Touch Screen Collaborative Music: Designing NIME for Older People with Dementia

Stu Favilla
Faculty of Art, Health Sciences & Design
Swinburne University of Technology,
Melbourne, Australia
sfavilla@bigpond.com

Sonja Pedell
Faculty of Art, Health Sciences & Design
Swinburne University of Technology,
Melbourne, Australia
spedell@swin.edu.au

ABSTRACT
This paper presents new touch-screen collaborative music interaction for people with dementia. The authors argue that dementia technology has yet to focus on collaborative multi-user group musical interactions. The project aims to contribute to dementia care while addressing a significant gap in current literature. Two trials explore contrasting musical scenarios: the performance of abstract electronic music and the distributed performance of J.S. Bach's *Goldberg Variations*. Findings presented in this paper demonstrate that people with dementia can successfully perform and engage in collaborative music performance activities with little or no scaffolded instruction. Further findings suggest that people with dementia can develop and retain musical performance skills over time. This paper proposes a number of guidelines and design solutions.

Keywords
Touch-screen technology; Collaborative Interaction; Dementia

1. DEMENTIA AND MUSIC
Defined as a syndrome, dementia is a collective name for several degenerative brain disorders, which include Alzheimer's disease (the most common form of dementia), dementia of the *Lewy Bodies*, and *Frontotemporal* dementia [21]. Attributed to injury or disease, dementia can affect people at any age and is progressive and eventually fatal. It affects memory, cognition, behaviour and emotion. Alzheimer's International reports global dementia numbers to increase fourfold in the vicinity of 135 million by 2050 (Alzheimer's International, 2013).

Within dementia care, music therapy is used to control mood, problem behaviours and even reduce the need for some pharmacological and physical treatments [15]. Music therapy's aim to "promote communication, relationships, learning, mobilisation expression, organisation and other therapeutic needs" provides meaningful engagement for people with dementia continuing right to the final stages of the disease [21]. Both *receptive* (music listening) and *active* types of music therapy (where participants are actively involved playing instruments) are tailored to suit the individual's particular needs (ibid). Music therapy sessions are often carried out in groups embracing improvisation and supporting reminiscence activities. Growing evidence (although mostly anecdotal) is revealing musical memory's robustness, oftentimes spared right into the later stages of the disease [6].

1.1 Touch Screens and Dementia
Touch screen and tablet technologies are playing a valuable role in dementia care. Studies such as [20], [21] demonstrate how touch screen tablets, such as the iPad, can be effective in both the care facility and home environments. Touch screen technologies have been used to support reminiscence, aid recall, increase interpersonal interactions, promote intergenerational relationships, improve staff and resident relationships and enhance quality of life. Easier to use than a computer and more portable, the use of touch screen technology "encourages increased interpersonal interaction and a positive social environment." [20, pp.27]

At present there are few published studies investigating music interaction with dementia users [16][18][14]. Although ambient music iPad apps such as *Trope* & *Bloom* [6] are often installed onto dementia care iPads, there have been no published studies investigating their use. Collaborative and multi-user music interaction, a special focus within the NIME community, has yet to be trialled and documented for older people with dementia.

Upton et al., [20] suggest that touch screen tablets require a scaffolded (one-to-one mentoring) interaction approach in dementia care. Although this may demonstrate itself over time to be the most appropriate model for dementia user interaction, a one-carer-to-one-dementia user model is neither practical, nor possible to provide in most care facilities. Situated groups of people with dementia, around tables or in sitting areas are common. In this scenario, collaborative and multi-user music activities could be valuable, where a single caregiver can mentor/scaffold an ensemble of people with dementia.

Touch screen tablet computers have been used to create powerful and expressive controllers for digital music. Jazz Mutant's LEMUR controller has demonstrated the power of multi-modal and multi-touch control. Contemporary iPad Apps including *Midi-touch* and *TouchOSC* [7] are well suited to developing *collaborative* [1], *multi-user* [9] performance systems whereby a number of performers iPads each transmit to a single host computer. The host computer interprets the control gestures and produces the resulting sound, which is amplified for the musicians (and audience).

The gathering of controllers to a single host computer creates opportunities where many players can actively contribute to the formation of just one sound, create a texture or part in the musical fabric, or participate in complex interactions. Additionally the computer can provide agency in the creative process where algorithms compose melody, harmonization, audio-mixing or engage random and generative processes. The success of a system depends on the balance of complexity and expressivity [1] and on how well the player is engaged and encouraged [8].

2. RESEARCH STUDY
We set ourselves the task of designing a NIME project to collaboratively engage a group of older adults with dementia using a range of music touch screen applications. 12-14 participants were recruited from an activity group of elderly people with dementia (and their carers) organised by Wyndham City Council as part of their ageing-well program. The council

had purchased 12 iPads with the objective to engage older people with dementia in technology use. The management realised that the older people had no iPad experience, and that the centre had no suitable applications to engage this group over an extended period. Our initial aims were to explore the potential of iPads and music while focusing on the needs and capabilities amongst those in our group of participants. We wanted to discover the potential and limits of such an activity and co-design (with the dementia participants) controllers and music interactions that were enjoyable and engaging.

The group met at a community centre facility during their routine Friday morning activity session. The 12 iPads were managed via a sync/recharge station and a central computer and another laptop was used to develop music interaction software using Max5 object orientated programming language. Interactions and performances were recorded for study comparisons.

The study involved four stages:

1. Preliminary observation of participant interactions with existing music apps
2. Collaborative design of a music controller
    a. Abstract electronic sound
    b. Distributed performance of Bach
3. Interaction studies identifying skill development

For stages 2 and 3, a separate laptop computer was used to host music sound and interaction software. Portable personal speaker systems were connected to this computer for the participants to monitor their performance.

Data was collected in various forms, initially through journaling observations and voluntary interviews, and then by recording iPad gestural control data and video. IPad controller software was designed in *TouchOSC* and set to transmit to a single host laptop computer. The host computer software was composed in Max5 alongside data recording and analysis software engines.

2.1 Data collection: Observations

The first visits to the centre were spent getting to know the group of participants. This was an essential and important step in our research process and it took a number of weeks to establish trust and a good rapport. Activities undertaken during this phase of the research included playing games on the iPads together, exploring existing commercial music apps and singing around a piano (played by one of the researchers).

The exploration of commercial music apps proved very enlightening. These music apps consisted of the *Tiny Piano* (http://www.tinypiano.com/) and *Rhythm Pad* apps (http://rhythmpad.com/). Neither of these applications kept any of the participants engaged for very long (approx. 5 minutes). Through observations we concluded the main reasons for this were:

1. Screen controls and objects were way too small (both to see and locate with the fingertip)
2. iPad speaker sound was too quiet
3. The sounds demonstrated a blunted expression (i.e. same attack and dynamic)
4. Interaction was limited to one-shot triggering of sounds

In addition, participants commented on the toy-like quality of these apps. Riley, Alm, & Newell [14] discuss the importance of engaging older people with dementia without patronising them. Most of the participants also struggled to operate the apps successfully. This poses an interesting design challenge.

Further, close and careful observation revealed that many of the group participants suffered from other age-related conditions including:

1. Poor vision, due to macular degeneration and glaucoma (restricted fields of vision)
2. Significant hearing loss
3. Loss of touch and tactile sensitivity (*tactile agnosia*)
4. Motor tremors and mild spasms restricting fine motor control (*apraxia*)
5. Short and limited attention span
6. Cognitive impairment and mild *aphasia*

People with aphasia experience gaps in their recognition of speech, words, letters, symbols and numbers. As it is caused by degenerative disease and or injury, one patient's expression of aphasia is often unique [22].

These age-related factors represent a considerable challenge for NIME designers. The multi-modality of touch screen interaction clearly offers potential though. For example, we observed at the beginning of each session that most of the participants could not find (or remember) how to physically switch their iPads on. The power switch for the iPad is small and around the side of the tablet. Once the tablets were on and displaying the log-in window however, all participants would effectively accomplish the "slide and unlock" gesture to reach the tablet desktop screen. The swiping gesture was remembered from one session to the next, whereas the pushing of a small black plastic button was not.

We also observed a number of participants who had difficulty making capacitive contact with the touch screen surface. As far as we can ascertain this is due to the lack of moisture of the surface skin of their fingertips, the amount or distribution of pressure, (due to *apraxia* and /or *tactile agnosia*) or a combination of both.

3. INSTRUMENTS

Our approach was to adopt a collaborative design process using *TouchOSC and Max5.* Given these design constraints we opted for a simple controller approach and planned to maximise the expressive capabilities of the interactions. We also decided to amplify the sounds using external speakers (or headphones). To test our idea of music expression and simple control mechanisms we decided to put the participants in an unfamiliar musical setting, i.e. abstract electronic music.

Our first offering to the dementia group was an abstract synthesis instrument consisting of nine touch buttons arranged in a grid and a 2D (x/y) touchpad controller situated left (see figure1). We coupled these controllers via *OSC* (via *WiFi*) to an unusual abstract synthesis sound engine in Max5 comprising a simple FM synthesis algorithm, modulation tones and ring modulator effects. This sound engine was located on a laptop, which in turn was coupled to an audio interface and four loudspeakers. The parameters of the Max patch were mapped across the 2D touchpad to maximise a large range of sound transformation. Particular settings of the algorithm were saved as snapshots using the preset object and this allowed each of the nine buttons to play distinct sounds as departure points for 2D x/y control pad improvisation.

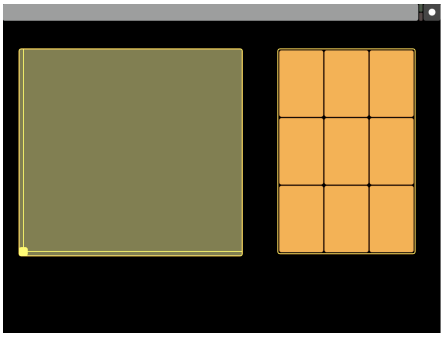

Figure 1. iPad Controller 1, 2D Touchpad and 9 Buttons

The system produced a large array of abstract yet expressive sounds including tones, whines, chortles, groans, roars, whistles and pops. First a sound is selected, using one of the nine buttons. Then by moving the x/y control pad, a large range of transformations and modifications could be made to the sound in real-time.

"*Sound is very good—very interesting. I like this!"* says one of the participants who loved the controller. The participant played with the app for well over an hour and had never played a musical instrument nor heard of electronic music before. The care-staff were all very surprised to see his enjoyment and engagement in the activity.

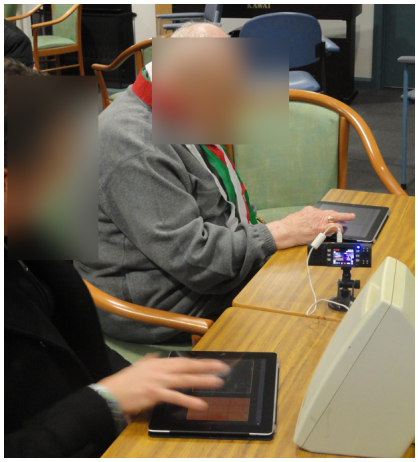

Figure .2 The Author & Participant Playing

Also other participants explored the controller in depth and played together in a number of improvised jam sessions. The simple layout required a minimum in scaffolding and mentoring, which consisted of a minimal 20 second demonstration. The facilitation of a separate loudspeaker greatly aided the enjoyment of music making. *"There are many different sounds and things you can do,"* commented one participant. A trace of x/y control pad movements over 5 minutes (see fig 3. left) compared to the author's (see figure 3. right) demonstrates a prolonged and methodical exploration.

We discovered right-handed players would sometimes accidently activate the buttons with their palm or other fingers while playing the x/y pad. Other participants that had previously played music commented that the controller bore no resemblance to any musical instrument. A few participants refused to play saying that the sounds (although interesting) were just noise or just too weird.

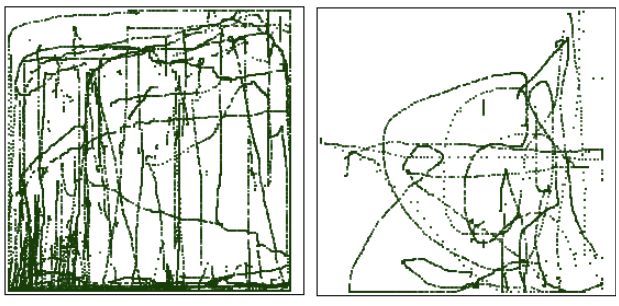

Figure 3. Five Minute Trace of Jam session (participant's interaction on the left and author's on right side)

3.1 Bach's Goldberg Variations

Responding to ongoing feedback, a number of controller iterations were trialled with the participants. The buttons were arranged to resemble a piano keyboard. The x/y control pad was re-located in the lower right and additional speaker panning controls were added (then later removed). The controllers were also rendered in four different colours for ensemble settings, green, orange, red and purple (see figure4 Controller Iterations).

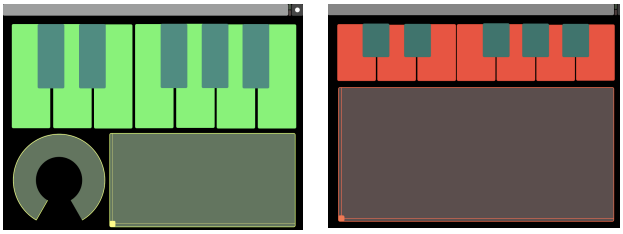

Figure 4. iPad Controller Iterations

During this trial phase the iPads' music activity shifted to a more conventional stimulating musical setting, that of Bach. The interaction centred on controlling the expression of a pre-recorded keyboard performance of Bach's *Goldberg Variations*. This pre-recorded MIDI performance was data-stripped in real-time. The x/y pad was mapped to control the attack (loudness & brightness along the *x*-axis), while the duration of each note was mapped to the *y*-axis, (notes being shortest towards the bottom of the screen).

Two participants would play as a duo, each iPad controlling either the bass (left-hand) or treble (right-hand) parts. The distribution of performance roles allows participants to collaboratively re-interpret the performance. The MIDI file data was recorded by a concert pianist and contained a great deal of expressive information, i.e. ornamentation, touch and timing. The control mapping preserved the timing and ornamentation yet allowed for the control of dynamics, touch and note duration (extending from very short staccato through to broad legato playing).

The keyboard was used to select different instrument sounds ranging from acoustic grand pianos, forte piano, harpsichord, guitar, harp etc. together with a range of modern electric pianos, *Wurlitzers* and clavichords. The sounds were equalised, blended and mixed with reverberation. Care was taken to present high quality realistic sounds each with its own distinct characteristics.

Care was also taken to reward the participant's movements with rich and responsive sonic detail. The quality of the engagement was strongly evident during these trials with participants commenting on the beauty and the quality of the musical experience. There was little need for explanation, simple demonstration sufficed. After a period of exploration, the participants were encouraged to listen to each other's playing and then respond. At this point the interaction would change, as each participant listened and adjusted to one another's dynamics, touch and expression. Often players would adjust their note durations to be in opposite, accentuating their own parts in the mix (see figure 5).

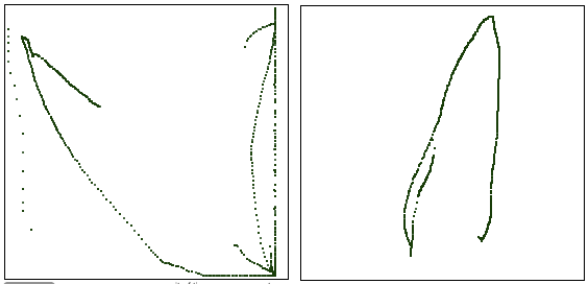

Figure 5. Two participant's joystick traces over 30 seconds

Other styles of piano music including Jazz and Ragtime were also trialled. However, the contrapuntal lines of the Bach examples were better suited to collaborative play where each participant could clearly identify their own part and how their actions related to changes in the sound and expression of the music.

4. INTERACTION STUDIES

Collaborative performance became a focus for a range of investigative work exploring changes in interaction over time. Video, audio, MIDI, OSC data alongside careful observation and staff feedback were gathered for study and analysis. Of special interest were a smaller group of four people who participated throughout all of the data recording sessions. Two of these participants in particular, had been disinterested during the previous iPad activities including games, Google searches and reminiscence activities.

These two participant's touch-pad traces demonstrated a change (refinement) in interaction style across a six week trial period with the Bach interactive activity. This was also confirmed by music and video data. Certain features emerged such as shorter deliberate movements (changing note durations), leaving the 2D controller in a specific place for a period, bursts of focused activity within a specific sector and long sideways sweeps changing musical dynamics.

These examples of actions (see examples in figure. 7) contrasted markedly with their initial style of play (see examples figure. 6). The initial style of play typically maintained a slow steady speed, with minimal changes to direction and circuit tracing around the perimeter of the touchpad. This development of style over time signalled a shift from *exploratory* to *performatory* action [10] or development of *adroit* action [4]. The emergence of *performative* data features suggests that these two participants developed and retained performance skill during the six week trial period.

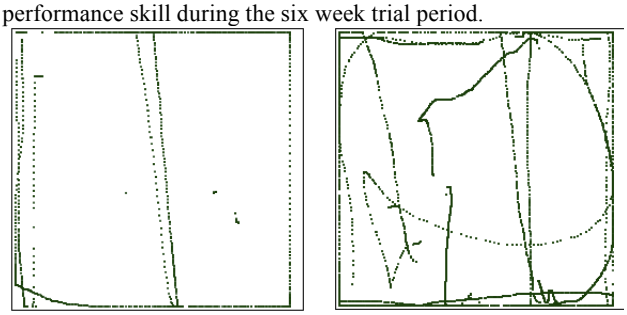

Figure 6. 1min *exploratory* actions (2users, week1)

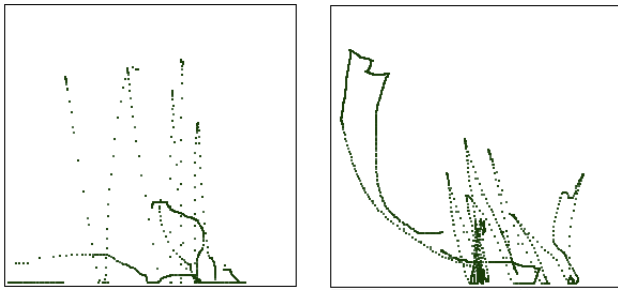

Figure 7. 30sec of *performative* actions (same users, week 6)

However, further studies with more participants are needed to confirm these findings. Nonetheless they are quite intriguing as they suggest that older people, with progressed dementia, are not only capable of performing and enjoying musical computer interaction, but also able to develop and retain performance skill over time.

5. DESIGNING FOR DEMENTIA

Our experience working with older people with dementia and iPads suggests that success is dependent on the ***quality*** of the musical interaction. To assist other NIME researchers, composers and musicians wishing to design for older people with dementia we propose the following eight guidelines.

5.1.1 Rich and stimulating exploration

We found that a number of participants were happy to play bizarre abstract electronic sounds ***and*** Bach's Goldberg variations. Unlike the commercial iPad apps that we also trialled, both the electronic and Bach interactions provided a large variation of expressiveness with a simple layout affording exploration.

5.1.2 Appropriate amplification

The quality of play is dependent on the quality of auditory feedback. The participants loved their own speakers and loved to hear the sounds of other participants through their own respective speakers around the table.

5.1.3 Responsive and expressive interaction

We also found the participants tuned in quickly to the expressive attributes of the interaction. They delighted in the discovery of bizarre chortles and beating effects. They enjoyed the detail of the sounds and their capacity to change the music's character.

5.1.4 Provide participants with identifiable roles

Successful collaborative play required clearly defined roles for each participant (such as playing the bass for example). They required separate fold-back speakers and benefited from being seated facing or side-by-side.

5.1.5 Encourage participants to engage each other

When participants listened to each other and played together the results were quite surprising. Some of the participants who were socially withdrawn clearly benefited from the inclusive and non-competitive activity.

5.1.6 Reward movement but allow for rest

All the participants in our group needed to rest during their musical interactions either from tiredness, spasms, pain or other related injuries. It is essential to take this into account when designing music interfaces for older people. Force feedback, haptile pressure sensors and auto centring controls are not appropriate for older people with dementia.

5.1.7 Simple design but not patronizing

Older people with dementia respond to simple and easy to use control interfaces. However, the participants in our study group responded well to rich and complex musical situations. IPad apps such as *Tiny Piano* and *Rhythm Pad* were considered by many of them to be suited for children.

5.1.8 Minimal scaffolding (short demonstration)

The participants in our group were much more interested in doing rather than being shown how to do something. Touch screen music interaction has the potential to provide endless hours of enjoyment and interest and help introduce dementia users to technology in group settings (see figure 8).

Figure 8. Group Setting

6. CONCLUSIONS

This paper presented new iPad controllers and interactive music software for engaging older people with dementia. We have identified a number of key design challenges for researchers concerning older people with dementia. This paper also demonstrates dementia to be a relevant new area for NIME research.

Results from two trials established that older people with dementia can successfully participate in collaborative music performance activities for extended periods (up to 90 minutes) with little or no scaffolded instruction. A six week trial suggests there is potential for older people with dementia to acquire and retain performative action (skilled performance) in a collaborative music setting.

The project offers eight design guides that can be adapted to a wide range of musical styles and scenarios. Our work suggests that careful attention to sound, collaborative interaction and touch screen control are essential for success.

7. NEXT STEPS

The findings of this study are currently limited by the size, scope and spread of dementia types and stages within the investigated group of participants. Although our group represents a typical cross-section of dementia stages and types, typical of day care centres, targeted studies with larger groups, could reveal therapeutic effects attributable to touch screen music activity.

Touch screen music interaction also has the potential for use in the home and through network interaction the power to connect socially isolated participants with their carers or be used to monitor participants' engagement and activity levels remotely. Work also needs to be done to develop musical scenarios involving larger numbers of participants. Our next collaborative projects are for four participants, four loudspeakers and one musician (laptop).

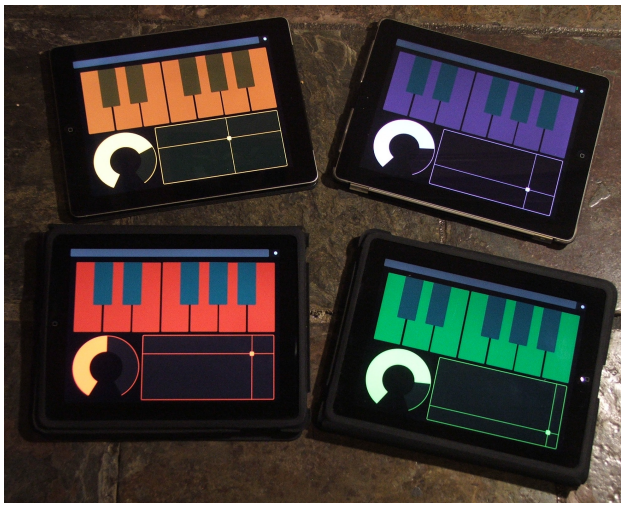

Figure 9. iPad Quartet

8. ACKNOWLEDGMENTS

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