relevant literature, handheld devices [22] and material props [6] are integral to creative work in a dementia context, since they can provide sensory stimulation, enable participation that is meaningful to the participants and promote forms of expression that are based on embodied actions rather than verbal communication. The blanket and the tray served as material surfaces to carry the sensor as well as a kind of interface mediating access to the technological object. As the dance artists pointed out in the training sessions, blankets and trays are ubiquitous in care homes and, as a result, they could enable them to 'introduce the unfamiliar technology through the familiar'. The tray, used at the beginning of the session, was small and taken to the residents, offering them the opportunity to pick up, return or refuse the sensor. This simple activity established from the beginning the agency that the residents could have over the process and the production of the sound. The blanket was used at the end and served as an object that could 'gather' the group together. Held by the whole group simultaneously, it enabled the production of one sound through collective movement.





Figure 3: Facilitator holding the tray with the echome sensors.



Figure 4: The group working with the blanket.

4. DISCUSSION

The feedback loop between movement and sound that was made possible through echome was not intended to make the residents aware of aspects of their movement they could not access otherwise (as for example in [8]) or to achieve sensorimotor learning (as for example in [24]). Rather the aim was to use the ‘sonic gestures’ [25] inherent in different sounds as prompts for stimulation and movement generation, by enlarging the amplitude of physical movement, increasing the range of excitation gestures and promoting social interaction. Theories on the embodied nature of music perception and cognition can be useful in elaborating on this aim. In his exposition of the Mimetic Motor Imagery (MMI) hypothesis, Arnie Cox argues that ‘part of how we comprehend music is by way of a kind of physical empathy that involves imagining making the sounds we are listening to’ [26]. According to Cox, a sound is perceived through motor imagery which may or may not manifest in overt movement and often operates beneath the threshold of conscious awareness [26]. Similarly, Rolf Godøy points out that the temporal unfolding of music is ‘transformed into “instantaneous” shape images’, which ‘are intimately linked with notions of body motion’ [27]. In other words, not only auditory perception is inextricably related to an image of the motion that may have produced the sound; the sound in itself is perceived in terms of motor imagery. Drawing on Godøy’s work, Deniz Peters argues that ‘we *feel* shapes in sounds upon hearing them alone – via embodied knowledge of the sound-touch relationship’ and points out that interactive

systems make the intrinsic relationship between ‘sonic shapes’ and ‘motion qualities’ explicit [28]. This tallies with the work of Dyer and colleagues, who propose an ecological paradigm for movement sonification design for motor learning. They argue for a “direct” approach to mapping in which sound quality perceptually correlates with the dynamics of ongoing movement’ [29].

However, since mobility decline is a symptom of dementia, it could be assumed that people living with dementia might have a limited range of movement. A ‘direct’ approach to mapping could mean that a limited movement range would limit the available sonic outputs. In other words, if a system is designed around the mobility range of prospective users, there is a risk that mobility issues circumscribe the possibilities of the interaction. To address this, echome features sounds with a variety of morphological characteristics. Furthermore, the parametric mapping enables changes in pitch trajectory and spectral content through motion which is small in amplitude and effort. As a result, when a resident creates sound through the handling of an echome sensor, the sonic gesture, i.e. the motion that is perceived in the sound, might have a more dynamic character than the physical movement that triggered the sound. This can be put in terms of a difference between the ‘control sphere’ (the motor input needed for producing the sound) and ‘the morphology sphere’ (the features of the perceived sound) [27]. It is this ‘space’ between the excitation gesture and the resulting sound that presents opportunities for facilitation.

4.1 Mimetic Motor Imagery and Facilitation

When a resident creates a sound, a facilitator has three options. She can operate within the control sphere and imitate the resident’s excitation gesture. Whilst copying the gesture, she can progressively change some of its features, for example by increasing its amplitude or extending it away from the body. In the project film, one of the facilitators explains how she copied the resident’s movement in an attempt to progressively make the movement bigger as well as encourage other residents to join in [23]. It is often the case that the person whose movement is copied responds to this invitation and adapts their established gesture to include the suggestions offered by the facilitator. In this way, movement sonification can provide a non-verbal form of interaction through which the facilitator can enrich the resident’s movement.

The second option is that the facilitator operates within the morphology sphere and gives bodily expression to the sonic gesture (or specific characteristics thereof). For example, at the beginning of the film documenting the project, a close-up shot on the resident holding the sensor shows a soft, downward shaking motion of the wrist which produces a percussive sound, whilst the rest of the arm remains supported by the chair [23]. One of the facilitators embodies the shape of the sound, executing a punching movement which involves both arms and alternately extends them in front of the body. The second facilitator vocalizes the sound through the repetition of the /tʃ/ affricate. A resident sitting opposite the first facilitator is copying the punching movement, whilst another member of the group, who is seated next to the resident with the sensor, is responding to the sound by air drumming, mimicking the hitting of an imaginary drum with an imaginary drumstick [23]. As this short example illustrates, one sound can give rise to multiple responses across several modalities. At the same time, the sound also offers a point of reference that gathers these responses within an identifiable and shared moment of interaction. In this way, movement sonification can both direct attention to the person holding the sensor and establish a coherent group dynamic.

Finally, the third option is when a facilitator operates within the control sphere and the morphology sphere simultaneously. In the example given in the first option, we can see that the facilitator, after copying the resident's excitation gesture by placing her arms in the same position, then adds an oscillating movement with her torso that mimics the motion of the sound. She finally uses the word 'jiggle' giving expression to the overall shape shared by the sound and movement [23].

In all three cases, the facilitator offers an embodied and crossmodal response which duplicates the resident's input by following either the physical movement and/or the shape of the sound. In this way, the resident's input is affirmed and becomes amplified through the facilitator's development of visual, vocal and kinesthetic schemata. Whereas the first option involves a process of copying the resident's external gesture, the second and third option render visible the motor imagery that underpins the auditory perception of the sound. Of course, this form of expression is subjective and the same sound could be perceived through different imagery depending on the person's background and training [26]. However, as long as the structural aspects of the external movement are consistent with the morphological features of the sound, then the movement can offer an additional stream of information through which the feedback loop between sound and movement can be intensified. As such, the dance artists' ability to identify, filter and embody the structural relationships between sonic gestures and motor imagery is paramount in enabling the resident to consolidate their relationship to the sound they are triggering. Correspondingly, when the residents are invited to work with a new sound, the dance artists need to be familiar with the sounds of the echome library, so that they can pick a sound with characteristics that matches the resident's movement, in terms of its direction, effort and range. Mimetic Motor Imagery (MMI) can therefore constitute an important aspect of the facilitation skillset that can be trained and employed towards maximizing the potential of movement sonification in social care contexts.

It bears noting that the MMI hypothesis has been advanced in terms of the experience of neurotypical subjects and/or the work of professional musicians. Nonetheless, the findings of the 'echome (and) in mature company' project demonstrate that an empathetic relationship to sound and movement remains operative for people living with dementia. Cox's initial exposition has drawn on theories of kinesthesia and kinesthetic empathy, which were also used in subsequent elaborations of his theory [30]. Broadly speaking, kinesthetic empathy refers to the neurological response and affective experience that can emerge from watching someone else move. However, kinesthetic empathy is not limited to experiences of movement and can be triggered by other forms of sensory information, including sound [31]. Following the way kinesthetic empathy has been conceptualized in dance studies [31], it could be argued that in the examples described above the resident gained a vicarious experience of the dance artist's movement and this intensified their relationship to the sound. However, because of the interactive dimension of the activity, a more complex relationship takes place. Unlike performance environments where spectators experience a choreography or a music score and cannot influence the unfolding of the material, in an interactive environment the residents have agency of how the movement develops, since they create the sound that feeds the movement. In some sessions, this has been grasped intuitively by the residents and evolved in a call and response

activity, where the sound created by the resident was used as a means to control or shape the dance artist's movement.

4.2. Project Evaluation

In the evaluation interviews, the dance artists noted that they witnessed in the residents an expanded range of movement, an interest in the behaviour of different sounds and a positive impact on mood and sociality. One artist described the sessions with echome as the creation of 'a big, social play space' [23]. Another dance artist explained that the use of interactive sound enabled her to encourage the residents' movement in a way that relied less on verbal instruction or visual demonstration [23]. This confirms [24] who compared the efficacy of movement sonification for sensorimotor learning with visual display and concluded that 'the use of sound can perhaps more explicitly include the body in the perception-action loop'. As the dance artist detailed, the use of echome allowed her to introduce more complex movement material, involving tension, textures and rhythms, without having to rely on verbal cueing or visual demonstration, which can be hard to follow and cause residents to disengage from the task [23].

The dance artists also reflected on the use of echome in comparison to acoustic instruments they would normally use, such as bells and shakers [23]. They pointed out that acoustic instruments require a specific kinetic repertoire for the generation of sound and as such they pose limits on the range of movement that can be employed in a session. This reflection tallies with my observations from a visit to the workshops offered by In Mature Company prior to the project with echome. In the session I observed, the artists offered each resident a bell, which required a specific way of holding the instrument. Although the movement was relatively simple, explanation and demonstration was needed for enabling the residents to produce sound. More importantly, an introduction of a new movement would necessitate the introduction of a different kind of instrument, which would necessitate the introduction of a new object. A wearable technology, however, offers access to multiple sounds and movements through the same object, rendering the progression between activities more streamlined. Although the aim of the project was not to evaluate the digital system over dance or music interventions, the dance artists' comparative understanding is informative. It highlights the specific ways in which movement sonification can support the delivery of creative activities but also suggests a more holistic approach to movement that encompasses but is not limited to sensorimotor function.

4. CONCLUSION

This paper discussed a project that explored the use of technology for movement sonification in a dementia context. It focused on the facilitation process of a group of dance artists who were experienced in delivering creative dance sessions in dementia care homes and received training in working with the echome technology. The paper made the following three contributions. It presented the use of movement sonification within a setting and in relation to a condition that has received scant attention within movement sonification research. It comparatively discussed the project findings in relation to person-centered approaches to dance and music for dementia. Specifically, it identified the advantages that movement sonification can offer over the use of acoustic instruments as well as the way in which movement sonification can constitute an effective tool for introducing novel and/or enriching



existing movement vocabulary. It employed an embodied approach to music cognition, specifically the hypothesis of Mimetic Motor Imagery, to elucidate the way the relationship between movement and sound can offer a ground for the interaction between resident and facilitator. The arguments presented in this paper have the following implications for the field of movement sonification.

The importance of a person-centered and flexible design for movement sonification systems has been argued in recent research [1], [2]. Within this field, flexibility is addressed in terms of parameterization at the level of the system's design. Responding to the needs of a real-world environment as well as the symptoms of cognitive impairment, 'echome (and) in mature company' took a different approach, whereby the individualization of the system and the creation of meaningful relationships between sound and movement became mediated through an assemblage that involved digital tools, material artefacts and interpersonal interaction. Although the sonification of the movement was achieved through the digital system, the creation of interpretative relationships between sound and movement was mediated by the input of the dance artists as well as the material affordances of the artefacts through which the digital hardware was utilized in group activities. The development of movement sonification systems therefore could be considered not only in terms of technological functionalities and design protocols, but also in terms of the forms of practice that could support the use of these systems in different social contexts. As such, the involvement of dance artists (or other kinds of facilitators) is not only crucial for supporting user acceptance; it has methodological implications, since their motion responses can externalize the relationship between movement and sound.

The 'echome (and) in mature company' project demonstrated that the use of movement sonification in dementia environments can reveal/give expression to the dynamic patterns of movement that are available to the person living with dementia. Since the theory of MMI has been advanced in terms of the experience of neurotypical subjects and/or the work of professional musicians, the question that emerges is whether, or to what extent, MMI can remain operative despite the cognitive impairment caused by dementia. If this is the case, then future applications of movement sonification could focus on the stimulation of MMI to bypass the dementia-associated symptoms that hinder physical activity, such as poor coordination and dyspraxia.

Finally, the findings of this project invite a reconsideration of the relationship between movement and sound beyond didactic or diagnostic purposes. Whereas movement sonification has been primarily conceived as a tool for sensorimotor, solitary learning, the research design and analysis of the 'echome (and) in mature company' project suggests that it can support processes of social interaction and communication. Significantly, Cox points out that MMI is at the heart of 'music's socializing power: It provides a medium whereby we can enact participation and community—literally, a state of sharing, where the thing shared is a state of being, by way of a shared state of doing' [26]. It could be argued that using movement sonification in a way that focuses on crossmodal correspondences and interpersonal engagement can not only bypass the symptoms related to cognitive impairment. It fosters a form of communication (being seen, heard and responded to) that affirms the whole person. As one

dance artist put it, in this process, 'having dementia doesn't feel like a barrier, it feels like an opening' [23].

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