Agency and Creativity in Musical Interaction for those living with Dementia and Cognitive Decline

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ABSTRACT

Musical interventions are becoming a more popular tool in dementia care. Although the use of music is developing in a range of contexts such as choirs, song writing groups, and more specific therapies, these often rely on musical knowledge or the expertise of facilitators. Limited tools are available which facilitate unguided musical experiences, fostering agency for their users through musical creativity. We present a workshop-based study exploring the use of a procedural music platform designed for those living with dementia and cognitive decline. The paper takes a mixed-methods approach, exploring a range of procedural processes, and reviewing participant engagement during their use. We demonstrate the use of the platform and highlight its potential for engagement. We evaluate the techniques implemented and demonstrate an inverse relationship between operational complexity and interaction. We conclude it is possible to facilitate engaging musical interactions which foster agency and creativity while maintaining rich and age-appropriate outputs.

Author Keywords

Accessible Digital Musical Instruments (ADMI), Agency, Dementia and cognitive decline, Procedural Composition

CCS Concepts

•**Human-centered computing** → **Accessibility technologies; Accessibility systems and tools;**

NIME'24, 4–6 September, Utrecht, The Netherlands.

1. INTRODUCTION

Dementia is a wide umbrella for a range of progressive conditions which affect the brain. It poses a growing concern for an aging population, with increasing challenges to memory, problem solving, cognitive function and decision making, which are severe enough to affect everyday life. There is a growing body of research which highlights the positive impact sustained engagement with music can have on the well-being of older adults [19, 20]; for those living with dementia musical interventions have been shown to aid key aspects such as the sense of self [1], and awareness of the moment and memories of the past [18, 17]. Music and arts-based activities play an increasing role [15] in therapy, providing vital non-pharmacological methods to support cognition, communication, social connection, and well-being. Implementations are wide, featuring social activities such as choir singing [38, 50], the development of personhood and memory function through song writing [30, 2, 11], and opportunities to participate in creative music-making [17, 51]. Although music activities have the potential to foster agency, Zeilig [58] notes that people living with dementia are often seen as passive participants, or only able to offer limited creative contributions.

We argue that many current approaches to balancing these challenges in participation focus on selecting 'basic' instruments and situations for musical creativity (commonly voice or percussion led [17, 51]). Although perhaps chosen specifically for their simplicity to encourage greater accessibility, this can have the effect of isolating people living with dementia's contributions to that of playing along in a basic manner with music made by 'experts', limiting the potential for agency and its transformational effects. The magical transformations seen in people living with dementia 'coming alive again' need to be seen as not 'magical', but instead as the careful, responsive and concrete actions that have been taken to best support people living with dementia to reach their creative potential [13, 16]. For these reasons, music and other creative arts activities, with their ability to be enjoyed through to later stages of dementia, need to be carefully considered in terms of their design and affordances.

To address these challenges we have developed a procedural composition platform designed to facilitate agency for those living with dementia through unguided creative musical interaction. This paper outlines a workshop-based

activity using the platform undertaken as part of a series of sessions run at a dementia cafe hosted by a community partner. We evaluate the use of the platform, a range of procedural techniques that underpin its operation and the potential it has for engagement.

2. RELATED WORK

2.1 Agency, Creativity and Music

Agency is often characterised as the sense of control or ownership that an individual experiences over both an action they take and its consequences [26]. The study of agency frequently prioritises its language and cognitive components, leading to the assumption that dementia, with its impacts on language and memory, necessarily leads to a loss in agency [8, 55]. Dementia research also more generally follows a biomedical deficit model, focusing on the skills lost by people living with dementia and what they are no longer able to achieve [14, 16, 31]. This deficit model contributes to the social stigma that comes with a dementia diagnosis [57], undermining the sense of worth, agency, and self of a person living with dementia [12, 45]. This also affects them on a societal level, where common social practices lead to them increasingly being denied opportunities to contribute to society in a meaningful way [47].

Contrasting this, research instead suggests that agency is more complex than what fits within this deficit model [46], and that people living with dementia continue to have a strong sense of agency when given opportunities to do so [41]. For instance, people with dementia are quite capable of demonstrating agency through their creative and intentional abilities [33, 58]. There is growing evidence of the value of arts-based activities in providing people living with dementia opportunities to be active agents in their own creative flourishing [17, 56]. Music contains open-ended structures that can scaffold the creativity, playfulness and feelings of togetherness in people living with dementia, while also enabling their sense of agency by allowing them to modify these structures to match their desires and interests [46]. This openness nurtures inclusion and participation, generating feelings of agency, wellbeing, and the reinforcement of a sense of self as grounded and belonging [58].

2.2 Accessible Musical Interaction

Within the scope of arts-based activities for dementia there is much work and research focusing on accessible tools, with a comprehensive overview provided by MacRitchie [39]. 51 technologies were reviewed, with 28 focused specifically on musical interaction. The majority of these technologies (19) targeted 'music listening', providing access to playlists and simplified listening devices. 9 technologies focused on 'music making': Kenning et al. [32], Smith et al. [51], and Dowlen et al. [17] use rhythmic percussive instruments; Cheng et al. [9, 10] and Han et al. [27] use a simialr tuned percussive instrument (children's glockenspiel); with Benveniste et al. [6] and Bouley et al. [7] taking a more gamified approach, using game controllers to interact with a computer-based single note melody instrument. Although accessible, there are limitations to the creative agency facilitated by such tools and in most cases their simplicity hinders the richness and maturity of their musical potential.

Within the NIME, SMC and ICMC communities the discourse around accessible musical instruments is well represented as reviewed by Frid [23, 24], and more recently Lucas et al. [37] and Forster et al. [21]. Within this space there is limited research focusing on dementia or cognitive decline, the two exceptions being Favilla et al. [20] and Pigrem et al. [40].

3. DESIGN METHODOLOGY

The goal for the platform designed for the workshops was to enable creativity, and foster agency in meaningful and unguided musical interactions. From a physical perspective we wanted to present an approachable device which promoted interaction through materials and design factors, while simplifying interaction and providing strong multi-modal feedback. From a functional perspective we were keen to test and evaluate range of approaches to procedural composition. We also wanted to explore a range of complexity levels to establish a relationship with cognitive load.

3.1 The Interface

The interface used in the research is known as the 'SliderBox' (pictured below in figure 1) and was developed iteratively over a year working with groups of older adults living with dementia in the Sheffield region. We presented the device and 5 supporting design criteria at the NIME 2023 conference, reported in [40]. Powered by Bela [43] the device is capable of standalone operation, however in this part of the research serves as an 'accessible MIDI controller' (AMC) interfacing with the Ableton Live Environment.

The Interface is lasercut from wood and well finished to facilitate an approachable and physically enticing device with which to inspire interaction. The potential for material factors to guide and support interaction in digital musical instruments has been explored by some within the NIME community [25, 48, 49, 29] and has resonance with more recent notions of entanglements in HCI [22, 4, 5]. The Interface houses 8 analogue sliders and 8 momentary pushbuttons. Feedback is provided to the user through LED lights in the buttons and LED light strips alongside each slider. Basic gestalt grouping principles (colour and position) are used to connect each slider, button and LED group into a more singular unit for parameter control.

The Bela Mini handles sensor interaction and serves as a MIDI device to connect to a computer. Following some basic windowing and 'debounce' processes, interaction data is converted to MIDI and passed as CC data. The Bela also receives user feedback (sent again as MIDI CC data) which is converted into an SPI message and passed to the LEDs in real-time.

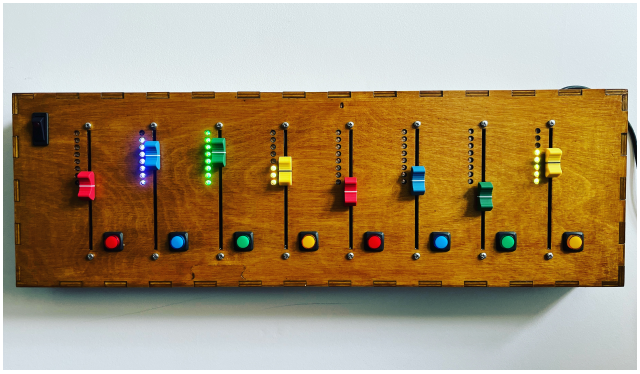

Figure 1: The Sliderbox - An 8 channel Accessible Musical Interface, featuring 8 analogue sliders, 8 momentary buttons and 8 led strips [40]

3.2 Audio Playgrounds

Through our wider work with similar groups (to date over 40 activity sessions, engaging with over 500 participants including activity coordinators, music therapists and care professionals), the importance of a 'mature' and 'aesthetically rich' musical output had been highlighted. Although there was the possibility of impaired cognitive processing in our participant group, the experience still needed to be appropriate for the age of the participant, and designed with the agency of the user in mind.

In order to facilitate rich musical interactions for those with minimal or no musical training we developed the notion of an 'Audio Playground' (AP). The playgrounds combined a range of procedural techniques to facilitate the live composition of a basic piece of music, which fostered the potential for nuance and personalisation in its final form and structure. Each techniques had to be navigable with a single button press and a slider.

Beyond maturity of output, several key interaction factors guided the design of the Audio Playgrounds:

- No 'out of key' notes: through our work and consultation to date the limitations of musical ability and its effect on confidence and interaction has been noted. We felt it relevant to limit the potential for dissonant combinations of musical elements while working with those without musical knowledge or training.
- Freedom in the rhythmical domain (within reason): It was considered to discourage interaction if there was noticeable latency between button presses and sound events. In the case of the slider data there was no quantisation, and in the case of the buttons interactions were quantised to a 16th note grid in the Ableton environment. The quantisation value prevented galloping and phased playback between parts while enabling the level of synchronicity expected in western music.
- As agency in the musical experience was a key point of interest, it was decided that each playground should foster the potential for nuance in its form and structure. This was intended to enable greater connection between participants and their musical interactions and foster personalisation of experience.
- As technology can pose an increasing barrier for those living with dementia its role in the process was hidden. To provide an inclusive and accessible solution, screen, mouse or keyboard based operations were removed for the user.

Two Audio Playground sessions were developed. Both sessions featured conventional instrumentation (drums, keys, bass, melody, and percussion). AP1 was an upbeat track with a straight 8 rhythm, driving bass-line, and keyboard parts. AP2, in contrast, was a softer downbeat track with a shuffled feel, featuring wistful piano motifs and contemplative chord changes. The musical parts in each Audio Playground are displayed below in Table 1.

CH	Audio Playground 1	Audio Playground 2
1	Glockenspiel	Vocal
2	Keyboard Stab	Synth Pad
3	Keyboard Motif	Guitar Arpeggio
4	Cowbell	Percussion Hit
5	Drum kit	Piano
6	Bass Guitar	Drum Kit
7	Mixed Percussion	Piano Motif
8	Keyboard	Bass

Table 1: Audio Playground 1 & 2 - Instrumentation by channel

Each playground employed similar approaches to procedural composition. Sound playback included two main paradigms - looped playback and one-shot. Four channels of each playground facilitated continuous (looped) musical content, with the nature and structure of the content changing with interaction. The remaining four channels facilitated one-shot playback with varying degrees of change with each interaction. The rationale for these two paradigms was to enable instant structure and musical context from the looped elements, while providing space for discovery and personalisation through development of the loops and addition of the one-shot samples. Due to the range of cognition and dexterity within the group the playgrounds needed to work for all ability levels, and in some cases with minimal interaction.

All of the content for the Audio Playgrounds was precomposed. The looped channels played back 8 and 16 bar MIDI files, with the one-shot channels using a mix of MIDI files and round-robin sample banks. In order to ensure the combinations were harmonious all pitched parts were played in the same key, with the use of modal movement between the parts to provide change in the mood of the piece as the participants interacted. To simplify the process chord tones and pentatonic scales were used to minimise 'Fruity' note combinations (scale clashes between different musical parts).

3.2.1 Procedural Approaches

Two key procedural approaches were used in the Audio Playgrounds: 1) follow actions in Ableton Live were used to create a round-robin approach to the playback of different pre-composed MIDI clips. A button press would step forward to the next clip in the chain, which would loop until another trigger message was received. 2) A random walk was taken through a set of pitched samples facilitating a random, yet harmonically coherent melody. In one case a combination of both approaches was taken, where an arpeggio played on a guitar was inverted to a random degree with each button press. Although basic in approach, the techniques enabled rich combinations of musical parts, which were easily navigated into new harmonic spaces through interaction. It was our goal to establish the potential for each compositional approach and the role they play in future development of the platform.

As memory and wider cognitive abilities are key challenges for those living with dementia we were particularly interested in the relationship between the complexity of each interaction and the frequency of engagement. Taylor et. al. [53] evidenced a desire for greater complexity from participants, however noted a subsequent decrease in enjoyment when implemented through lower quantisation value for temporal onset of stems (full bar / half bar / quarter bar levels). We were interested in exploring this space in greater detail to better understand the relationship between complexity and cognitive challenge. Within each procedural approach a range of complexity levels was induced based on the number of different 'actions' possible with that part. For example: would a single button always trigger the same part, or step between two (or three) possible options in a round-robin. The complexity levels implemented are explored in greater detailing the following sections.

3.2.2 One Action

Single action operations facilitated a single musical change for each button press. For example initiating the playback of a one-shot sample or MIDI clip, or the incorporation of a drum roll in to a looping drum part. The button press always had a singular and repeatable effect on the musical material.

3.2.3 Two Action

Two action operations facilitated one of two musical changes for each button press. For example stepping between two different MIDI clips (i.e. two different baselines or keyboard parts). Unlike the single action operations the button press would do one of two things - play part A or play part B depending on what part was already playing.

3.2.4 Three Action

Three action operations facilitated three possible musical changes for each button press. For example stepping between three different percussion parts, or three different degrees of inversion of a triad.

3.2.5 Five Action (randomised)

Five action operations were less predicable, with a wider range of possible responses to a button press. Each Audio Playground session featured one five action action control which triggered an advancement of a random walk through a set of glockenspiel (AP1) or vocal (AP2) samples. In each case there were 5 equally weighted possibilities (each note of a pentatonic scale).

The different procedural approaches used on each channel of the two Audio Playground sessions are highlighted below in tables 2 and 3.

CH	Voice	Type	Approach	Actions
1	Glock	1-Shot	Random Walk	Random
2	Key Stab	1-Shot	Round-Robin	2 action
3	Organ Roll	1-Shot	None	1 action
4	Cowbell	1-Shot	None	1 action
5	Drums	Looped	R-Robin	1 action
6	Bass	Looped	Round-Robin	2 action
7	Percussion	Looped	Round-Robin	3 action
8	Keys	Looped	Round-Robin	2 action

Table 2: Audio Playground 1 - Procedural Composition Approaches

CH	Voice	Type	Approach	Actions
1	Voice	1-Shot	Random Walk	Random
2	Synth Pad	1-Shot	Round-Robin	2 action
3	Gtr Arp	Looped	Inversion	3 action
4	Percussion	1-Shot	None	1 action
5	Piano	Looped	Round-Robin	2 action
6	Drums	Looped	Round-Robin	1 action
7	Piano Roll	1-Shot	None	1 action
8	Bass	Looped	Round-Robin	2 action

Table 3: Audio Playground 2 - Procedural Compositional Approaches

4. THE STUDY

The study was undertaken as part of a series of three workshops run in partnership with a local wellbeing organisation. On visiting their regular fortnightly dementia cafe with prototype devices (reported in [40]), attendees (a group of older adults with varied abilities and disabilities) self-selected to join a set of music-focused sessions. People attended with their friends and loved ones, and were very clear that they did not want to be separated into "those with dementia" and "those without", i.e. it was important for the activities to be run for the group as a whole. Over the three workshops (held over four weeks) we explored a range of topics and musically focused activities, mediated through digital technologies. We used the Sliderbox (fig 1) on all three occasions to playback music (wkshop 1), mix stems of popular music (wkshop 2), and to create new music (wkshop 3). This paper focuses on the third and final workshop and an activity which used the Sliderbox to control the Audio Playground sessions.

The nature of the sessions were very informal and the focus was providing musical activities as opposed to more controlled experimental conditions. Within this space our research framework guided the design of the workshops and the activities undertaken in each. All activities were undertaken in a group environment with the group members sitting around a large table. The activities across the three workshops were designed to scaffold musical experiences such that participants could increasingly develop agency mediated through the device, and consider themselves as active musical agents. The Audio Playground activity took place at the end of this scaffolding process. The workshops focused on one device in order for the participants to develop familiarity with it, and any interactions observed in the later workshops could be teased apart somewhat from initial reactions to the device itself.

4.1 Participants

Eight participants joined the third workshop reported here (M4, F4, 7 older adults, 1 middle-aged). The group was made up of some living with dementia, some awaiting diagnosis, and their carers. Participants who had attended previous sessions were familiar with the Sliderbox, however it was the first time for all participants using the Audio Playgrounds and interacting with unfamiliar and changeable music. One participant self reported to be musical, although unfamiliar with digital technology or procedural composition.

4.2 Procedure

The Sliderbox was presented to the participants in a group environment, who explored AP1 and then AP2. It should be noted that this presentation approach would have contributed to learning effects within the group (as highlighted in [44]), however was concurrent with the naturalistic setting of the workshops. Instructions were kept minimal to ensure an unguided approach to interaction: *'Press some buttons, use some sliders. See what you like and how you like it sounding".* Participant were asked to explore the device and reassured there was no right or wrong way to interact. If unsure the direction to *'press some buttons and explore the outcome'* was given. Participants were given the choice to interact alone, or in a group of two so as to enable and normalise support if needed (four participants chose to undertake the task in a group of two: P5&6 and P7&8). Interactions lasted between 4 and 5 minutes in duration for each participant.

In order to record interaction, at the beginning of the session a 360-degree camera was placed in the middle of the table; the camera captured a continuous 360-degree image, making it ideal for use in groups. Its size and appearance were also factors in making sure the recordings were as unobtrusive as possible for the attendees. The camera captured the whole workshop and specific windows of interaction during the study tasks were later exported for analysis and coding.

4.3 Analysis

Following the workshop the 360-degree recordings of the sessions were windowed to highlight each participant's actions in the tasks. The exported files were windowed using the following criteria: i) the beginning of an interaction was initiated when one participant was either passed the device by another person (researcher or another participant), or the participant pulled the device towards their body (or positioned themselves closer to the device) in order to begin using it, ii) the end of an interaction was signalled when the device was moved by the participant to someone else in the group (researcher or participant), or the device was moved by the researcher on receiving a signal from the participant that they had finished using it.

4.3.1 Interaction

Each unique interaction with the Sliderbox was noted. Totals were established for each interface element and later used to establish patterns of interaction based on procedural approach and complexity level. The data was charted using the Excel platform and is displayed and discussed in the following section.

4.3.2 Engagement

Assessing engagement in a naturalistic setting can be challenging, and as researchers we often rely on later coding and analysis of video data. As dementia is a complex and degenerative condition several specific approaches to establishing engagements can be found ([36, 42, 28]). In order to establish levels of engagement throughout the activity for each participant, we used the Video Analysis Scale of Engagement VASE [36]. The VASE provides a method to establish engagement using a 7 point scale rating of four key indicators of engagement: 1) facial expressions; 2) bodily movements; 3) attention and awareness; and 4) emotional response [35]. The VASE assessment process uses an HTML based viewer enabling real-time annotation of video data, later exported as a CSV file [34]. Traditionally a mean average of the four indicators is taken to establish a single figure engagement score for a particular participant. Although designed for more advanced dementia, the four metrics were in our case relevant to the situation and the scale wide enough to capture the spectrum of abilities within the group.

5. RESULTS

All data collected as part of the study was a product of analysis and coding of the 360 videos. Following the session the video was reviewed and each participant's interaction windowed and exported as a separate video file. The video files were reviewed and coded independently by authors JP and JM.

5.1 Procedural Approaches

The use of both looping and one-shot procedural implementations were equally favoured, with both methods used fairly evenly across the two Audio Playground sessions. The looped channels were used in 48.21% and 51.32% of interactions in AP1 and AP2 respectively. The one-shot channels were used in 51.79% and 48.68% of interactions in AP1 and AP2 respectively.

5.2 Complexity Measures

The number of unique button presses on each of the 8 channels was counted and its relationship to the varied complexity measure established. The frequency of button presses for each channel in the two Audio Playgrounds is displayed below (figures 2 and 3) along side the level of interaction complexity in each case.

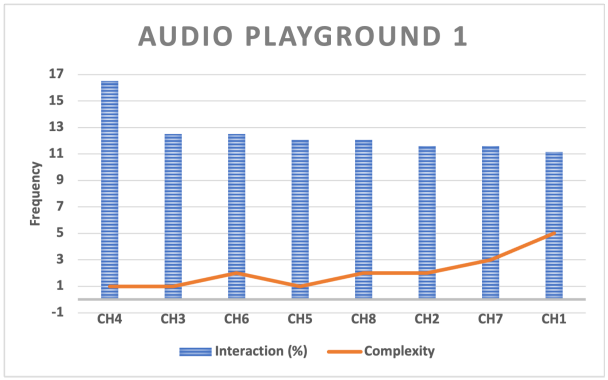

Figure 2: Audio Playground 1: Relationship between Complexity and Interaction

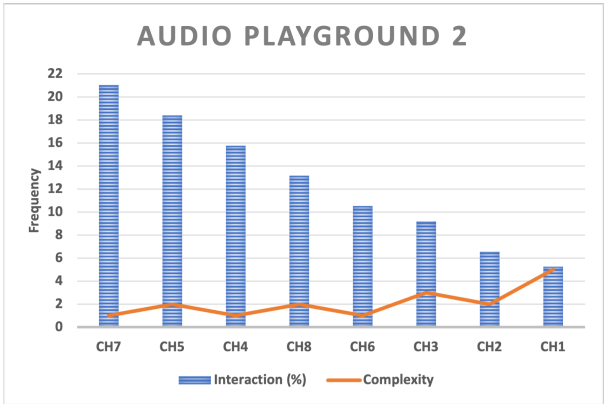

Figure 3: Audio Playground 2: Relationship between Complexity and Interaction

In both Audio Playground sessions lower levels of complexity in general resulted in a higher percentage of interaction with that particular channel. The most used interface element in both cases (CH4 and CH7 respectively) fostered the lowest complexity level. The second most used interface element in the case of AP1 (jointly CH3 and CH6) also fostered lower complexity levels (1 and 2 actions respectively). The second most used interface element in the case of AP2 (CH5) was again of a lower level of complexity (2 actions). In the case of more complex interactions (CH1 of both sessions), the interface element has the lowest engagement score in both AP1 and AP2.

The data suggests limiting complexity to one or two action functions results in greater levels of engagement. It should be noted that this was the first time any of the participants had interacted with the platform, so potentially with greater enculturation and learning time this may change for some.

5.3 Modes of Interaction

During the analysis period two core modes of interaction with the Audio Playgrounds were established: 1) range finding; and 2) creative interaction. These modes underpinned the nature of participant's interactions with all participants demonstrating one or both approaches. These modes of interaction are explored in the following sections.

5.3.1 Range Finding

Most interactions began with a phase of range finding. During this stage participants explored the potential of the platform by testing each button and slider. Although slightly different in implementation for each participant, interaction was generally more methodical with users working from one side of the interface to the other. This mode was indicated by more isolation button presses which were less connected to the musical material playing and bolder interactions which prioritised one musical part at time. The goal of this stage for all seemed to be gaining familiarity and exploring the potential for interaction.

5.3.2 Creative Exploration

In most participants (6/8) a particular shift in interaction style occurred and choices become less about mapping and discovering and more about creating and developing something new. This mode was indicated by more musically focused actions. Button presses were made more in time with the track and other mix elements and slider movements became more subtle and focused on mixing parts together as opposed to creating clarity for singular parts. Navigation across the device was less linear and more responsive to changes in musical output. Facial expression became less curious and more contemplative indicated by greater concentration and wider body and head movements in time to the music and in response to changes made. Participants returned to interface controls they had already tested and made smaller and more refined changes based on surrounding interactions and developments in the piece.

5.4 Participant Engagement Score

To establish the VASE score for each participant, the video for each participant's activity with the Audio Playgrounds was reviewed by two separate raters and engagement scores established for the four metrics. There was minimal deviation between raters (max=1.75, mean=0.91, SD=0.49 in AP1 and max=1.86, mean=0.65, SD=0.54). The mean average of both raters has been published. Table 4 and 5 present the VASE score for each participant using the two Audio Playgrounds.

5.5 Qualitative Feedback

Participants were encouraged to discuss their experiences during every workshop, and after the audio playground tasks were asked specifically for their thoughts. One participant stated that the *"concentration"* the activity had encouraged was remarkable. Another participant talked about liking *"being able to do it myself"* and had mentioned this in the context of having difficulty with computers. Another participant said they *"liked to mess about with [the sliders]"*, and likened it to being a DJ. The group setting of the activity enabled learning effects around the table, and an opportunity to build off what the other participants had created. For example, one participant mentioned *"I was trying to pick some of what <participant> was doing, and then something from <another participant> and something from <another participant>"*.

P	Face	Body	Attent.	Emotion	Mean
1	3.67	5.52	5.70	3.55	**4.61**
2	3.00	5.50	4.88	2.00	**3.84**
3	3.75	6.00	6.17	2.89	**4.70**
4	3.46	5.39	4.00	3.21	**4.02**
5	3.57	4.27	5.18	3.14	**4.04**
6	2.83	3.50	2.00	3.00	**2.83**
7	3.21	4.33	4.00	3.89	**3.86**
8	2.50	3.38	3.75	2.67	**3.07**

Table 4: Audio Playground 1: Participant Engagement Scores (VASE)

P	Face	Body	Attent.	Emotion	Mean
1	3.36	4.83	4.31	3.38	**3.97**
2	3.52	5.00	5.64	3.40	**4.39**
3	4.17	5.00	7.00	3.06	**4.81**
4	4.60	5.38	5.73	3.94	**4.91**
5	3.88	5.00	6.50	3.50	**4.72**
6	3.17	2.86	2.60	2.83	**2.86**
7	3.29	3.86	3.83	3.40	**3.59**
8	2.83	3.67	4.67	3.83	**3.75**

Table 5: Audio Playground 2: Participant Engagement Scores (VASE)

6. DISCUSSION

This is a point in a longer exploration into the use of music technology for those living with dementia, but one that has provided a strong direction for future research. We believe we have developed the beginnings of a platform which can facilitate agency embedded into unguided creative decision making, enabling greater access to musical expression for those living with cognitive decline.

6.1 Procedural Approaches

Although basic, the approaches tested here were effective. They enabled freedom for participants to navigate a range of potential musical possibilities while being shepherded from negative harmonic or melodic results. The balance of the two approaches worked well to enable continuous musical output while providing options for participants to personalise their experience.

The round-robin method enabled degrees of control musically, while facilitating a perceivable change in response to interaction. The predictability inbuilt into the process appeared to foster intentional autonomous choices on part of the user in response to their creative decision making.

The random-walk method was less favoured, although this maybe a factor of its implementation at this stage of the research. The lack of predictability was noticed by most participants, with some becoming sceptical about controls that used it. Due to the use of a pentatonic scale, there was some potential for dissonant combination with other mix el-

ements, and the five possible outcomes from a single button press increased complexity leading to a notable reduction in interaction.

In future implementations the round-robin method will be favoured for the benefit of its inbuilt predictability. The variability of the random walk method is considered to pose a greater cognitive load, which presents more challenges to those living with dementia.

6.2 Response to Complexity levels

Overall, we observe an inverse relationship between complexity and interaction. Increases in complexity (either through increasing invariability or operational complexity) result in less interaction with a particular interface element and underlying procedure. One and two action operations in this case were most successful in promoting repeat interaction across both Audio Playground sessions. In both cases three and five action operations appeared to cause greater confusion in participants and discourage further interaction. This aligns with findings from [52] where requests for complexity, realised through more freedom in timing, were met with lower enjoyment levels. This denotes an area for future research in finding ways to increase richness and extension in the musical experience without triggering a negative response to complexity, a key design recommendation reflected by Pigrem et al. [40].

6.3 Modes of Interaction

The two modes of interaction explored (range finding and creative engagement) highlight a particular shift in participant interaction towards a more autonomous and embodied experience. Similar approaches to discovery with a new musical device were reported by McPherson et al. [44] in relation to unguided learning. The two modes of interaction we explore also find resonance with the notions of 'divergent exploration' and 'convergent honing behaviour', highlighted by Tubb [54]. This is an area of particular interest to our research with minimal current work focused on facilitating this agency or exploring its potential in musical interventions designed for those living with dementia. This initial proof of concept highlights space for greater exploration as work within the community develops.

6.4 Engagement

In terms of engagement our data demonstrates the potential for such platforms in use with those living with dementia. Although some of our participants were in the early stages of their dementia, they remained engaged throughout the workshop tasks, with engagement level increasing throughout for most (6/8) participants in their second use of the device (AP2). Although one participant had lower engagement levels during the task, it was clear through conversation across all workshops that their interest lay more in dancing rather than in controlling the music. They also had a hearing impairment which may have affected how engaging the audio playground material was for them. We are keen to see how this relationship will develop further with successive interactions.

As dementia is quite a unique and progressive disease, and approaches to observing and quantifying the benefits of musical interventions are relatively new, we find ourselves with minimal surrounding data with which to compare our results. In comparison with existing usage of the VASE scale [36] the engagement scores we observed were high, with minimal challenging or negative behaviours observed. Through continuing to assess using these approaches greater benchmarks for performance can be established and comparison and evaluation of progress will be possible.

7. CONCLUSION

To conclude, our research starts a conversation surrounding the agency provided to those living with dementia through musical interventions, and how factors such as creativity and unguided exploration can be achieved. We demonstrate the potential they have to foster independence and autonomy, and present and evaluate a platform to facilitate their use. We hope sharing through this work with the community, we can develop greater discourse surrounding dementia and the need to design for cognitive decline.

8. ACKNOWLEDGMENTS

We would like to thank all those who have supported or participated in our research to date, as well as the stakeholders and community partners who make it all possible, in particular for this study, Jo-Anne Levesley. This research is funded by a UKRI Future Leaders Fellowship to author JM (Grant Number MR/T040580/1).

9. ETHICAL STANDARDS

The research has involved multiple stakeholders in consultancy and involvement activities, as set out in [3]. Participants were contacted through one of our community partners, an established group in the community for people living with dementia, and volunteered to take part in our workshops. Information was provided in several ways (print, talking through by a researcher and by a community organiser) to facilitate the full participation of people living with dementia. The participants provided their written informed consent, and all published data is fully anonymous. The research was reviewed and approved by the Departmental Ethics Committee at The University of Sheffield (United Kingdom), reference 052547.

10. REFERENCES

[1] A. Baird and W. F. Thompson. The impact of music on the self in dementia. *Journal of Alzheimer's Disease*, 61(3):827–841, 2018.

[2] F. A. Baker and P. A. Stretton-Smith. Group therapeutic songwriting and dementia: exploring the perspectives of participants through interpretative phenomenological analysis. *Music Therapy Perspectives*, 36(1):50–66, 2018.

[3] G. Bammer. Key issues in co-creation with stakeholders when research problems are complex. *Evidence & Policy*, 15(3):423–435, 2019.

[4] K. Barad. Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of women in culture and society*, 28(3):801–831, 2003.

[5] K. Barad. *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning.* duke university Press, 2007.

[6] S. Benveniste, P. Jouvelot, B. Pin, and R. Péquignot. The minwii project: renarcissization of patients suffering from alzheimer's disease through video game-based music therapy. *Entertainment Computing*, 3(4):111–120, 2012.

[7] M. Boulay, S. Benveniste, S. Boespflug, P. Jouvelot, and A.-S. Rigaud. A pilot usability study of minwii, a

music therapy game for demented patients. *Technology and health care*, 19(4):233–246, 2011.

[8] G. Boyle. Autonomy in long-term care: a need, a right or a luxury? *Disability & society*, 23(4):299–310, 2008.

[9] H.-I. Cheng and R. Alifa. An ergonomic study for developing a digital musical instrument for the elderly. *ICIC express letters. Part B, Applications: an international journal of research and surveys*, 10(8):749–754, 2019.

[10] H.-I. Cheng, R. Alifa, and H. Lee. The effectiveness of music therapy system for the elderly with mild cognitive impairment. In *Proceedings of the 2019 7th International Conference on Information Technology: IoT and Smart City*, pages 445–448, 2019.

[11] I. Clark, N. Christopher, P. Stretton-Smith, and K. Lawson. The experiences of people living with dementia and their care partners participating in an online therapeutic songwriting program. *Dementia*, page 14713012231224069, 2023.

[12] C. Clarke and E. Wolverson. *Positive psychology approaches to dementia - Introduction*. Jessica Kingsley Publishers, 2016.

[13] S. Clift and T. Stickley. *Arts, health and wellbeing: A theoretical inquiry for practice*. Cambridge Scholars Publishing, 2017.

[14] Y. Cuijpers and H. Van Lente. Early diagnostics and alzheimer's disease: Beyond 'cure'and 'care'. *Technological Forecasting and Social Change*, 93:54–67, 2015.

[15] D. Cutler. Key workers: Creative ageing in lockdown and after, 2020.

[16] R. Dowlen and R. Fleetwood-Smith. 10 from symptoms to citizenship. *A Critical History of Dementia Studies*, 2023.

[17] R. Dowlen, J. Keady, C. Milligan, C. Swarbrick, N. Ponsillo, L. Geddes, and B. Riley. In the moment with music: An exploration of the embodied and sensory experiences of people living with dementia during improvised music-making. *Ageing & Society*, 42(11):2642–2664, 2022.

[18] M. Elliott, P. Gardner, M. Narushima, and L. McCleary. Music lessons: Exploring the role and meaning of music for older adults with dementia. *Canadian Journal on Aging/La Revue canadienne du vieillissement*, 39(4):586–599, 2020.

[19] D. Fancourt, A. Steptoe, and D. Cadar. Community engagement and dementia risk: time-to-event analyses from a national cohort study. *J Epidemiol Community Health*, 74(1):71–77, 2020.

[20] S. Favilla and S. Pedell. Touch screen collaborative music: Designing nime for older people with dementia. In *NIME*, pages 35–39, 2014.

[21] A. Förster and M. Komesker. Loopblocks: design and preliminary evaluation of an accessible tangible musical step sequencer. In *NIME 2021*. PubPub, 2021.

[22] C. Frauenberger. Entanglement hci the next wave? *ACM Transactions on Computer-Human Interaction (TOCHI)*, 27(1):1–27, 2019.

[23] E. Frid. Accessible digital musical instruments-a survey of inclusive instruments. In *Proceedings of the International Computer Music Conference*, pages 53–59. International Computer Music Association, 2018.

[24] E. Frid. Accessible digital musical instruments—a review of musical interfaces in inclusive music practice. *Multimodal Technologies and Interaction*, 3(3):57, 2019.

[25] B. L. Giordano and S. McAdams. Material identification of real impact sounds: Effects of size variation in steel, glass, wood, and plexiglass plates. *The Journal of the Acoustical Society of America*, 119(2):1171–1181, 2006.

[26] P. Haggard and M. Tsakiris. The experience of agency: Feelings, judgments, and responsibility. *Current Directions in Psychological Science*, 18(4):242–246, 2009.

[27] E. Han, J. Park, H. Kim, G. Jo, H.-K. Do, and B. I. Lee. Cognitive intervention with musical stimuli using digital devices on mild cognitive impairment: A pilot study. In *Healthcare*, volume 8, page 45. MDPI, 2020.

[28] M. C. Hillebrand, E.-F. Lehmann, L. Weise, E. Jakob, and G. Wilz. The dementia coding system (decs): Development and initial evaluation of a coding system to assess positive, challenging, and music-related behaviors of people with dementia. *Nordic Journal of Music Therapy*, 32(3):185–201, 2023.

[29] S. Holland, T. Mudd, K. Wilkie-McKenna, A. McPherson, and M. M. Wanderley. *New Directions in Music and Human-Computer Interaction*. Springer, 2019.

[30] I. S. Hong and M. J. Choi. Songwriting oriented activities improve the cognitive functions of the aged with dementia. *The Arts in Psychotherapy*, 38(4):221–228, 2011.

[31] L.-C. Hydén and E. Antelius. *Living with dementia: relations, responses and agency in everyday life*. Bloomsbury Publishing, 2017.

[32] G. Kenning, A. Ilsar, R. Brankaert, and M. Evans. Improvisation and reciprocal design: Soundplay for dementia. In *Dementia Lab Conference*, pages 82–91. Springer, 2019.

[33] P. C. Kontos. Ethnographic reflections on selfhood, embodiment and alzheimer's disease. *Ageing & Society*, 24(6):829–849, 2004.

[34] D. Lai, J. Crutch, Seb, J. West, E. Harding, E. Brotherhood, R. Takhar, N. Firth, and M. Camic, Paul. Vase source code, Aug. 2020.

[35] D. Lai, S. Crutch, P. M. Camic, J. West, E. Harding, and E. Brotherhood. Video analysis scale of engagement (vase): Initial and final protocols, 2020.

[36] L. D. Lai, S. J. Crutch, J. West, E. Harding, E. V. Brotherhood, R. Takhar, N. Firth, and P. M. Camic. Development of the video analysis scale of engagement (vase) for people with advanced dementia. *Wellcome Open Research*, 5, 2020.

[37] A. Lucas, J. Harrison, F. Schroeder, and M. Ortiz. Cross-pollinating ecological perspectives in admi design and evaluation. In *NIME 2021*. PubPub, 2021.

[38] J.-B. Mabire, N. Bouaziz, A. de Malherbe, and K. Charras. Inclusive choir for persons living with dementia: A qualitative study. *Activities, Adaptation & Aging*, 47(4):501–518, 2023.

[39] J. MacRitchie, G. A. Floridou, J. Christensen, R. Timmers, and L. de Witte. The use of technology for arts-based activities in older adults living with mild cognitive impairment or dementia: A scoping review. *Dementia*, 22(1):252–280, 2023.

[40] J. MacRitchie, J. Pigrem, and A. McPherson. Instructions not included: dementia-friendly approaches to dmi design. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. New Interfaces for Musical

Expression, 2023.

[41] E. Mariani, M. Vernooij-Dassen, R. Koopmans, Y. Engels, and R. Chattat. Shared decision-making in dementia care planning: barriers and facilitators in two european countries. *Aging & Mental Health*, 21(1):31–39, 2017.

[42] O. McDermott, M. Orrell, and H. M. Ridder. The development of music in dementia assessment scales (midas). *Nordic Journal of Music Therapy*, 24(3):232–251, 2015.

[43] A. McPherson and V. Zappi. An environment for submillisecond-latency audio and sensor processing on beaglebone black. In *Audio Engineering Society Convention 138*. Audio Engineering Society, 2015.

[44] A. P. McPherson, A. Chamberlain, A. Hazzard, S. McGrath, and S. Benford. Designing for exploratory play with a hackable digital musical instrument. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*, pages 1233–1245, 2016.

[45] G. J. Mitchell, S. L. Dupuis, and P. Kontos. Dementia discourse: From imposed suffering to knowing other-wise. *Journal of Applied Hermeneutics*, 2013.

[46] R. Motta-Ochoa, N. Incio Serra, A. Frantz, and S. Blain-Moraes. Enacting agency: movement, dementia, and interaction. *Arts & Health*, 14(2):133–148, 2022.

[47] D. O'Connor, J. Mann, and E. Wiersma. Stigma, discrimination and agency: Diagnostic disclosure as an everyday practice shaping social citizenship. *Journal of Aging Studies*, 44:45–51, 2018.

[48] J. Pigrem and A. McPherson. Do we speak sensor? cultural constraints of embodied interaction. New Interfaces for Musical Expression, 2018.

[49] J. Pigrem, A. Mcpherson, N. Bryan-Kinns, and R. Jack. Sound-> object-> gesture: Physical affordances of virtual materials. In *AudioMostly 2022*, pages 59–66. 2022.

[50] T. Särkämö. Singing the blues away: reduction of depression in dementia by recreational choir singing. *The Lancet Healthy Longevity*, 3(3):e124–e125, 2022.

[51] S. K. Smith, A. Innes, and S. Bushell. Music-making in the community with people living with dementia and care-partners–'i'm leaving feeling on top of the world'. *Health & Social Care in the Community*, 30(1):114–123, 2022.

[52] J. R. Taylor, A. J. Milne, and J. Macritchie. New musical interfaces for older adults in residential care: assessing a user-centred design approach. *Disability and Rehabilitation: Assistive Technology*, pages 1–13, 2021.

[53] J. R. Taylor, A. J. Milne, and J. Macritchie. New musical interfaces for older adults in residential care: assessing a user-centred design approach. *Disability and Rehabilitation: Assistive Technology*, 18(5):519–531, 2023.

[54] R. Tubb and S. Dixon. The divergent interface: Supporting creative exploration of parameter spaces. In *NIME*, pages 227–232, 2014.

[55] M. van der Byl Williams and H. Zeilig. Broadening and deepening the understanding of agency in dementia. *Medical Humanities*, 2022.

[56] M. C. Ward, C. Milligan, E. Rose, M. Elliott, and B. R. Wainwright. The benefits of community-based participatory arts activities for people living with dementia: a thematic scoping review. *Arts & health*, 13(3):213–239, 2021.

[57] G. Wong and M. Knapp. Should we move dementia research funding from a cure to its care?, 2020.

[58] H. Zeilig, V. Tischler, M. van der Byl Williams, J. West, and S. Strohmaier. Co-creativity, well-being and agency: A case study analysis of a co-creative arts group for people with dementia. *Journal of Aging Studies*, 49:16–24, 2019.