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Principles for Music Creation by Novices in Networked Music Environments

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Abstract

Networked music environments (NMEs) allow experimental artists to explore the implications of interconnecting their computers for musical purposes. Despite an evident progress in recent years of networked music research, very little attention has been paid to a very common potential kind of user: *novices in music*, that is, users with little or no previous music knowledge. Indeed, the same way that principles of Rich Internet Applications like YouTube and Flickr have turned the passive user into an active producer of content, we are investigating the issues to be considered by networked music environments in order to allow effective support of musical creation and experimentation by novices. CODES—a Web-based environment designed to support cooperative ways of music creation by novices—puts these principles into practice. The goal of this paper is to present, discuss and illustrate two main principles: (1) music creation by novices should be prototypical; and (2) music creation by novices should be cooperative. These principles have emerged during CODES design and development and we think they are a good starting point for further investigation of a novice-oriented perspective of NME dimensions.

1. Introduction

Music technology has undergone considerable changes over the last decades, mainly because of the increasing use of the Internet. One of its potential uses is networked music—subject of a special issue of *Organised Sound* (Schedel & Young, 2005). Network music allows experimental artists to explore the implications of interconnecting their computers for musical purposes. Thus, music works result from the convergence of social and technological aspects of the Internet, attracting the interest of the music technology community. The existing applications—as described in a survey by Barbosa (2003)—have evolved towards sophisticated projects and concepts including, for example, real-time distributed performance systems featuring various forms of multi-user interaction and collaboration.

However, very little attention has been paid to a common potential user: *novices in music* (also called ordinary users, non-musicians or simply 'novices'). This kind of user is not expected to have any previous musical knowledge.

Considering music as a social activity (Gurevich, 2006; Keller, Flores, Pimenta, Capasso, & Tinajero, 2011, this issue), new modalities for sharing musical experiences are created since Rich Internet Applications such as YouTube (2009), MySpace (Media, 2009), and Flickr (2009) have turned the passive user into an active producer of content, getting used to new purposes, like engagement, entertainment and self-expression. So we are interested in investigating social ways of music creation by novices.

Within a social computing scenario we have developed CODES (COoperative Music Prototype DESign), a Web-based networked music environment designed to support cooperative ways of music creation by novices. CODES puts the principles discussed in this paper into practice. Using CODES, a novice may experiment with music by combining, listening to and rearranging sound

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patterns and cooperating with partners in order to create musical pieces collaboratively. We call these pieces 'music prototypes' (MPs). The cooperative mechanisms of CODES were specifically designed and built to support a dynamic and creative environment, enabling knowledge sharing by means of rich interaction and argumentation mechanisms associated with MP evolution. They allow any user to identify and understand others' contributions, and also to preserve each creator's original ideas, intentions and 'authorship'. More details about these cooperative mechanisms can be found in Pimenta, Miletto, Flores, and Hoppe (2010). These features define CODES as a music creation system instead of simply a music publishing system. CODES offers a high level of music representation and user interface features that allow easy and direct manipulation (drag-and-drop) of icons representing sound patterns.

The goal of this paper is to present, discuss and illustrate aspects of novice-oriented compositional activities—mostly obtained as findings discovered during CODES's development and usage—and to propose principles to be taken into account for developing novice-oriented networked music environments. These principles are: (a) music creation by novices should be prototypical; and (b) music creation by novices should be cooperative.

A prototypical process in music creation means that novices can draft simple musical pieces—musical prototypes (MPs)—which can be tested, modified, and repeatedly listened to allow for cyclical refinement of an initial musical sketch until a final version is reached. This process resembles prototyping cycles adopted in industry and in incremental software development. Since music creation can be thought as a design activity, it seems natural and straightforward to adopt a prototypical process. In cooperative music creation, the refinement of an initial musical idea is the result of the collaboration among the authors. All members of a group (a social network built by explicit invitation) cooperate until a final consensual MP version is reached. This process is noticeably a particular kind of Human-Centred Collaborative Design in which the result is an MP.

Through the prototypical and cooperative nature of CODES, novices have the opportunity to be active participants in their own musical experiences, just like experienced musicians. New requirements should be taken into account when we consider this new user profile. Elsewhere, we have suggested the term 'the Web composers' (Miletto, Pimenta, Hoppe, & Flores, 2009), users actively participating in Cooperative Musical Prototyping (CMP).

This paper is structured as follows: the next section discusses our concept of novice and Section 3 presents some related work. Section 4 summarizes how CODES makes music creation by novices possible. First, we put forth the reasons why novice-oriented music environments should be prototypical and why they should be cooperative, in Sections 5 and 6, respectively. An evaluation showing what actual novice users are saying about CODES, along with the results of our experimental work is presented in Section 7. Finally, in Section 8 we state the conclusions of the paper.

2. Novice orientation

By definition, we call *novice* any person who is new to or inexperienced in a certain domain. In networked musical environments (NMEs), we consider a *novice* a music beginner, a person who lacks musical knowledge or who is learning the rudiments of music. In contrast to an expert (a musician, either professional or amateur), a novice is any person that is new to musical activities. Novices are not necessarily children (as considered by Solis (2003)). Novices in music are not necessarily digitally excluded (known colloquially as a 'non-user'—those who do not have skills, time or the resources to use Information Technology—as in Bradley, Barnard and Lloyd (2010)). In our work, the term 'novice' is related specifically to anyone without musical training, someone who is not expected to have any previous musical knowledge or who does not have enough knowledge to be classified as an amateur musician. In short, a novice is a non-musician.

Frequently, novices are interested in creating and participating in musical experiments, but they lack environments oriented to their own profile. Like Weinberg (2002), we intend to provide any user—either lay people or experienced musicians—access to meaningful and engaging musical experiences. Our intention is to put musical activities and knowledge in layman's terms, avoiding complex or technical features and trying to express musical activities, ideas, properties and knowledge using metaphors that the average individual can understand, so that she may enjoy music making without being worried about technicalities.

Some peculiarities make music creation different from the activities carried out in other fields. For instance, composing is a complex activity where there is no agreement about which activities have to be performed and in which sequence: each person (composer or not) may have a unique way of working. As a consequence, most composers have not yet developed the tradition of sharing their musical ideas and collaborating while composing. Thus composing is considered a solitary activity only done by experts.

Providing support for novices and for musicians are not equivalent things (Miletto, Flores, Pimenta, & Santagada, 2007). Musician-oriented music systems usually include full and complex information, concepts, and interface functionalities which are part of the 'musician's world', such as musical notation, filters, oscillators, among others. Such systems are used by composers, musicians, and performers for musical composition,

musical performance, and sound synthesis purposes. The learning curve necessary to engage with such increasingly sophisticated musician-oriented music systems sometimes makes them inaccessible to novices.

The main motivation of our work is the belief that no previous musical knowledge should be required to participate in any creative musical activity. We believe that novices may be able to do musical creative work if they are given adequate support. Thus, we focus less on the musical quality of the finished work, and emphasize the possibility of access to compositional activities.

From our point of view, novice-oriented music systems should be more exploratory. For novices, music creation could be considered as a design activity: the design of sounds and/or the design of combinations of sounds (existing or new), forming new sound sequences or simple musical pieces. However, novices in music usually do not have enough knowledge or confidence to create music by themselves: they may not have access to a musical instrument and may not know how to play it, nor do they know how to represent music using traditional notation. Therefore, novices in music need effective interactive support to cooperate with each other for producing music. Our work investigates the issues to be considered by NMEs in order to provide effective support for musical creation and experimentation by novices.

3. Related work: networked music creation environments

The growing interest of the computer music community in Networked Music Environments (NMEs) during the last decade is a clear indication that networked music is becoming a hot research topic. Most NMEs cited in a survey about Interconnected Musical Networks, by Weinberg (2005) are intended for music composition. CODES is similar to several of these systems—such as the WebDrum System (Burk, 2011), Daisyphone (Bryan-Kinns, 2004), PitchWeb (Duckworth, 2000), Public Sound Objects—PSOs—(Barbosa, 2005), EduMusical (Benini, Ficheman, Zuffo, Deus Lopes, & Batista, 2004), and JamSpace (Gurevich, 2006). CODES enables users to contribute their own material and manipulate (listening, altering, refining, etc.) others' contributions, usually through asynchronous interaction and off-line manipulation.

Other stand-alone systems like Garage Band (Apple, 2011) feature standard matrices where MIDI files and recorded/imported audio files can be manipulated, tested, and modified. The program offers users tools to make minor adjustments to sequences and sounds. These synthesis and mixing features are typically related to musician's activities and concepts. Given its standalone profile, Garage Band works well for the casual hobbyist. Its increasing popularity is probably due to its outstanding usability aspects. Indeed, it is possible to claim that among NME developers there is general agreement that usability is an essential quality of NMEs. Regarding the importance assigned to usability issues, CODES is comparable to Garage Band, with the enhancements of cooperative features and mechanisms that foster music collaboration.

Through an analysis of existing NMEs, we note that many works on CM have been proposed in response to precise, specific artistic demands. Even though some characteristics related to novice-orientation could be also found in some of these NMEs, the lack of a common framework to conceptualize, design and evaluate existing NMEs is evident.

Indeed, despite apparent progress in recent years in establishing 'good practices' for the design of NMEs, the definition of principles related to a novice-oriented perspective of NMEs remains an open question. More work is needed to extend their scope to cope with the multiple NME dimensions related to novice orientation, guiding NMEs development in order to assess and compare their features.

Table 3 in Section 7 briefly summarizes a comparison between several NMEs and CODES. A detailed review of the features of the main novice-oriented environments for collective musical creation or experimentation can be found in Miletto (2009). We assume this comparison is a good starting point to identify the capabilities and limitations of each of the NMEs, and to improve the understanding of the underlying principles. Our intention is to provide guidelines (not strong recommendations or strict requirements). In order to show how these principles may be put into practice, the next section will discuss issues related to the novice-oriented point of view for NME development. We will also describe a set of mechanisms (defined and implemented in CODES) specifically designed with a focus on novice-orientation.

4. Music creation by novices: how CODES made it possible

The Music creation is done only by combining the sound patterns available at the CODES sound library. Since the sound patterns are based on technology music production, CODES is supposed to allow electronic music creation. Advanced computer music functionalities like wave shape, filters, sound synthesis, etc. are not included so far. Since CODES is focused on novice users, the music tasks are designed to be as similar as possible with those ones carried out by common Web users. To make this possible, CODES enables novice users to perform four main tasks at a high level of interaction. Such tasks include creating, editing, sharing, and publishing musical prototypes. Users can create a new MP by clicking on the option shown in Figure 1 (label a), choosing its name, and optionally its musical style. Since some music styles

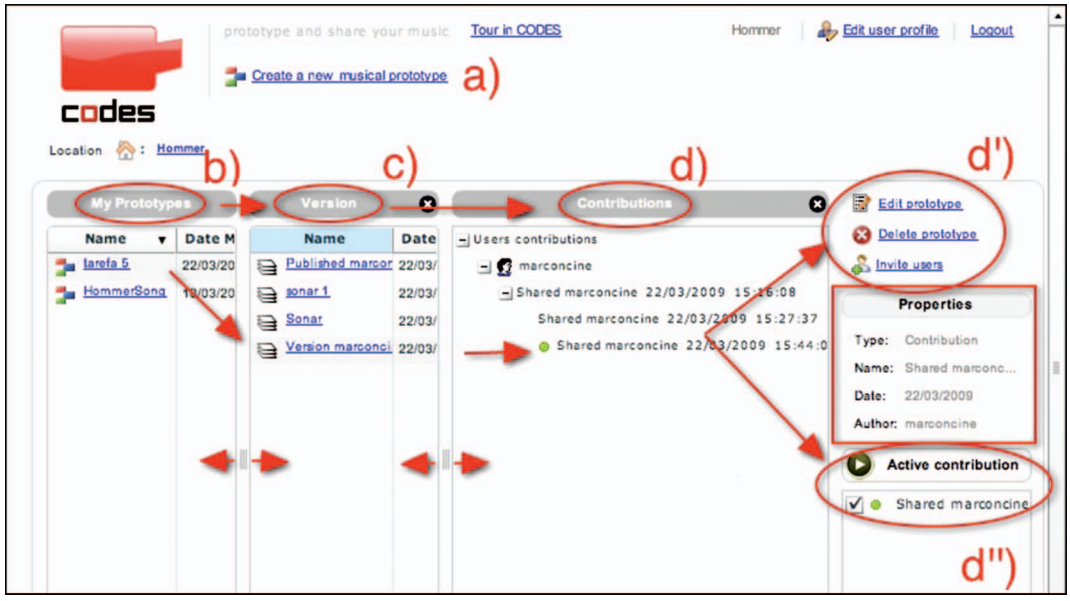

Fig. 1. Excerpt of the screen which lists the users' musical prototypes.

are available as a sound library, it is possible to mix sound patterns from different styles in the same MP.

Figure 1 shows how CODES organizes the users' prototype list. Users can see their MP information as a hierarchical structure by clicking on a link from a list (Figure 1, label b). Each MP can have one or more versions (Figure 1, label c) and one or more contributions (Figure 1, label d). Such contributions can be selected and combined either to be listened to (Figure 1, label d') or to be edited (Figure 1, label d').

Editing in CODES involves the modification of MPs by direct manipulation of sound patterns (see a description of the prototypical nature of edition in CODES at Section 5). To share a musical prototype, the 'owner' can invite CODES users through a search engine or by explicit e-mail invitations to non-members, asking them for their cooperation (this process is illustrated in Figure 2). When someone accepts such an invitation, this user becomes a prototype partner and can manipulate the MP just like the owner does.

At any time users can listen to the musical prototype and link arguments to their decisions, following a structure similar to that of a design rationale. Thus, all prototypes' partners can discuss and share ideas about each step of the prototype refinement process, in order to understand each others' decisions.

When someone likes the sounds result, a 'publication request' can be triggered and the group may deliberate and discuss the publication of this musical prototype on the CODES home page. This activity is named 'musical prototype publishing'. As an alternative to publishing their music, users may export (download) their musical prototype asan MP3 file and edit it or share it.

Throughout the design of CODES, we sought to emphasize two paramount principles which summarize the lessons learned so far. These have emerged during CODES' development and confirmed by evaluations by CODES users in actual usage, to be considered when providing support to novice-oriented music creation activities: (a) it should be prototypical; and (b) it should be cooperative. We chose to explore these principles because they have received little attention within the networked music domain. We will discuss these principles further in the following sections, presenting and illustrating how CODES takes advantage of a novice-oriented perspective.

5. Novice-oriented music environments should be prototypical

In the CODES musical prototyping process, MPs are repeatedly tested, listened to and modified by their author and on-line partners.

In the music literature, 'draft' is the term used for such creative work. But here the emphasis is focused on the prototyping process and not on the product itself. Consequently, in this paper 'prototype' and 'draft' refer to the same object.

Just like any other design-related prototyping process, CODES music prototyping is iterative, incremental and evolutionary: an initial musical idea (the first version of the MP) is produced and refined through a number of

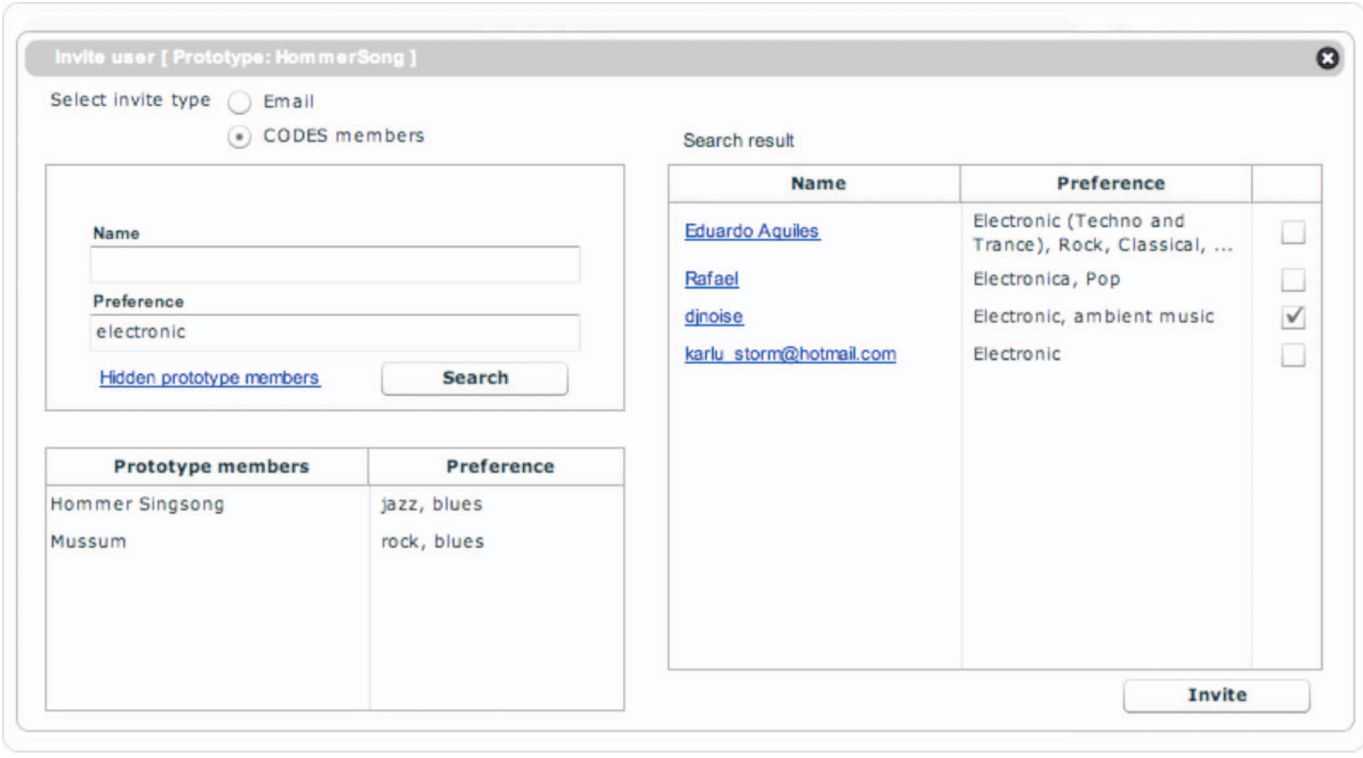

Fig. 2. Screenshot of CODES inviting window.

stages before reaching the final version. Moreover, this refinement process helps users to discover, validate, or derive new musical ideas from their initial musical ideas. We believe prototyping is one of the most interesting aspects of using CODES. It enables creation and experimentation of new musical ideas, by means of rich interaction mechanisms—associated with each prototype edition and modification and designed to improve user engagement with the system. Freedom of MP manipulation and experimentation is a basis for successful music prototyping. Given that our intention was to design a musical environment where music prototyping would be natural for novices, CODES interaction design was approached from an HCI perspective.

In order to create a new prototype using CODES, the user needs to select pre-existing sound patterns from a sound library.

A sound pattern is a predefined 4 s MP3 music sample represented by an icon. Users may create a prototype in an editing area (see screenshot of the CODES editing level in Figure 4, Section 6) by selecting and inserting sound patterns (typically 'dragging-and-dropping' icons from sound library to editing area), removing a sound pattern previously inserted in a MP, and defining how to mix them—for example, sequentially or simultaneously. This 4 s duration was established to make it easy for their combination in the music rhythm.

The sound library contains a lot of predefined sound patterns classified by a few music styles and it is our intention to provide extensibility mechanisms in order to allow the user definition of new sound patterns and/or import sound patterns from other libraries. The idea behind sound patterns is to behave like building blocks, helping provide novices with the musical information they need to quickly and easily create sound sequences in their musical prototype.

Before selecting a sound pattern, the user can play it to check if it is the right choice. The sounds displayed in the editing area are played from left to right. Users can edit (insert, remove, resize and change the order of sound patterns) and also play the MP at any time, in a dynamic and interactive way.

From an HCI perspective, any design should start by a study aiming at identifying and knowing the users, their goals and what tasks they need to perform to achieve them. Since the target user group is composed of novices in music, it is very difficult to define goals and tasks based on existing software applications for music creation. Indeed, most of their interface features are only suitable for musicians, not for novices. First of all, musicians know music theory. They know how to read traditional music notation and musical symbols. Even other types of notation (like tablature) contain alternative symbols for musical concepts, and the problem remains: these concepts are not part of a novice's world. Music notation

is a non-intuitive concept for any novice to learn. In addition, musicians also have theoretical and practical knowledge about musical instruments, have access to them, and know the technical issues relating to how to play them.

As a consequence, music software often relies on traditional music representations and on metaphors based on musicians' experiences. The MIDI protocol itself, which is designed to interconnect digital musical instruments and computers, is based upon 'musical performance event', like keys being pressed, changes in timbre and in tonality, tempo changes, etc. Even more recent interaction styles (like the style adopted by Max/MSP (Cycling74, 2009)) are metaphors of something musicians are used to doing: cabling, patching and routing, and require the experienced musician's knowledge and practical experience. Consequently they are inadequate for novices.

Since we did not have similar environments to use as a basis, we adopted an incremental and iterative design approach to identify novices' needs, to design and fit the system to the users and their needs, to evaluate the design and use the evaluation result as feedback until a good design could be achieved. The resulting prototyping process is cyclic, yielding a simple but rich interaction result. For example, to edit an MP in CODES sound patterns are dragged from the sound library—they are always visible and can be just dropped into the MP editing area.

The CODES user interface has three levels of interaction for different user profiles: (a) a Public Level, (b) a Musical Prototype Editing Level, and (c) a Sound Pattern Editing Level (see Figure 3 for an excerpt of the screens representing each of the levels). Basically, the two user roles are CODES members (registered users) and non-members (general public, non-registered visitors). The non-members are typically Web users who can access the CODES home page (shown in Figure 3(a)), listen to the published musical prototypes, rate them, and search music by author or style.

Once logged in CODES, members can interact with the two other levels (shown in Figures 3(b) and (c)), find/invite partners in order to cooperate and share their musical ideas, edit musical prototypes, and engage in conversation/argumentation as described in the next section.

Manipulation of prototype oriented information is goal-motivated with typical prototype element manipulation, including insertion, modification, combination, replacement, and listening of sound patterns. Socially oriented objects are all related to conversation (messages and comments). One significant consequence of recognizing social-oriented objects as relevant information is that, instead of considering modifications as only explicit transformations on an MP, we also consider the changes on social-oriented objects. That is, we interpret modifications on a shared object space as meaningful changes in both MP and social context.

6. Novice-oriented music environments should be cooperative

Music creation by novices needs to provide a very specific kind of support for collaborative activities (Pimenta et al., 2010). In fact, the conventional cooperative approaches with fixed goals and roles, not allowing unsystematic and opportunistic negotiation are not adequate for the dynamic, creative, and collaborative nature typically related to collaboration in music, such as CODES's Cooperative Music Prototyping (CMP).

Since the Web is nowadays a very common platform for social and collaborative activities, the CODES project has moved the focus of attention from an individual

Fig. 3. Screenshots of the three main levels of CODES.

to a cooperative music prototyping process. CODES provides an effective interactive support to make novices cooperate with each other in music making. Indeed, novices in music may not have enough knowledge and confidence to create music by themselves. However, by means of interactions with and advice from more experienced users, they may improve their performance while participating in a collective music prototyping activity.

The process of group formation, partnership and participation in group activities in CODES is simple: invitations can be sent as shown in Figure 2. This procedure is very straightforward: once logged into the system, members can send explicit invitations to other users (members or not). A CODES member may invite (a) other CODES members (through a search in the members list) or (b) external users (non-members) through explicit invitations by email. If the invitation is accepted, they are considered partners and may contribute directly on the same MP, editing it like the owner does. Obviously, many users may be partners in distinct MPs through invitations (by the MP owner) for each MP. The names of all partners who share a musical prototype and the group status are visible in the members area (see (a) in Figure 4).

People don't necessarily share taste, style, musical goals or communicate on-line in similar manners. Even novices may have very different musical backgrounds and interests. However, since CODES partnership forms a social network (built by explicit invitations) people cooperate until a final consensual stage of MP is achieved. The final result of this collaboration is not pre-defined, it emerges from the cyclic interactions of the group, based on contributions from/to each other.

Whether groups are just aggregations or collections of individuals who tend to do what they have always done as individual creators, in the course of collaboration they understand, accept, and respond appropriately to the group's concerns, preferences, and priorities recognizing individual style preferences and others' preferences. This may require considerable negotiations involving trade-offs and compromises and explicit agreements with their partners. It is not possible to ensure that people with similar taste and goals end up being partners, but diversity of concerns and preferences usually produces creative, radically innovative proposals for MP initiatives. Moreover, since attempts to influence others are transparent, the differences are dealt with assertively by opponents in a joint creative process: group members explicitly discuss what they think about the MP. This dynamic activity encompasses encoding, transmitting, and decoding of both objective and subjective information.

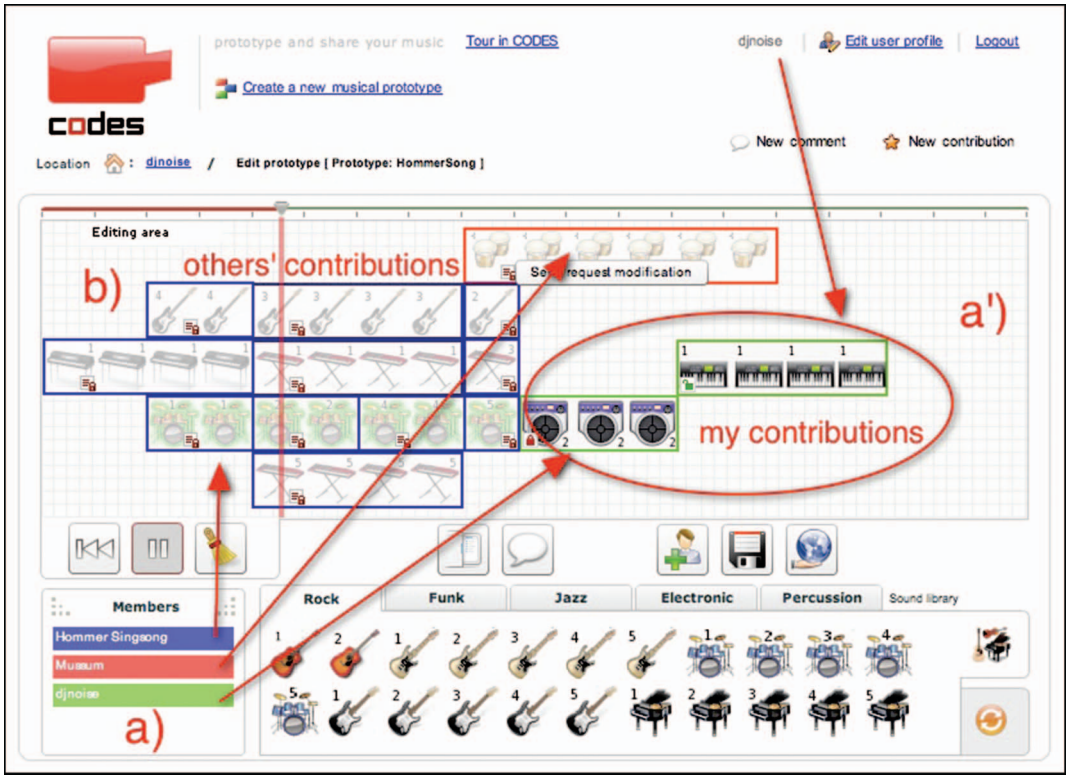

Fig. 4. Three users cooperating in a shared MP at CODES MP Editing Level.

A music prototype may be the result of the individual prototyping process but may also be the result of collaborative design, involving the participation and contribution of many users. In this case, the MP is an artifact shared by all members who cooperate by means of actions to manipulate the shared artifact (MP)—including the objective information commented above—and by means of explicit conversation and argumentation—corresponding to the subjective information. Effective communication serves such purposes as influencing others, giving, receiving, and using feedback, allowing members to create, be aware of, and support the MP evolution. At any time users can listen to the musical prototype and link arguments to their decisions, following a design rationale (Shum, 1996). Thus, all prototype partners can discuss and exchange ideas about each step of the prototype refinement process, in order to understand someone else's decisions.

Each author's contribution in the shared workspace is identified by colour: for example, the edges of sound pattern icons are colourful (the colour obviously chosen by the user, as illustrated in Figure 4, part a'). In the members' area (Figure 4, part a), a user may show or hide other users' contributions (see the other users' layers as shown in Figure 4, part b) by clicking over the user id. It is possible to listen to each layer separately, to compare and combine contributions, and, of course, to save the result. The group status shows when there are new comments or new versions with icons. Figure 4 shows an example of three users cooperating on the same MP.

When someone contributes by adding a new sound pattern to an MP, it will be, by default, locked for other users, with a blurred appearance. If some user wants to prototype or edit the other's locked layer (or sound patterns), CODES offers a special mechanism called 'modification request'.

The multiple actors—all who are cooperating in the refinement of the musical prototype—hold different perspectives on the creative process and its results (the MP), each one with different backgrounds and due to the context they come from. Therefore, it is essential to support mutual understanding by means of the music prototyping rationale, explicitly recording open issues, ideas, decisions and arguments.

The Music Prototyping Rationale (MPR) mechanism of CODES is another effective way to represent and record explanations and argumentations for each action or decision made during CMP. Each user may associate comments and arguments (in favour or against) any action on any prototype element. Each argument is related to a user or the whole group and the current layer.

In CODES, the basic elements of the MPR are 'issues', 'positions' and 'comments'. Issues correspond to decisions or actions that have been made or states which have been reached during the MP creation and refinement. A Position is a statement or assertion that resolves the issue. In the case of CODES, positions can be pros, cons, idea, and important. Comments are asserted in order to agree with a specific course of action (comments in favour) or to express some objection (comments against). Every decision or action may be linked to (pro or con) arguments.

CODES also adopts the notion of awareness (Liechti, 2000), which is the understanding of the actions of other users providing to each user a context for her own actions. CODES offers three kinds of awareness mechanisms:

- MPR allows users to know the reasons behind other members' actions;
- Modification Marks indicate to a user that a prototype has been modified by others. CODES uses modification marks as the awareness mechanism to alert new events to a user, like modifications on a prototype or suggestions made by others; and
- Version Controls with layers keep an explicitly recorded track of the steps that led to the current prototype state.

Notice that the actors cooperate via the shared objects space, that is, either indirectly by means of musical prototypes they manipulate and modify, or directly by means of conversation. In fact, we think this support for cooperative music prototyping is a particular kind of Human Centred Collaborative Design. The basic idea of our CMP process is that members cooperate not only by means of explicit conversation and actions on a shared object space, but also by interpreting the messages and actions of other actors in accordance with a model of their thinking and acting, which is built during the course of their interaction. A shared object space involves prototype-oriented information, which comprises all information about musical prototypes, including their composition (the combination of sound patterns, the versions formed by layers) and social-oriented information (including interactions between actors during the process).

7. Evaluating CODES: novices evaluation on a novice-oriented Web environment for music creation

CODES has been made available for use by actual users within academic contexts. Following well-known subjective evaluation methods from the HCI field, we made some experiments to obtain qualitative results from the use of the CODES environment and its functionalities. Our goal was not only to get overall feedback (mainly subjective) from users but also to try out our proposals for NMEs as well. CODES evaluation has been conducted through different usability evaluation methods, including Heuristic Evaluation (Nielsen, 1992, 1994a, 1994b), and User Testing (Rubin, 1994).

User testing has involved actual users whose selection took into account the following criteria:

- all users must be novices (in the sense explained in Section 2); clearly, age and sex are not relevant;
  (a) all users are volunteers, free of charge: there was not any method to increase response rates, like financial incentives because of the limitations of funds;
  (b) all users are digitally included—having familiarity with Web-based RIA applications and direct manipulation user interfaces; however, there is no assumption that users have connections to any social networks and no previous knowledge about cooperative or collaborative tools are required;
- the maximal number of participants in experiments (simultaneous users) were 30; this limitation was related to reliability and scalability issues: nowadays, an extensive traffic-aware stress testing is not yet available and thus it is unknown whether and how the system behaves under stated conditions for a specified period of time as well as its capacity to handle the growing amount of work.

A group of 26 individuals, representative of the CODES typical users with respect to the criteria above (mostly students, with ages ranging from 20 to 35 years, having no musical expertise, and using CODES for the first time), was formed. Their user profiles include mostly males (60%), a group with age 24 years old or more (80%), with post graduation (40%), bachelor (40%), and undergraduate students (20%), and mostly (80%) having musical experiences related basically to music sharing—download and sending MP3 files—with no previous experience in music creation or music notation.

The evaluation procedure has included two experiments so far. Beyond collecting answers to the satisfaction questionnaire and verifying the usability problems, the experiments also aimed to focus on distinct versions of the cooperation mechanisms. See Table 1 which summarizes the goals and number of participants of the experiments.

The tasks planned for the experiments were designed to simulate a scenario in which a novice user would learn how to interact, create, edit, and cooperate on a MP. Particularly, a cooperative scenario was composed specifically by three different tasks at the MP editing level. The tasks included creation, edition, and sharing of a MP. Time taken to complete all the tasks ranged from 20 to 50 min.

Table 1. Summary of evaluation experiments carried out in CODES.

	Goal	#Users
Experiment 1	MP using versioning tree approach	5
Experiment 2	MP using layer approach	21

Figure 5 shows the User Testing (Rubin, 1994) carried out in the presence of a facilitator (observer), a usability expert. He just read each task for the user, and took notes of any problems found and any verbal comments from them. The subjects were instructed to say what they thought while interacting with CODES, thus using the 'thinking aloud' method (Nielsen, 1992). Interaction and user comments were also recorded with a video camera aimed at the computer screen (see Figure 5).

In both experiments, after performing the tasks, users filled out a form where 11 open and closed questions were posed to respondents. For closed questions, users should select one out of a set of usually five responses: Totally Agree (TA), Agree (A), Neutral (N), Disagree (D), and Totally Disagree (TD). A strength of the questionnaire is that it is brief.

These choices compose a Likert scale item, and have been widely used in social and management research. In our experiments, TA and A are considered as favourable responses (FR = TA + A). The numerical score of all responses is called Total Responses (TR = TA + A + N + D + TD).

The open questionnaire posed questions concerning the Nielsen's heuristics (see http://www.useit.com/papers/heuristic/heuristic_list.html) like visibility, contextualization, control and freedom, feedback, flexibility, and the musical representation used in CODES.

Although the survey could be improved, the results are very promising. From the responses to open questions, we can obtain two important measures for this type of survey, i.e. overall satisfaction and likelihood of future use.

Fig. 5. A recorded session of user testing with CODES.

Moreover, some users have detected important drawbacks concerning the system feedback, according to the following quotes: 'Sometimes, the system should give more feedback'. 'I do not know which session I am posting the comment in'. 'I did not know why I should choose a colour when registering myself in the system'. 'What does this icon in the editing area mean?'. These remarks concern issues we have to pay more attention to in future versions of CODES.

Despite these few negative remarks, from responses to closed questions the overall test results were favourable (see the column PFR at Table 2).

As shown in the work presented in Section 2, one of the main advantages of CODES is that it supports effective cooperation among novices. In general, the related works are considered networked music systems basically for technical reasons (especially for easy access, publishing material, server support, maintenance, etc.). In addition to these reasons, this research considers the Web to be the best way for users to cooperate with each other. The experiments were developed within a very restricted context, but until now it has been possible to conclude that the system is intuitive and easy to use, making users feel motivated by using CODES for enhancing and sharing their musical experiences. As part of the evaluation, we have compared CODES with other NMEs presented in Section 2, using the classification criteria that we consider essential for collaboration in novice-oriented systems on the Web. Table 3 presents other networked music systems and CODES in the last column to highlight the differences between them.

Regarding the 'musical process' criterion, although situated as an entertainment system, CODES can be used also for 'performance' and 'musical creation' by means of experimentation with sound patterns. Since users can add and remove sound patterns while listening to the musical prototype, CODES enables live performance through interaction with the musical piece while it plays.

Regarding 'sound format', the point was to provide export/import sound formats in order to allow exporting/importing musical pieces/prototypes from/to one environment/system to/from other. We decided that CODES would work with MP3 files to take advantage of Flex engines for sound manipulation, producing engaging audio results to stimulate novice interactions.

CODES, like other related systems, uses a graphical 'sound representation'. In addition it uses an iconic representation to try to give some clues about the sound. Similar to most networked music systems, CODES uses a client-server as Web 'architecture' to provide free access to Web users. Considering that users access the system at different times and that they have musical ideas at any time, CODES has adopted an asynchronous 'interaction' and communication infrastructure. Nevertheless, synchronism can offer interesting possibilities and can be taken into account in future developments.

To access and 'run' CODES, the Flash Player plug-in is required. This is a widely distributed proprietary multimedia and application player, built into most of the browsers. Whereas few systems use chat or drawing in the screen as a 'communication tool', CODES, in contrast, uses e-mail and its original support mechanism for music prototyping rationale as a permanent argumentation tool. Thus, users can understand the positions and reasons of other users. Arguments in CODES are of consensual explanation, not individual messages interchanged between the actors. Decisions are goal-motivated consensual choices, concerning alternatives to the

Table 2. Questions, numerical score of favourable responses (FR), Total, of responses (TR) and the percentage of favourable responses (PFR) of the satisfaction questionnaire filled out by users after using CODES.

Affirmative sentences	TA	A	N	D	TD	FR	TR	PFR
1. The expressions and language used are clear and easy to understand.	15	11	0	0	0	26	26	100%
2. It is easy to learn how to use the system.	10	11	5	0	0	21	26	80.8%
3. After learning the system, it remains interesting and easy to use.	20		6	0	0	20	26	77%
4. The feedback from the system is adequately presented and easy to interpret.	11	10	5	0	0	21	26	80.8%
5. The look and feel of CODES is pleasant.	20	6		0	0	26	26	100%
6. The graphical sound representation in CODES helps to identify the sound content even without listening to it.	20	0	4	2	0	20	26	77%
7. Everybody may change all contributions.	0	11	5	0	10	11	26	42%
8. The alerts allow easy understanding of the changes in the system.	20	5		1		26	26	96%
9. The comments are useful for understanding the changes and versions of the music being created.	16	5	5			21	26	80.8%
10. The contribution list represents an easy way of identify and understand the sequence of changes in the music.	11	10	5			21	26	80.8%
11. The cooperation mechanisms in CODES allow the group to achieve a consensual final outcome.	21	5				26	26	100%

Table 3. Comparing CODES with other NMEs.

	Jam Space	Pitch Web	Edu Musical	Web Drum	Daisy phone	PSO	CODES
Sound format	MIDI	MP3					MP3
Musical process	Jam session	Performance	Composition	Performance	Performance	Performance	Experimentation, Performance, CMP (see Section 5.1)
Sound representation	Scratch tracks	Geometric shapes	Piano roll	Grid	Dots, circle	Bouncing balls	Iconic sounds patterns
Sound export	–	–	.mus	–	–	–	MP3
Architecture	Client-server	Client-server					
Access	Restrict	Free	Restrict	Free		Free	Free
Interaction	Synchronous asynchronous	Synchronous	Synchronous asynchronous	Synchronous	Synchronous	Synchronous	Asynchronous
Communication tools	–	Chat	Chat	Chat	Shared screen (draw)	–	Mail/MPR (see Section 5)
Persistence	–	–	Yes	–	Yes	–	Yes
Group Memory	–	–	–	–	–	–	Yes
Awareness	–	–	–	–	–	–	Yes
Interaction	–	–	–	–	–	–	Yes
trace	–	–	–	–	–	–	
Argumentation	–	–	–	–	–	–	Yes
Authorship	–	–	–	–	–	–	Yes
Requirements	Software Hardware LAN	ShockWave, QuickTime, Beatnick	Java	JSyn	Java, Beatnick	Java	Flash player
Target public	Musicians, novices	Composers, novices	OSESP students	Novices	Novices	Novices	Novices

course of actions. Every decision or action may be linked to arguments (pro or contra).

The great difference between CODES and other networked music systems is in the novice-orientation characteristics supported by the CSCW mechanisms. Indeed, most systems do not consider 'persistence', 'group memory', 'awareness', 'interaction trace', 'argumentation', and 'authorship' as important aspects to support collective musical activities. Considering Cooperative musical prototyping as a process that involves groups of people working together on a MP as a shared workspace, this research illustrates how these criteria can be incorporated into the design process.

8. Conclusion

In this paper, we have presented two principles for networked music environments in order to provide support for music creation by novices. These principles have emerged to address the idiosyncrasies of novice-oriented contexts for music creation. The novice-oriented aspects of CODES are characterized by support for dynamic and prototypical music creation processes and by actual cooperation, social knowledge construction, argumentation and negotiation among the different actors of musical prototypes design activities. Knowledge sharing is enabled by means of rich (novice-oriented) interaction and addresses the idiosyncrasies of the CMP context.

CODES has shown that networked music environments can offer more than 'consumer' possibilities for novices in music. Since we have integrated tools, processes, and concepts in a single environment, novice users can create music prototypes, cooperate effectively, and experience the feeling of being part of an artistic experience. Music creation by novices is ultimately about people having fun and entertainment, not about following a fixed set of rules for music making.

Having access to rich interaction and argumentation mechanisms, and experiencing the process of music prototyping, we believe users may get a better understanding of the complex activities involved in musical creation and experimentation. In CODES, partners cooperate not only by means of explicit actions on a shared object space and by explicit conversation, but also by interpreting the actions and the comments of other actors during their creative process. Of course, designers of networked music environments are free to adopt other cooperative mechanisms. Social construction of knowledge is the notion that underlies this principle, and there is no reason to exclude any other mechanism if its ideas are compatible with it.

However, CODES is not just about supporting novice people: features built for novices may help everyone. If we think of musical skills as a continuum—not merely knowing or not knowing music—CODES may provide support for musical activities by ordinary users to professional musicians. Thus, if actual novices can learn using CODES, musicians may become 'novices' when using CODES to experiment with new ideas and share their opinions.

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