Daisyphone: The Design and Impact of a Novel Environment for Remote Group Music Improvisation

N. Bryan-Kinns
IMC Group, Dept. Computer Science
Queen Mary, University of London
Mile End, London, UK. E1 4NS
nickbk@dcs.qmul.ac.uk

Abstract
Music has lost its role as a central part of many people's everyday action. This paper reports on the design and impact of a novel environment for remote group music improvisation with the view to understanding how we could design more engaging, social, and serendipitous musical environments. The design reported here focuses on the representation of looping music, support for remote collaboration, and support for idea formulation. Observations of use suggest that the environment developed does encourage some group music, and we identify clear areas for future design consideration.

Categories and Subject Descriptors: H.5.3 [Group and Organization Interfaces]; H.5.5 [Sound and Music Computing]: Methodologies and techniques.

General Terms: Design; Human Factors; Performance.

Keywords: Music improvisation; remote group creativity; novel interface.

INTRODUCTION

For thousands of years music has played a part in the action of our everyday lives - songs of greeting, joy, sorrow, work, and so on. Nowadays many of us live in cultures where music no longer plays this role. Instead music is seen as a highly stylized activity requiring serious practice, performance, and accuracy [17]. Recent technological developments such as personal stereos and affordable recording devices, as well as the work of composers such as Reich (*e.g.* see [22]), have started to redress this imbalance through the reintroduction of *everydayness* into our music. For music to retake is place in the action of our everyday lives it needs to be more accessible, spontaneous, and social. This social music making, or *group music improvisation*, has striking similarities to conversation in that it is typically co—present and multimodal, and combines musical signals with verbal and visual cues. In music though, there may be multiple overlapping contributions, and the process of improvisation, or 'instant composition' [15], provides aesthetic satisfaction in itself. Whilst we have seen the development and wide acceptance of informal personal technologies for different forms of conversation such as instant messaging on desktop computers and text messaging on mobile phones (*e.g.* an increase of monthly traffic of text messages on mobile phones from around 5,000 million in Jan 2001 to 30,000 million in Dec 2002; [11]), there is still little evidence of new ways and means of informal *ad-hoc* musical interaction being supported and fostered in everyday life by everyday people. The project reported here seeks to explore how new forms of interaction could support group improvisation of music by people who aren't in the same place, with a future view of this being a new form of social interaction for everyday folk.

The rest of the paper is organized as follows: first new forms of musical interaction are outlined, then the design and rationale for a novel group music interaction environment referred to as Daisyphone are outlined. This is followed by descriptions of studies of the use of Daisyphone, observations and reflections on the results of the studies, and finally the paper is concluded.

MUSICAL INTERACTION

For the purposes of this project new forms of music interaction can be usefully categorized along two dimensions: participation (from individual to local group and remote group) and aim (from composition to improvisation), as exemplified in table 1. Of course, there is a fine line between improvisation and composition. In this paper we assume that those environments which aim to support 'instant composition', where the process of composition is part of the performance itself, are more aimed at improvisation those which aim to support the creation, revision, and review of musical pieces over a longer period of time with an end product to be performed later and possibly by others.

Interfaces for individual composition are exemplified by systems based on the metaphor of a recording studio such as CuBase (Steinberg Media Technologies AG) which supports individual users in the composition, revision and reworking of music. New instruments for individual music making range from virtual instruments recreating physical instruments such as the 'virtual theremin' [2] which substitutes the hand based control of pitch and volume of the conventional theremin with a mouse based interface, through to novel interfaces such as the Audio Visual Environment Suites (AVES) which support real time performance of pieces with abstract audio and visuals [18]. It is worth noting that such instruments could easily be subverted for use by several people locally.

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Currently the means we have to share music with others are predominantly restricted to conventional instruments which require years of training and practice to master, and more importantly do not lend themselves informal social interactions (its difficult to carry a tuba with you all day in case you want to strike up a jam with someone). New developments have started to investigate novel ways to create and share music with others around us such as Jam-O-Drum [4] or Fireflies [26] which provide simple interaction with rhythms on an individual and group basis through small handheld devices, or COOL [13] which provides a central shared instrument around which people gather to create. Also, novel interfaces such as the Augmented composer [3] support the composition of musical phrases through the arrangement of computer recognizable cards on a table supplemented by aural and visual feedback. Blaine and Fels [5] provide an overview of typical developments in the field of supporting collaborative music which highlights the lack of development in remote group music improvisation – only 3 of 18 developments reviewed supported remote improvisation. Moreover, most support for remote group music collaboration is actually for remote *composition* rather than *improvisation*. That is, systems such as Rocket Networks [12] and early versions of FMOL [15], which support the sharing of music files in order to allow musicians to collaborate on composing a piece of music together. Typically this involves individual compositions, sharing of compositions, revision, review, negotiation of final form, and production of a finished piece. This is quite different from the forms of interaction that will provide us with the scope for more informal and everyday creation of music with others in our lives.

Research such as WebDrum [8], and Metatone [16] have begun to explore the collaborative and communicative requirements for group improvisation in geographically remote locations. This typically involves developing a shared visualization of the music being jointly produced and some communication support. In WebDrum II the basic mechanics of the tool are that a short loop of music (in the order of seconds) made up of 8 instruments is shared between the players who can edit notes on instruments they have ownership of. Edits to the loop are shared between players *via* a server, users can change ownership of instruments, and a simple text chat tool is provided to aid collaboration. In this way players can semi-synchronously improvise music together without the inherent network delays creating too much of an impact on their experience.

Table 1. Examples of novel musical instruments

	Composition	**Improvisation**
Individual	CuBase	Virtual Theremin [2] AVES [18]
Local group	Augmented composer [3]	Fireflies [26] Jam-O-Drum [4] COOL [13]
Remote group	Rocket [12] FMOL [15]	MetaTone [16] WebDrum II [8]

Moving Beyond Simply Sharing Notes

Not only are there few environments which support remote group music improvisation, but current approaches to understanding collaboration in general such as distributed cognition [14] are not immediately appropriate in this context. Such approaches tend to focus on the *logistics* of the interaction such as how representations are used to co-ordinate action, or how information is shared and transmitted. We need to understand more about our experience of such collaborations, and therefore need to start raising the design issues from those of logistics to those of how to support creative expression. One might express this as the Winnicottian distinction between *existing* and *feeling real* – how do we design to provide a space in which to *feel real* which, according to some psychoanalytic views, is a basic need of our social nature:

"I am claiming that we have to feel ourselves alive within another person to feel alive within ourselves, and that such a need is basic to our social nature – it makes the difference, in Winnicott's terms, between "feeling real" and merely "existing"." [27]

This 'feeling real' and 'alive' has similarities to phenomenological descriptions of 'flow' [9] – the state in which we feel totally engaged and immersed in the task at hand. The difference here is that we are primarily concerned with 'feeling real' through interaction with others rather than a more individualistic view as typified by research on flow.

DESIGN

The work reported here started in 2002 and draws inspiration from investigations in previous years by post graduates of the Interaction Media and Communication research group at Queen Mary, University of London [16][20]. The aim of the work is to investigate ways in which we could design environments for remote group music improvisation which are easily grasped by players, and encourage spontaneous social interaction. As a first step a prototype environment referred to as Daisyphone was developed. The design of Daisyphone focuses on novel representations of music and support for human interaction whilst taking into account the possible form factors of personal interaction devices such as PDAs, mobile phones, and graphic tablets. Three design criteria of Daisyphone are explored in this section as follows:

- Representation and interaction with looping music.
- Support for remote collaboration.
- Support for formulation of musical ideas.

Representation of Music

Current approaches to representing loops of music typically lay the sequence of notes in the loop from left to right as would be seen in a device such as a music sequencer. However, we believe that this is not an intuitive way of representing looping music. When observing novices it is often clear that they find this representation difficult to use, and their loops to not 'join up' – there is no musical flow from the end of the loop to its start. Instead there is a break

where the loop restarts as illustrated in the composition in figure 1.

This work aims to develop an environment in which novices can easily grasp the looping nature of the music they are producing. We judged that compared to linear representations, circles provide the most obvious representation of the cyclical nature of looping music. Circular representations of music can be seen in developments of music boxes, player pianos, and other musical machines from the 1880s onwards (see [21]). These play longer loops of music than the barrel style devices which had been in use for bell ringing for many hundreds of years previous. Notes to be played are indicated by pins or holes in the disc which cause plucking of musical combs or striking of percussive instruments. In a typical music box such as a Polyhon, the disc rotates whilst the play-head with associated instruments remains static underneath it. Needless to say, one cannot easily collaborate with other people using such music boxes as the representation is static and constantly moving, but they do provide a neat physical representation of looping music. Some interesting early patents for disc-playing musical boxes had the discs stationary with rotating play-heads (Lochmann, 1886), and Miguel Boom even patented a re-pinnable disc in 1882 which allowed consumers as well as producers to create and edit the stored music. More recent circular representations of looping music are few and far between. Notable exceptions are COOL's physical rotating disc of notes [13] and Soundscapes developed by Interval Research Corporation in 1995 (see [18]).

The design of Daisyphone combines a circular representation of music with a moving play head. Notes are arranged in sequence around the circle, and the play head rotates around the circle playing the notes underneath it.

Interaction Design

Daisyphone is intended to be used on a variety of form factors, by a variety of users, and to move away from preconceptions of what desktop PC music systems might be. As such, no standard desktop user interface features such as buttons, menus, or drop down lists are used. This section describes the novel interaction design and its use.

Figure 1 illustrates a typical session of Daisyphone use, and figure 2 illustrates Daisyphone running on a graphical tablet used in some of the studies. Much of the screen is taken up by the circular daisy on which musical notes are placed and removed by clicking the small circles. The pitch of notes decreases with distance from the centre. Four different musical sounds are provided and represented by the square, round, diamond, and triangle shapes which players select by clicking on the central stamen of the daisy (a modal operation). Saturation of color represents the volume of the note, and hue indicates who contributed it – each player is assigned a unique hue when they join a Daisyphone session. In figure 1 there are two players who are represented by green and blue hues. Note that unlike other musical devices such as Poco [23] in which physical form is intended to have some musical semantic, the shapes of notes are abstract leaving players to interpret the sounds they make rather than being cued by them.

The grey line or 'arm' illustrated in the figure reaching from the centre of the circle to the bottom of the screen continually rotates clockwise and plays notes that are below it – this is the play head.

In Daisyphone graphical annotation is continuous and persistent – whenever the player presses their mouse button, or touches their pen to the tablet, a graphical mark is made in the players' hue and shared with others. This means that players can easily add comments, and some notion of the history of the interaction is maintained. Also, this is intended to provide a more 'messy' interface than usual with group music devices in an attempt to encourage exploration, fun, and contextualization (*cf.* [10]). In figure 1 we can see that the players have written words around the daisy, drawn smiley faces, written their names, and commented on each others' work. In addition, we can easily see that there was a ring of notes in the centre of the daisy as the annotation has persisted, but the notes have since been removed (probably because they sounded awful).

In the top left hand corner a session selector displays miniature representations of the content and activity of other sessions. Clicking on these circles changes the player's current session. In figure 1 there appears to be only one session in use as only one of these circles has any content.

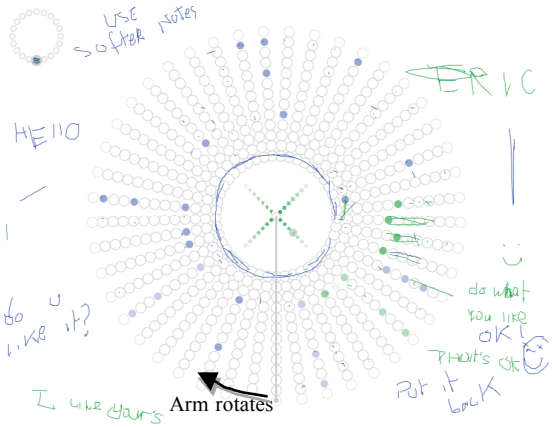


Figure 1: Daisyphone.

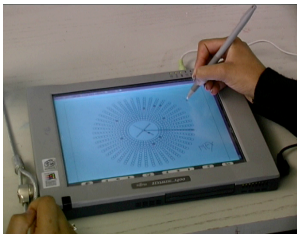


Figure 2: Daisyphone on a tablet PC.

Remote Collaboration

Next to representation of the music itself, the most important design considerations are what support for collaboration should be designed into the environment. A study of the use of WebDrum II [8] provides some useful insight into such design criteria by outlining what features

of human communication are needed to support group music improvisation [6][7]. In the study three trios of postgraduate students were asked to learn to use WebDrum II over the period of a week, and were then asked to perform a piece of music for two judges who monitored the music remotely. They were given up to thirty minutes, or until they felt satisfied with the music. As the players were remotely located they had to co-ordinate the composition through WebDrum II; the logs of the text chat were saved for later analysis. After the performance players were briefly interviewed about their experience and key issues they had as they learnt to use WebDrum II, and as they performed their piece. From analysis of the logs and the interviews it was suggested that four features of human interaction are necessary to increase the propensity of players to jointly produce creatively. These design features were taken into account in Daisyphone's design as follows:

Localization within the artifact being produced – being able to indicate which aspect of the group composition you are referring to in discussion *e.g.* highlighting a certain phrase for further work.

The persistent and continuous graphical annotation in Daisyphone allows players to make a wide range of graphical marks including localization within the music being created. For example, figure 3 illustrates a session in which a player has circled a line of notes and written 'check it'.

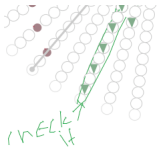


Figure 3: Example of localization using annotation

Mutual awareness of actions – knowing who is contributing what to the group music is supported by the assignment of unique hues to players as they join a Daisyphone session. These are then used whenever a player contributes notes and annotations. Moreover, the session selector 'twinkles' with the hue of players as they make contributions so providing some awareness of activity in other sessions.

Mutual modifiability – being able to modify each others' contributions.

In Daisyphone, players can modify each others' notes as easily as they can modify their own, and moreover, there is no restriction on who use what instruments. This is intended to provide a more egalitarian musical experience than other group music improvisation tools such as WebDrum II [8] which impose ownership of instruments on players. Furthermore, it provides yet another dimension of novelty from traditional group music improvisation where it is not possible to change what other people have contributed, or what they are playing. Interestingly, from observations of Daisyphone's use it is apparent that people very rarely modify each others' contributions even though they can.

Shared and consistent representation – everyone sees what everyone else sees.

In Daisyphone each player sees the same graphical representation and hears the same music being produced. This is because contributions of notes and annotations are shared between up to 10 clients *via* a central server which also keeps a log of all activities. As the clients are loosely coordinated, they may not hear the loop precisely at the same time as each other, but they are sufficiently synchronized to provide the experience of shared composition and improvisation of loops. Technically this approach requires low network bandwidth, and there is no need for streaming audio as simple indicators of notes can be used to share the musical contributions. Moreover, it makes it appropriate for implementation on a number of different platforms and form factors because common technology such as Java can be used.

Idea Formulation

Composition and improvisation rely on creativity and the ability to express ideas at various levels of completeness. Therefore, as well as being able to interact with the music and other players, there needs to be some scope for idea exploration, expression, and consolidation. The question then arises of how to support group idea formulation and expression. We use Tabor's musings on 'spaces for half-formed thoughts' [25] to inspire our design criteria for idea formulation. This is an imagined space for manipulating and fusing half-formed information and ideas experimentally, intuitively, and only half-consciously, and takes its inspiration from notions of designers' and architects' solution spaces in which they explore possible forms and designs. Tabor's description of such a space for forming thoughts is:

"1: Its metaphor is spatial, but its spatial character is not limited by the constraints of real space and physics

2: It contains flowing patterns that reflect incoming data about the world. But we don't just see these patterns: we sense them as sounds and vibrations; we feel them as wind in hair, taste on tongue, tension in muscles

3: Informational patterns are manifested in varying densities of this smoky space; and

4: We can sharpen the outlines of things, make them harder and clearer. But we'd only do so when we feel our ideas are ready to coalesce " [25].

For this design we transform Tabor's features into more pragmatic design features for Daisyphone which we hope will encourage musical idea formulation and expression:

1: **Spatial metaphor** – there is a strong spatial metaphor in Daisyphone where the two dimensional space of the musical device determines the pitch and sequence of notes, and yet it is not constrained by the linear form of typical sequencers and musical scores.

2: **Multimodality** – notes are represented both as sound and as graphical representations which the players interact with.

3: **Patterns** – musical sequences and chords are the information patterns formed in the interface; persistent annotation provides a way of grasping particular patterns in a mass of 'smoky' notes.

4: **Variable focus** – the 'messy' annotation provides players with a means of testing out different ideas graphically before committing them to the musical representation.

Bringing the Design Together

We argue that current group music improvisation environments tend not to address all three design criteria used in this paper – they focus on musical interaction (*e.g.* the Electric Circus), or the logistics of collaboration (*e.g.* Rocket Networks) or idea exploration and performance (*e.g.* Audio Visual Environment Suites). The aim of Daisyphone is to balance musical interaction with collaboration and idea formulation. Experiences of the use of Daisyphone and its ability to meet such an aim are discussed in the rest of this paper.

STUDIES OF DAISYPHONE IN USE

Daisyphone is an ongoing design project which is iteratively developed through studies. This section describes the context for four studies of Daisyphone's use – one pilot, two experience studies, and an examination of ongoing public use of Daisyphone. The aims of the studies are to gather observations of people playing music together in a novel environment in order to identify forms of behavior and responses to the novel interaction. Results of such observations inform our understandings of remote group improvisation and have implications for future designs. The following section presents results of observations in these studies and examination of logs of Daisyphone usage.

Pilot

In order to get Daisyphone ready for the first study, it was briefly piloted with academics from the authors' department. An email was sent to the group of 10 academics indicating the web site to be used and a general description of the tool. They used the tool remotely in their own offices and encountered others who were present in the system. Over a period of two days it became abundantly clear that in future studies players would need to be able to clear the contents of Daisyphone otherwise the environment became full of redundant notes and contributions. This wholesale restarting of the musical collaboration was not anticipated – in early designs it was assumed that players would remove contributions as well as add to them. This is a theme that is returned to in later studies and designs. So, after the pilot the Daisyphone server was modified to make it handle more than one session without having to be restarted.

Experience studies

Two experience studies followed the same format. The first was with school pupils visiting the author's department. 10 pupils aged 16 took part (2 had musical experience and were currently practicing) – these divided into 4 self selecting groups (boy<->boy; girl<->girl&girl; girl&girl<->boy; boy<->boy). After the study Daisyphone was modified to allow players to change the session themselves. The second study took place with 11 attendees of the Interactive Graphical Communication Workshop held in London in August 2003 who were typical post-graduate academics.

In both studies players were given a brief introduction on how Daisyphone works covering the following topics: How to set notes; How to unset notes; How to select different instruments; The shared nature of the representation.

Players were asked to work with semi-remote co-player(s) to try to create a recognizable tune *e.g.* a TV theme tune, or a tune they liked. They had up to 20 minutes to complete the task. During the session with the school pupils players could ask for a new Daisyphone session giving them a blank canvas to work with. This was negotiated between the players of the group. They could return to previous work if they wished; none of the groups revisited old work. After the sessions players were asked to complete a short questionnaire.

Figure 4 illustrates the physical setup of the studies which was intended to provide semi-remote collaboration where non-Daisyphone interaction between remote players could easily be identified and recorded. As such, two desks were set 10m apart to reduce audio contact between the tables. Visual contact could be achieved by turning away from the table, and vocal communication achieved through shouting. Each desk had on it: a tablet running Daisyphone, an instruction sheet, and a pair of speakers connected to the tablet. The tablets used were Fujitsu Stylistic 1400 running Windows 98 and Internet Explorer. These were wirelessly networked on an *ad-hoc* WIFI network with an iBook running the server software.

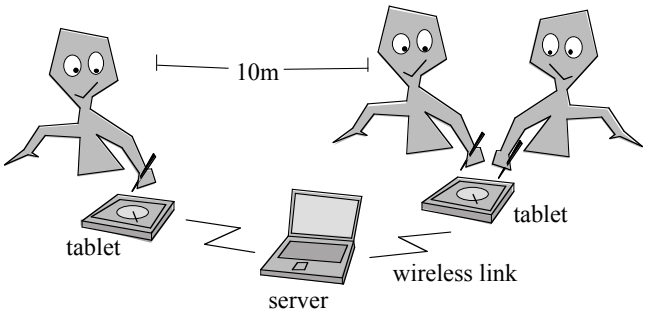


Figure 4: Physical setup of studies

Public Usage

Daisyphone has been publicly available for use over the internet[1] since its launch on 25 Oct 2003 [19]. In November 2003 it received between 4 and 18 players per day from all over the world. Logs of public use are still collected and examined daily.

[1] http://gouda.dcs.qmul.ac.uk

OBSERVATIONS

70 minutes of logs of school pupils' activities and 41 minutes from IGC workshop activities were gathered (ignoring initial setup, and closing interactions) along with ongoing logs of public use. These logs were analyzed by re-playing the interaction using a log tool and examining overviews of the data in order to identify emergent behavior, and the patterns of interaction that occurred. These analyses are reported in this section.

The log tool developed for Daisyphone provides an interactive overview of contributions. A typical overview of a 4 minute interaction between two players is shown in figure 5. Time is represented horizontally from left to right, points in the timeline indicate a contribution of some sort with each column representing one second of interaction, so the amount of activity is indicated by how tall the columns are. As with Daisyphone itself, colors represent users – in this example group **A** is red/ purple, whereas group **B** is blue. Note that there are multiple saturations of the same color as saturation represents the volume of the contribution. Yellow points indicate the removal of notes in Daisyphone. The interaction was manually grouped into segments by the numbers added at the top of the diagram. Clicking within the overview causes a Daisyphone connected to the log tool to replay the state of the interaction at that point in time.

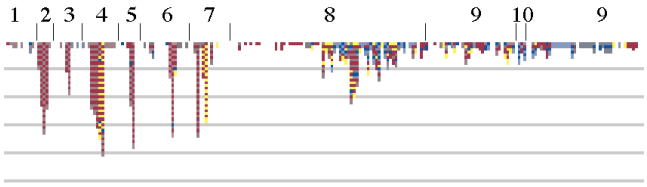


Figure 5. Overview of a 4 minute interaction

In the example in figure 5 the following segments of interaction were identified from replaying the logs:

1. **A** adds individual notes.
2. **A** draws a straight line of notes.
3. **A** draws another straight line of notes.
4. **A** draws another straight line of notes, doubles back, and then draws it again (the yellow blocks indicate removal of notes). **B** starts placing individual notes (some blue blocks are visible).
5. **A** draws a straight line.
6. **A** draws a straight line using the triangles. **B** starts placing notes in a curve.
7. **A** draws a straight line then erases it. **B** places notes to make a tune.
8. At this point **A** alternates between setting and erasing two notes, and **B** continues to place notes carefully to make a tune.
9. In both sections labeled 9, **A** and **B** appear to be bored by their interaction and are placing notes randomly around the Daisyphone.
10. In this short section **B** draws a line of notes between 2 lines of notes drawn by **A** previously.

Typical Behavior

One of the aims of this project is to identify what happens to people's interaction when they use a novel environment such as Daisyphone, in particular, what forms of behavior emerge. From analysis of the playback and overviews of all interactions it is clear that there are several consistent behaviors which emerge with Daisyphone regardless of players' backgrounds. These behaviors center around the inferred focus of players' actions – whether they focus on the graphical forms they produce, and/ or the music they produce, which is a typical design challenge for collaborative music environments [5]. Focus can be described in a sequence from apparently random through graphical focus to musical focus as described in the following paragraphs.

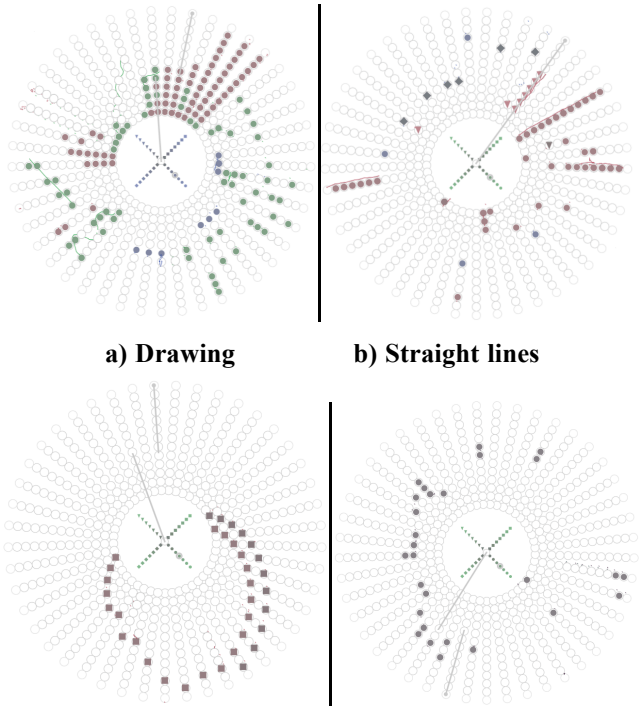
A frequent activity, especially towards the end of a session is **random** contribution of notes with no apparent rationale (17% of the time in the logs). In such situations notes are added very quickly and erratically which we suggest indicates that players are bored with the session. This form of behavior returns again to the issue of how to move composition and improvisation on when users are not 'house keeping' their musical environment. Such behavior has no apparent graphical or musical motivation.

Drawing using notes on the Daisyphone which has no apparent musical focus (22% of logs) takes three main forms: filling in all available notes (this sounds terrible, see figure 6a), writing one's name, and drawing objects with notes *e.g.* a cat. When drawing occurs it tends to happen at the start of sessions, and moreover in such sessions players typically do not proceed to make any musical contributions. In such cases Daisyphone is used purely as a drawing device with the focus solely on the visuals.

An interesting activity which has both graphical and musical focus is the contribution of **geometric** patterns of notes (25% of logs). The basic form of this is the contribution of **straight lines** (12%) radiating from the centre of the Daisyphone (figure 6b). This provides a musical experience which is quite percussive - several notes contiguous in the musical scale being played at the same time, and is also visually pleasant. A more advanced form of geometric contribution is that of **curved lines** (13%) drawn around the Daisyphone (figure 6c). These lines look both visually appealing and sound pleasant (typically a rising or falling sequence of notes).

Throughout sessions players often contribute individual **notes** (figure 6d). These are classified as notes which are **placed** (27% of logs) and those which are **modified** (9% of logs). It is worth remembering at this point that the aim of Daisyphone is to encourage more group music interaction – the proportions indicate that musical contributions form over a third of the kinds of contributions which shows a level of success in meeting the design aims. Placed notes are typically added slowly over a period of time in order to attempt to make a tune (as opposed to random contributions which are quickly and erratically added). Modified notes on the other hand, closely follow erased

notes and provided some indication that players change their musical contributions in line with how it sounds. Placing notes typically happens on players' initial use of Daisyphone whereas modification happens towards the end of a session.



a) Drawing **b) Straight lines**

c) Curves **d) Notes**

Figure 6: Typical behaviors

Structure of Interaction

Overall, the typical sequence of actions in Daisyphone is illustrated in figure 7. Sessions usually start with players exploring Daisyphone – placing notes and then waiting to see how they sound. Some players then go straight into random contributions, but regardless of how they start, all players end sessions with random contributions messing up their previous composition. Some players move into drawing on the Daisyphone *e.g.* writing their name. Finally, 25% of players move on to contributing geometric shapes starting with straight lines and moving on to curved lines. Very few players (9%) then move on to modify their own and other players' contributions to the music indicating some sort of engagement.

Daisyphone is a collaborative instrument, so it is important to understand how players react to others' contributions. Of all the contributions made in the studies, 80% were classified as having no regard for the current content of Daisyphone (*e.g.* random contributions, lines which don't fit with current tunes, *etc.*), 13% were classified as being made with reference to previous contributions by the same person (*e.g.* adding to a tune they were working on), and only 7% appeared to be made with some consideration for others' contributions (*e.g.* mimicking other's patterns or lines, adding to others' tunes, *etc.*). Contributions made with reference to others' contributions are particularly interesting as they show some level of *feeling real* in the group activity – building on and playing with other people's contributions. These are the forms of interaction that we need to be designing group creative environments to support. Moreover, the picking up, mimicking, and transformation of other people's musical contributions has strong parallels in the alignment of words and gestures in everyday conversation which indicates a level of interaction and engagement with each other where joint meaning and understanding is being created [24].

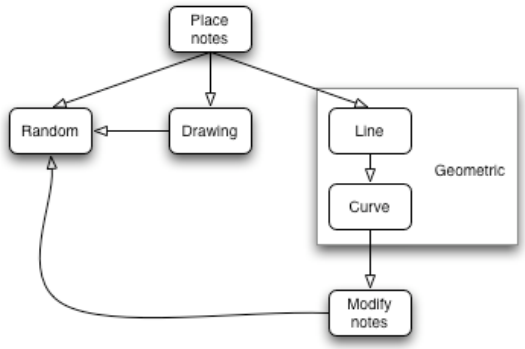


Figure 7: Typical sequence of activity in sessions

It is also useful to compare the typical sequence of interaction illustrated in figure 7 with typical sequences of other forms of group music improvisation. Table 2 provides a very rough comparison of the use of Daisyphone to the use of WebDrum II [6], and typical jazz improvisation [1]. In jazz improvisation a group usually starts by assigning their instruments and selecting a leader who then calls for the song to be played and sets the tempo. The group improvisation then proceeds within the framework of the song with some innovation happening by the lead player. In the WebDrum II study it was observed that players tended to assign instruments and then compose tunes individually (even though they were in the same musical space). Once completed the players would attempt to fit the different pieces together to make a coherent whole which was often a difficult process. In the observations of Daisyphone reported here, there was still individual composition, but modification of each others' contributions was greater than in the use of WebDrum II. However, music in Daisyphone tended to descend into chaos and random note contribution possibly indicating some boredom with the composition or frustration with the persistence of results of experimentation.

Table 2. Structure of interaction

Jazz	WebDrum II	Daisyphone
Assign instruments and leader	Assign instruments	Explore sounds and notes
Leader calls for song and tempo	Individual composition	Individual composition
Improvisation within framework of song	Discuss fit of parts and rework	Modify own and other's contributions
End	End	Descend into chaos

In some ways this structure reflects the different levels of expertise of the players – the jazz improvisation structure reflects the activities of experienced musicians, whereas in the WebDrum II situation players had only weeks to learn their instrument and practice collaboration. Daisyphone players were typically novices who had to learn a new instrument and how to interact with others at the same time. So, we are essentially seeing people learning to create music individually and with each other in a fluid and natural way which may develop into more formalized structures as they use the environments for longer periods of time. Further work needs to explore the use of Daisyphone over longer periods of time and with players who become experts in its use.

In the questionnaires pupils were asked whether they felt that they could create a tune that they liked with Daisyphone. 50% agreed that they probably could, 33% thought that they couldn't, and 17% said that they could a little. However, when asked to describe how Daisyphone worked they were all able to give an accurate description of how to make tunes with it, including changing the volume and instruments. This description was given in their own words rather than repeating the introduction provided at the start of their session. In terms of improvements, they key problem for the pupils was the lack of instruments, especially bass and rhythm style instruments.

The circular nature of Daisyphone had some unexpected impact on the way players created their pieces. We had imaging that players would start adding notes at the top of the circle and work clockwise *i.e.* in a sequence as people tend to do with linear composition representations. However, neither of these suppositions were true. Firstly, players showed no overall trend in where they started contributing their notes. Secondly, players did not always contribute a single linear sequence – often they placed small musical motifs around the Daisyphone and then linked them together to make a longer piece. We suggest that this shows that the players were more in touch with the looping nature of the music than they were in other loop editing environments, and that this shows promise as a design approach for encouraging novice interaction.

Social Behavior

In addition to interacting with each other through musical notes, players also interact through written words. Three uses of writing are suggested from the observations: as a form of social interaction, as a way of discussing the music being produced, and as a way of marking one's production.

Discussing the music produced is by far the least frequent activity outside the contribution of notes. For example, of 39 textual contributions in the schools study, only 3 were with reference to the music (for example, see figure 3). In contrast, player's are more likely to write their name on the Daisyphone, possibly as a form of *marking* the space as their own, or to engage in social interaction with each other through text. By far the most frequent non-musical interaction in the schools study was social interaction as exemplified in the quote below taken from players' contributions in figure 8 (non-textual actions enclosed in <>; **A** is pink, **B** is purple). In the on-going public studies, there is much more marking of the space with players' names, and less social communication. Clearly the school pupils had social links with each other and moreover knew when others were in Daisyphone which had an impact on what they did over and above the contribution of notes.

A: hey
B: hi
A: ur getting
A: <cross out 'getting'>
B: wat u doing?
A: get lost!
B: wot?
A: <draw arrow to link 'wot?' to 'get lost'>
B: u get lost

The physical setup of the schools and IGC study was intended to provide some scope for direct communication if necessary. Interestingly, this only happened as a last resort. For example, when one player started to mess up the other player's contributions, initially the other player wrote 'hey' on the edge of the Daisyphone, and when this failed to stop her work being messed up actually shouted 'hey' across the room to the protagonist to try to get them to stop. Given the nature of the communication supported in Daisyphone (graphic annotation, not text chat), the lack of need to resort to physical verbalization can be seen as a positive indication of its success as a social medium.

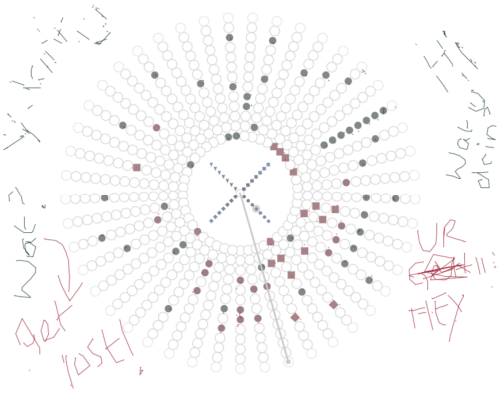


Figure 8: Social interaction in Daisyphone

REFLECTIONS

This section reflects on the observations of Daisyphone's use. Possibly the most striking reflection on this project is that in the short amount of time players had to learn to use Daisyphone they were able to intuitively create tuneful compositions. This is especially striking for the public version where very terse instructions are provided and there is no direct tutoring in its use, and yet there are tuneful compositions being created daily. In fact, some of the compositions on the public version show very subtle use of the volume of notes to create a beat and dynamic. For example, figure 9 is a screenshot from the ongoing public trails of Daisyphone on 30 October 2003. In the centre of the circle percussion notes (triangles) have been placed, mostly light grey (quiet), but there are two darker notes which provide an accented beat. Moreover, the melody is an ascending and descending tune with louder notes

typically at the end of each phrase creating a musical dynamic. This indicates to us that in terms of the design criteria for idea formulation, Daisyphone was providing a useful multimodal and spatial representation of the music being created.

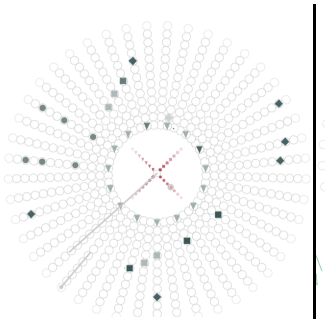


Figure 9: Advanced use

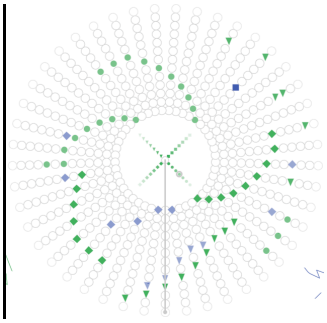


Figure 10: Engagement

In terms of focus, players' typical move from concentration on visuals to the more musical view discussed previously indicates that to some extent Daisyphone supports the design criteria for idea formulation in terms of exploring different patterns of presentation in multimodal ways. We suggest that Daisyphone's visual design provides a means for players' to easily move from their initial graphical focus to a more musical focus and in doing so enables players to explore the development of their understandings of the underlying musical structure without necessarily requiring detailed training.

The looping nature of the music appears to be well understood in Daisyphone. This was evidenced through the contiguity of musical compositions produced during the studies. For example, in figure 9 the central circle forms a simple loop of beats, and the loop appears to be divided into four quadrants which lead into each other rather than being one sequence in which there is a pause from the end of the loop to the start of the loop. This indicates that the design criteria of a novel representation of looping music which emphasized the cyclical nature of music was successful.

Related to the theme of learning to use Daisyphone are observations on players' previous musical experience. Throughout the studies it was observed that those who had no musical training were able to form music through trial and error and eventually grasped the musical concept behind Daisyphone. Those who were skilled musicians quickly picked up the 'style' of Daisyphone and were able to create versions of common songs such as 'la cucaracha'. However, those players who had had some basic music education (this was especially true of the school pupils) tended to be confused by the lack of conventional notation and structure in Daisyphone – they would ask where specific musical notes were (*e.g.* "Where 're the notes? Where's A?"), and where the bars were. This suggests that at their stage of musical education they were concentrating on the form of representation (the conventional music score) rather than learning the elements of music itself (notes and harmonies). We see interesting possibilities in the use of novel representations such as Daisyphone in the teaching of music through exploration of the music form rather than learning of a specific representation. Future development could include some sort of overlays for different interpretations of the notes *e.g.* highlighting notes on a blues scale, or indicating harmonics when notes are selected.

In terms of group creativity, as with WebDrum II, we found that players tend to initially create on their own which is to be expected when exploring and learning a novel form of interaction. Encouragingly, we also observed some picking up of others' musical ideas through the interaction (7% of the interactions were classified in this manner). These were mainly in terms of picking up on others' geometric patterns. For example, people who had been drawing straight lines tended to change to curves when they had seen another player drawing curves. Interestingly they then tended to create sequences of multiple joined curves rather than simply copying basic curves. We suggest that this indicates some engagement between the players in terms of exploring each others' musical ideas and contributions. The most encouraging signs of people creating together comes when people started to make complementary contributions to others' tunes. Figure 10 illustrates a case from the IGC study in which the blue and green players are interacting together in a session. The green player creates the bulk of the music, but the blue player adds extra contributions which complement the green player's *e.g.* the blue triangles at the bottom follow the green curve, and at the left of the circle the blue player has extended a green sequence with two of their own notes.

An interesting aspect of the observations of Daisyphone's use was the frequent writing of player's names either as graphical annotation or as a name made of notes which happened more in the public version of Daisyphone. We suggest that this indicates that there is a need for some way for players to 'make it mine' and publicly indicate their ownership of spaces over and above being assigned a specific color. We will explore this design requirement in further studies – we do not believe that providing features such as photographs of players or textual naming of spaces is the appropriate direction to follow, but that a more informal mechanism needs to be developed *e.g.* a way of quickly adding a musical or graphical signature or 'tag' to spaces to indicate ownership.

One recurrent theme running through the development of Daisyphone was the persistence of players' contributions. Initial pilots indicated that it would be essential for people to be able to get fresh Daisyphones as people do not clean up after themselves. This progressed into the development of the session selector in current the version of Daisyphone. However, the persistence of the notes seems to adversely affect the interaction which typically ends with a process of random contributions or scribbling. There may be many reasons for this, we suggest that Daisyphone does not allow people to bring different aspects of their constructions into and out of focus – it is very difficult to throw some things away and keep others, so instead players tend to throw everything away. Further design of the

interaction needs to develop better indication of what contributions are important, or interesting, and which can be left to gradually fade away. As a first step we are developing versions of Daisyphone in which notes decay after a short period of time. This will make the interaction more like conventional improvisation and may change the way that people explore musical ideas. Careful consideration of the decay time will be needed so that enough synchronization between players takes place before the notes disappear. We hope that this form of interaction will encourage more sketching and exploration of musical ideas, and hopefully more co-exploration of musical ideas.

CONCLUSIONS

Taking the development of the telephone as an analogy, in designing for group creativity we are currently at the stage of Alexander Graham Bell transmitting the immortal words 'Mr. Watson, come here, I want to see you'. That is, we have some idea of the underlying technologies, and useful directions they might be developed in towards our goals, but we are still a long way from realizing the goal of informal social interaction through music.

We believe that Daisyphone is a promising way to support remote group music improvisation which is the building block for more informal interaction through music. Some sense of players *feeling real* was achieved in the studies as indicated by engagement with others and the tendency to claim ownership of spaces. The next steps include overcoming clutter in a messy interface, and understanding how to design more engaging interfaces. We will start our journey by exploring decay in digital artifacts, and will deploy versions of Daisyphone in a wider range of places (*e.g.* art exhibitions and offices), employ different forms of devices (*e.g.* embedded displays and mobile phones), and study its continued use over a longer period of time.

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