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Musicking with an interactive musical system: The effects of task motivation and user interface mode on non-musicians' creative engagement

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ABSTRACT

Creative engagement with novel musical interfaces can be rewarding for non-musicians. However, designing novel musical interfaces for non-musicians can be challenging because they lack conceptual and technical musical skills. In this paper we explore the effects of task motivation (experiential goal vs utilitarian goal) and user interface mode (whether the content is editable, and whether content can be replayed), on non-musicians' creative engagement with novel musical interfaces. We show through an empirical study of twenty-four participants that an experiential exploratory goal encourages users' creative engagement compared to a utilitarian creative goal. We found that being able to replay records is less important when participants have an experiential exploratory goal than when they have a utilitarian creative goal. Results also indicate that allowing people to replay their musical ideas increased some aspects of their creative engagement which was further increased when they were able to edit their creations. We also found that creative engagement increased when the interface supported users in planning ahead. A descriptive model of non-musician's creative engagement with musical interfaces is proposed including three modes of musicking. An optimal trajectory of creative engagement through these modes is suggested and a description of inferred motivations, output, status and activities during creative processes is discussed. Design implications are proposed for supporting novices' creative engagement taking into consideration their motivation and skills, and supporting insight and real-time activity.

1. Introduction

In the past few decades Human-Computer Interaction research has moved beyond concerns of usability to study experience related topics such as beauty, enjoyment, fun, emotion, and engagement (Alben, 1996; Forlizzi and Battarbee, 2004; Hassenzahl and Tractinsky, 2006; Mark A. Blythe, 2005; McCarthy and Wright, 2007). Indeed, engagement has been identified as one of the most desirable and essential experiential qualities of HCI activities (Lehmann et al., 2012; O'Brien and Toms, 2008; 2010; O'Brien, 2010). Within studies of engagement, creative engagement has been identified as a sustained and intrinsically rewarding engagement experience (Candy and Bilda, 2009; Hansen et al., 2011). This is where a user is engaged in an active, reflective and constructive cognitive process in pursuing a creative outcome with an interactive system (Bilda et al., 2008; Edmonds, 2011; Edmonds et al., 2006; Wu and Bryan-Kinns, 2017). In this way creative engagement emphasizes users' creative experience over their creative output, and helps to make an interactive experience a 'memorable one, rather than a 'pretty one (Candy and Bilda, 2009). As a relatively new and elusive concept in HCI, the challenge for studying creative engagement include the lack of an agreed definition and positioning within the broader context of HCI. This is partly because most previous discussion took place within the context of interactive arts (Bilda et al., 2008; Edmonds et al., 2006) and education (de Abreu and Barbosa, 2017; Dindler, 2014; Reid and Solomonides, 2007), resulting in a lack of design suggestions for supporting creative engagement in other domains. There is also a lack of evaluation criteria as creative experiences should not be evaluated solely on the quality of the contributions or the output as the creative output is valued on a personal level (Sawyer, 2011). Of particular interest to this paper is the challenge of how to design support for novices' creative engagement and to inform future design of such systems.

1.1. Music making

Music making is an ideal activity to study in terms of creative engagement as it is regarded as a fundamental form of creative human activity which has played a major role in human intellectual evolution (Bryan-Kinns, 2013; Sawyer, 2011; Small, 2011). Moreover, it combines self expression and creativity with entertainment. It also provides an

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excellent ground for studying and comparing the interactions of a range of users, for example individuals and groups, amateurs and experts, children and adults, etc. (Jordà et al., 2007). The experience of creating and enjoying music through playing is often rewarding, offering "an affirmation of life" because of these exploratory, engaging, intuitive and enjoyable qualities (Cage, 1961; Hansen et al., 2011). Studying support for music making activities can contribute to HCI research in a wide variety of topics, theories, methodologies and technologies, especially as music making and HCI share concerns of simplifying complex tasks (Wallis et al., 2013). For example, recent research in the fields of New Interfaces for Musical Expression (NIME) (Poupyrev et al., 2001) and Human-Computer Interaction (HCI) have a range of overlapping research themes that could illuminate both fields in terms of theory and methodology (Holland et al., 2013; Jensenius and Lyons, 2017). These overlapping themes include: methodology for evaluation, i.e. ethnographic inquiry, situated approach (Orio et al., 2001); cognitive topics such as spatial cognition, embodied cognition(Xambó, 2017); interaction topics such as parameter mapping (Hunt et al., 2003), control, i.e. haptic or gestural control (Jensenius, 2014; Miranda and Wanderley, 2006; Verplank et al., 2002), multimodal interaction, i.e. audiovisual interfaces (Frauenberger and Stockman, 2009; Levin, 2000; Tanaka and Knapp, 2002), tangible interaction (Jordà et al., 2007; Xambó et al., 2017); experience topics such as intimacy (Fels, 2004), playfulness, creativity (Tanaka et al., 2005), participation (Wu et al., 2017), engagement (Bryan-Kinns, 2013; Wallis et al., 2013); and social topics related to Computer Supported Collaborative Work (CSCW) such as collaborative music making (Bengler and Bryan-Kinns, 2013; Blaine and Fels, 2003).

1.2. Musicking

In the NIME field the term 'musicking' (Small, 2011) has emerged to describe a more accessible music making activity that is not exclusive to trained musicians (Bengler and Bryan-Kinns, 2013; Hansen et al., 2011; Jordà et al., 2007; Kaltenbrunner et al., 2006; Parson, 2009; Robson, 2002). This trend has produced designs which have enabled non-musicians to actively *play with* music rather than only passively listening to music (Hansen et al., 2011; Resnick et al., 1996). This paper considers non-musicians as amateurs of musicking who are interested in musicking activities but with no intention to be professional musicians. Non-musicians should be distinguished from people who are musical beginners who have the intention to become professionals later on, as non-musicians will have less access to formal music training (Davis et al., 2013a; Weinberg and Driscoll, 2005) and less motivation to engage in formal music training. Musical creativity, which has often been considered the exclusive domain of professionals, is reported to be hard for non-musicians to achieve (Weinberg and Driscoll, 2005). Studies reveal that it is difficult for non-musicians to develop their musical ideas from scratch due to their lack of conceptual and technical music making knowledge and skill (ibid). Studies also indicate that not only are novices restricted by their abilities but also by their lack of confidence in producing creative outcome (Davis et al., 2013a).

1.3. Creativity support tools

The domain of Creativity Support Tools (CST) has been exploring the design and evaluation of systems to facilitate creative processes for more than a decade, particularly for professional purposes (Carroll, 2013; Carroll et al., 2009; Cherry and Latulipe, 2014; Davis et al., 2013a; Hewett et al., 2005; Hewett, 2005; Shneiderman, 2007; 2009), making it promising as a domain to inform the design of novel musical interfaces for creative experience and engagement. However, most research into supporting novice's creative acts focus on how to scaffold novices' creative output rather than to support their creative experience per se, for example, in the domain of design (Bonnardel and Marmèche, 2004), video making (Davis et al., 2013b) and painting (Benedetti et al., 2014). There is still substantial work to be done to understand novice's creative process from an experiential perspective and the factors that might affect their sustained creative engagement. Studies have highlighted that a user's *motivational orientations*, that is, whether a user is given an exploratory goal that aims for an hedonic experience or given a utilitarian goal that aims for a concrete output, will strongly affect their choices, experience, and engagement with products (Hassenzahl et al., 2008; Hassenzahl and Ullrich, 2007; Rozendaal et al., 2009; 2007; Soleimani and Law, 2015), as well as their creative performance (Collins and Amabile, 1999; Ironson and Davis, 1979; Selker, 2005a; Shalley, 1991). One challenge for studying designs which aim to support creative engagement is therefore whether to give novices an explicit utilitarian motivation to create an output or to simply ask them to explore the interface as a form of experiential motivation.

Most new musical interfaces designed for non-musicians follow the dynamic real-time conventions of conventional instrument design (Jordà et al., 2007) such as a guitar or flute, inherently offering an *improvisational* musicking mode (Sawyer, 2011) of interaction (as discussed in Section 2.3). In this case music is produced in real time in direct response to user input, much as it might be by a conventional instrument. Improvisation can be a barrier for non-musicians to create music because their working memory is insufficient (Schulze et al., 2011). Moreover, according to studies of CSTs outlined above, 'rich history keeping' is a fundamental mechanism for supporting creativity because having a record of which alternatives have been tried makes creative modification and improvement easier to achieve (Shneiderman, 2007; 2009). However, current musical interfaces that provide history keeping and allow for modifications, e.g. GarageBand[1] and Logic Pro,[2] are mostly designed with for a *compositional* musicking mode (Sawyer, 2011) (as discussed in Section 2.3). The two musicking modes of compose and improvise outlined here employ different user interface features (e.g. editing and replay versus real-time sound manipulation) and require different sets of user skills and activities in order to produce a creative output.

The rest of this paper is organized as follows: Section 2 introduces Interactive Musical Systems and literature on Creativity Support Tools, as well as features of musicking mode and motivation, which leads to the research question. This is followed by Section 3 which provides an overview of the design and implementation of Interactive Musical System used in the study reported in this paper. Section 4 introduces the experiment design including the hypothesis, independent and dependent variables, and study procedure. Section 5 presents the results of the study along with statistical analysis and thematic analysis. Section 6 provides a detailed discussion of the hypothesis in relation to the results, followed by a descriptive model of creative engagement and design implications. Limitations and future work are also discussed in Section 6. Finally, Section 7 concludes this paper with a summary.

2. Related work

Unlike traditional musical instruments that generate sound through physical acoustic mechanisms, new interfaces for musical expression generate sound digitally by mapping users' input to sound output (Tanaka, 2009). Generally, there are two paradigms of design in this domain: (i) a Digital Musical Instrument (DMI) which is designed for expert users involved in professional level music production and performance; (ii) an Interactive Musical System (IMS) designed for non-expert users for exploratory and experiential purposes (Murray-Browne, 2012). The interfaces discussed in this paper are within the scope of IMS because we are interested in supporting novices' creative engagement.

[1] ©Apple Inc.
[2] ©Apple Inc.

2.1. Interactive music systems

There are three typical design features of IMSs designed for individual participants (Wu and Bryan-Kinns, 2017): *i: Emphasize the experience.* Unlike the design of DMIs that emphasise the system's expressiveness, responsiveness and the final sound output, IMSs are designed to foster and facilitate engaging experiences that are rewarding to participants (Weinberg, 2003). As the priority in these systems is the process and experience, the design is typically not driven by the musical outcome but is more likely to be driven by experience related themes such as social dynamics, communication, awareness, the rules of interaction, and so on. *ii: Emphasize the intuitiveness.* As non-musicians usually have little or no skills and domain knowledge of music, the interfaces are designed with low entry fee to enable users to easily understand, learn, and intuitively interact with them (Fels, 2004; Wessel and Wright, 2002). Simplified mapping strategies between the input and sound, limited sound parameters, pre-recorded samples or pre-composed materials (D'Arcangelo, 2001) and generative algorithms to control all or part of the sound generation (Schacher et al., 2015; Weinberg and Driscoll, 2005) are often utilized to reduce the complexity of the interaction. Intuitive control mechanisms such as tangible interactions (Bengler and Bryan-Kinns, 2013; Jordà et al., 2007), mobile interactions (Bryan-Kinns, 2004), wearable interactions, spatial or gestural interactions (Beyer and Meier, 2011; McAlpine, 2017; Zamorano, 2012) and laptop-based interaction are widely adopted to provide intuitive interaction with low or little barriers to use (Xambó, 2017). *iii: Emphasize the liveness.* As discussed in (Overholt, 2009)'s framework for the design of expressive musical interfaces, the faster the real-time sound processing and generation is produced in response to a player's interaction, the higher level of control will the player will experience. The majority IMSs employ a dynamic real-time design paradigm offering immediate sound output in response to a player's interaction (Bengler and Bryan-Kinns, 2013; Bryan-Kinns, 2013; Jordà et al., 2007; Levin, 2000). Only a small number of ISMs have embedded history keeping mechanisms to enable players to revisit, reuse or revise previous creations, usually following a step sequencer design (Arellano and McPherson, 2014; Bryan-Kinns, 2004).

A number of design practices have emerged through the design and evaluation of ISMs which contribute to facilitating non-musicians' creative experience. Firstly, using physical objects to directly control or represent musical parameters, referred to as *tangible musical interfaces*, is one promising way engage non-musicians intuitively and creatively (Tezcan et al., 2017; Xambó, 2017), as the haptic feedback provided is easy to learn and utilize people's 'sophisticated skills for sensing and manipulating physical environment'(Ishii, 2008). These are realized in a number of ways including using portable devices to detect continuous motion or gestural data (Sheridan and Bryan-Kinns, 2008; Weinberg and Gan, 2001), using tabletop systems for players to arrange and to manipulate a set of musical objects (Jordà et al., 2007; Schwarz et al., 2017; Xambó et al., 2013), or using an instrument metaphor for players to control musical parameters directly through the interface (Bengler and Bryan-Kinns, 2013; Zappi and McPherson, 2014).

Secondly, there are practices which aim at providing intuitive feedback. ISM design often integrates graphics and audio in real-time to use graphics to reinforce physical interactions by offering supplementary information and feedback on players' interactions, the system state and the audio output (Gómez et al., 2007; Wang, 2014; Zadel and Scavone, 2006). Levin provided a summary of four metaphors for the relationships between computer graphics and electronic music in the field of visually-orchestrated computer music (Franco et al., 2004; Levin, 2000), including: *Timelines and diagrams* that use visual representations to display musical information, such as musical score display; *Control-panel displays* that mimic the physical controllers in analog synthesizers; *Reactive widgets* that use virtual objects to manipulate or to modify sound parameters; and *Painterly interfaces* that use drawings and free-form images from gestural interactions to generate or control sound.

Thirdly, there are practices which aim to creatively engage non-musicians through fostering a collective collaboration (Bengler and Bryan-Kinns, 2013; Blaine and Fels, 2003; Bryan-Kinns, 2004; 2013; Tanaka et al., 2005; Weinberg, 2003; Weinberg and Driscoll, 2005; Zamorano, 2012), suggesting the use of collective knowledge and creativity to support sustained musical creative engagement.

Despite the research in these three design practice directions, it remains unclear how to engage individual non-musicians in a creative experience.

2.2. Creativity Support Tools

The domain of Creativity Support Tools has been exploring the design and evaluation of systems to technologically mediate creative processes (Carroll, 2013; Cherry and Latulipe, 2014; Davis et al., 2013a; Hewett et al., 2005; Shneiderman, 2009), based on the view that creativity can be enhanced and fostered (Hewett, 2005; Sawyer, 2011), and that there are shared features across different domains of creative activities (Finke et al., 1992; Hewett, 2005).

The main approach to support creativity is through facilitating the activities involved in creative processes, including *collect* and *learn* from previous works; *relate* by consulting with peers and mentors at early, middle, and late stages; *create, explore, compose*, and *evaluate* possible solutions; *donate* and *disseminate* the results and contribute to libraries (Shneiderman, 2000). Some approaches seek to support creativity through influencing individual abilities, interests, attitudes, motivation, intelligence, knowledge, skills, beliefs, values and cognitive styles (Davis et al., 2013a; Hewett et al., 2005).

A set of practical design guidelines derived from the research and studies into supporting activities involved in creative processes and improving the potential of creative output are summarised below:

- Encourage users' confidence and willingness to take risks by providing easy mistake correction (Nickerson, 1998).
- Design the system with low thresholds, high ceilings, and wide walls with a wide range of functionalities but easy for novices to begin using (Shneiderman, 2007).
- Support exploratory search for rapid incremental and reversible exploration (Candy and Edmonds, 1997; Nickerson, 1998; Shneiderman, 2007).
- Provide multiple access routes into archives or relevant data (Hewett, 2005).
- Provide rich history-keeping mechanisms including recording different alternatives (Carroll et al., 2009; Shneiderman, 2007).
- Support the management of creative work (Lubart, 2005).
- Enable collaboration and social evaluation with peers and mentors (Shneiderman, 2000).
- Support communication between individuals collaboration on creative projects (Lubart, 2005).

The above guidelines could be used to inform the design of IMSs as a form of Creativity Support. However, there is inherently a conflict between the iterative creative process that calls for the rich-history keeping with accessible records, and the current designs of IMSs that offer real-time music making with no history keeping. Furthermore, these two conflicting features correspond to two different modes of creation in the domain of music (composition and improvisation) which have different characteristics, processes and skills (Sawyer, 2011).

2.3. A note on: composition, improvisation and comprovisation

Composition and improvisation are the two most commonly discussed creative modes in traditional Western music theories (Sawyer, 2011), having distinct features, and requiring different creative strategies, mental and physical skills. Composition is regarded as an iterative process of putting together musical elements, revising and storing them, whereas as improvisation is defined as a real-time performance process (Larson, 2005; Sawyer, 2011). Compared to composition, the real-time pressure of improvisation requires more reliance on automated cognitive activities without conscious attention, highly constrained music structures, and pre-existing familiar patterns in order to reduce decision-making tasks due to the limitations of conscious attention (ibid). Another distinction is whether the creative process involves rational reflection and revision (composition) or instantaneous innovation (improvisation). There is no tolerance of mistakes in the output of composition therefore revision of mistakes is indispensable for composition but not necessary for improvisation (Larson, 2005). Consider the representative activities of improvising with an instrument in a performance, and composing with audio composition software such as Logic Pro. When improvising with an instrument it is not possible to replay or to edit the previous creation. However, with software such as Logic, users can replay and edit previous creations.

With the emergence of electronic and experimental musical techniques since 1950s, the boundary between composition and improvisation began to blend (Holmes and Holmes, 2002). In the context of electronic music, a more common form of performance is now regarded as *comprovisation*, a creative process in which improvisation is used as a precursor to composition to generate musical ideas and extend existing structures, and in which composed structures and instruments are then widely used in an improvisational setting (Dudas, 2010). These emerging musicking activities tend to incorporate composed material within an improvisational setting (ibid), allowing compositional structure as well as the expressiveness of improvisation. One example would be live coding performances, a form of musical performance via real-time composition of music by means of writing code (Magnusson, 2011), which encourage improvisational creation using pre-composed sound materials and structures mixed with real-time programming of audio systems. Live coding also involves activities such as reuse and revision of the previous records as a live production. Another example would be live performance using hardware such as Launchpad[3] or Ableton Push[4], with which a player can play and record musical ideas such as rhythms, patterns of notes and combinations of these to one button, and replay, store, and restore them when necessary. However, in this setting there is no chance to edit the previous ideas.

The above literature discussed typical features of composition, improvisation, and comprovisation, for example whether the process is in real-time or not, and whether the process allows revisiting or revising records. Although most of current IMSs are designed with the real-time features for the mode of improvisation and comprovisation, it is not clear how features of the composition mode may affect non-musicians' approach to creative endeavo urs, especially as CST research suggests providing a mechanism of rich history keeping in keeping with a composition mode.

2.4. Effects of motivations

Motivation is regarded as an essential factor for creativity, without which creative innovations are unlikely to occur (Csikszentmihalyi and Sawyer, 2014; Selker, 2005b). Indeed, task motivation is regarded as one of the key components of creativity (Amabile, 1990; Hewett, 2005). Given the goal to behave more creatively, people tend to produce more creative responses, compared to what they would normally do without an assigned goal (Ironson and Davis, 1979). When setting a difficult productivity goal, high levels of creativity and productivity were attained by employees, while low levels of creativity were obtained with no creativity goal (Shalley, 1991). This might be caused by the different cognitive styles triggered by different motivations. Studies have suggested that a risky, exploratory cognitive style would facilitate creative thought, relative to the risk-averse, conservative cognitive style (Friedman and Förster, 2001).

Motivation has a profound impact on HCI product evaluation and user experience (Hassenzahl et al., 2008; Hassenzahl and Ullrich, 2007; Rozendaal et al., 2009; Novak et al., 2003; Rozendaal et al., 2007; Soleimani and Law, 2015). Research suggests that a user's motivational orientation, whether an experiential goal or a utilitarian goal, will strongly affect their choice and preference of a product (Hassenzahl et al., 2008), emotional experiences of an e-commerce website (Soleimani and Law, 2015), experience of control and engagement in voice mail browsing (Rozendaal et al., 2009), and also subsequent retrospective judgment of an interactive product (Hassenzahl and Ullrich, 2007). An experiential motivation usually aims for hedonic experience whereas a utilitarian motivation usually aims at a concrete result or output (Rozendaal et al., 2007). Furthermore, experiential and utilitarian motivations might have different effects on a user's flow, engagement, and experience. For example, online flow experience was more likely to be observed when users were engaged in task-oriented rather than experiential activities (Novak et al., 2003). Furthermore, among the three necessary preconditions of a *flow* state (clear goals, optimal challenges, and clear immediate feedback), a set of clear goals are suggested to be helpful to add direction and purpose to behaviors, thus serving to structure the experience (Csikszentmihalyi, 2014). In contrast, Rozendaal et al.'s study indicated that there might be a positive link between the increased engagement and experiential motivation (Rozendaal et al., 2007). They reported that when assigned with an experiential goal users' experience of engagement gradually increased with increased levels of richness in product appearance, which is not the case when assigned goal-directed tasks. Hassenzahl and Ullrich (2007) suggested that having an active instrumental goal negatively impacted on the experience of an interactive product, and also subsequent retrospective judgment, as a result of barriers made by increasing mental effort. A more neutral view on the effects of motivations has also been proposed. By examining the relationships between motivations and factors of user engagement in the context of an e-commerce environment, O'Brien (2010) provided predictive connections between hedonic and utilitarian motivations and aspects of engagement. She suggested an interconnection between utilitarian and hedonic motivations as they both have central effects on some aspects of engagement.

The above literature suggest that a clearly defined utilitarian motivation can contribute to more optimal creative performance, compared to an experiential goal which may be more uncertain or vague. The effects of motivation on engagement, however, is not so obvious. Whether a positive influence or not, the above related works reveal that there is a relationship between the different motivations and creative performance and engagement experience. In the context of NIME, musical interfaces for non-musicians are usually designed for an experiential purpose in the form of sound toys (Robson, 2002), music games (Hansen et al., 2011), and social tools (Bengler and Bryan-Kinns, 2013). It is not clear whether non-musician's creative engagement will be affected when they are given different motivations. Therefore a key concern of this paper is to examine whether different motivations will affect non-musicians' creative engagement with musical interfaces.

2.5. Research questions

As discussed above, factors that might affect non-musicians' creative engagement with musical interfaces can be summarized as: (i) the motivation of players, i.e. whether with an experiential or a utilitarian goal; (ii) the features of musicking modes, i.e. whether the musical interface allows players to replay records or revise records. Based on this our research are:

[3] ©Focusrite plc (Novation)

[4] ©Ableton

1. Whether different motivation orientations, either an experiential goal or a utilitarian goal, will affect non-musicians' creative engagement.
2. Whether the two representative features of the compositional musicking mode (replaying and revising records) will affect non-musicians' creative engagement.

3. MTBox

In order to investigate these research questions an intuitive musical interface, MTBox was designed. With MTBox, a player can compose or improvise music with pre-recorded musical samples by pressing the buttons. The following sections introduce the MTBox design, rationale of design choices, and its implementation in detail.

3.1. Tangible interaction

MTBox was designed as a tangible musical interface, following the TUI paradigm (Bengler and Bryan-Kinns, 2013; Jordà et al., 2007; Sheridan and Bryan-Kinns, 2008; Weinberg and Gan, 2001; Xambó et al., 2013; Zappi and McPherson, 2014) of music applications for users to manipulate and control sound directly and intuitively through buttons and rotary knobs. To remove preconceptions of instruments and to reduce non-musicians typical nervousness about playing with conventional instruments, MTBox was purposefully designed to *not* look or function like a conventional instrument such as a keyboard or a guitar (Overholt, 2009). Therefore, MTBox was designed as a cube because the form of a cube which does not look like a conventional musical instrument, is easy to pick up, and offers six separate surfaces that could be used for different functions, see Fig. 1. Offering different sounds on different surfaces responds to the results of a previous study which suggested utilizing separate spaces to help non-musicians to manage different sound objects (Wu and Bryan-Kinns, 2017).

Each vertical of the side of MTBox holds four buttons. Each button corresponds to one pre-recorded sample that belongs to one sound genre. As each side has buttons MTBox can be used by left handed and right handed people. Participants press a button to choose an audio sample. In terms of the sound design, there are melodic samples and beat samples. Each of group contains long samples (more than 3 notes/beats) and short samples (less than 3 notes/beats). Therefore there are four types of samples (melodic/long, melodic/short, beat/long, beat/short) and they are distributed on four sides of the MTBox. An iPod screen, a rotary knob and operational buttons (On and Off buttons, Play/Pause button, Back button) are embedded on the top surface. The iPod screen is for displaying the timeline interface. The rotary knob is for controlling the movement of the timeline interface. Both will be discussed in detail in Section 3.2. When the ON button is pressed, the

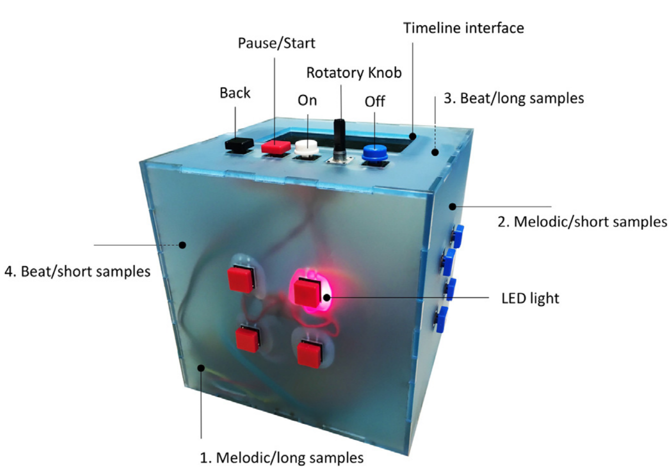

Fig. 1. MTBox.

chosen sample will be triggered and loop until the OFF button is pressed. The Pause/Play button is to pause the box or start play again. The back button is to reset the timeline interface to the current playback position after being scrolled. There is a LED embedded at the back of each button. If the corresponding sample is playing, the LED will illuminate. The choice of buttons instead of touch screen controls was made to reduce the need for visual attention to the controls with the help of physical feedback and affordances from buttons and knobs. For a similar reason, the choice of semi-transparent material is to allow the LED light to be seen from different angles giving additional visual feedback on the button state, and to hide the complex electronic components to avoid distraction. The MTBox is 15cm wide, 15cm heigh, and 15 cm deep. The size of screen is 9cm width and 5cm height.

3.2. Timeline interface

The timeline interface was displayed on an iPod screen embedded on top of MTBox, see Fig. 2. The timeline provides a visual *record* of the sound events created by participants, see Fig. 2. This was designed to respond to the CST design guidelines of providing history keeping (Shneiderman, 2007) and the call for providing support for compositional structures and events organization and modification (Franco et al., 2004). The timeline moves from right to left as time progresses. There are sixteen tracks on the timeline to record the activity of each sample individually. When a sample is started it loops and can be stopped. This is represented as a line recorded from its starting point to its stopping point on its corresponding track on the timeline. A real-time animation is simultaneously drawn in the middle of the track while the sound is active.

As a previous study suggested that non-musicians require readiness time in the creative process (Wu and Bryan-Kinns, 2017), MTBox was designed to allow players to plan musical events in the future by using the timeline. In the middle of the timeline, a red vertical line divides the timeline into two parts. The left side of the timeline records the previous musical events and the right of the timeline records the future musical events, whilst the middle indicates the current playing point. Using the rotary knob the timeline can be scrolled into the future (clockwise turn of the rotary knob). In this situation a player can start or stop samples ahead of current playing point, which will be recorded on the future timeline. The future records won't take effect until it reaches the vertical line in the middle.

3.3. UI features of musicking modes

As discussed above, the primary design features of systems to support different musicking modes are whether the system allows the activities of (i) replay and (ii) revision of previous and future records. In order to examine the effect of these features, the timeline was designed with two key user interface features beyond sound production:

- Changeable playing point that allows a player to scroll back to previous records or scroll forward to the future records with the rotary knob, and start to play from any point of the previous or the future records by pressing the Play button.
- Editable records that allows a player to scroll back and forth on the timeline and to edit (add, cut off, or extend) any record that has been created by pressing the On/Off buttons.

Fig. 3 shows an example when the timeline interface in Fig. 2 is scrolled to the previous time zone. When the Play button is pressed, the line indicating the current playing point will jump to that point, and the system will play the sound according to the records on the right.

To allow for comparison between these two user interface features, four user interface modes were designed for MTBox. Each mode was designed with or without the two functions so as to trigger different modes of musicking. Table 1 lists all MTBox modes and their functions.

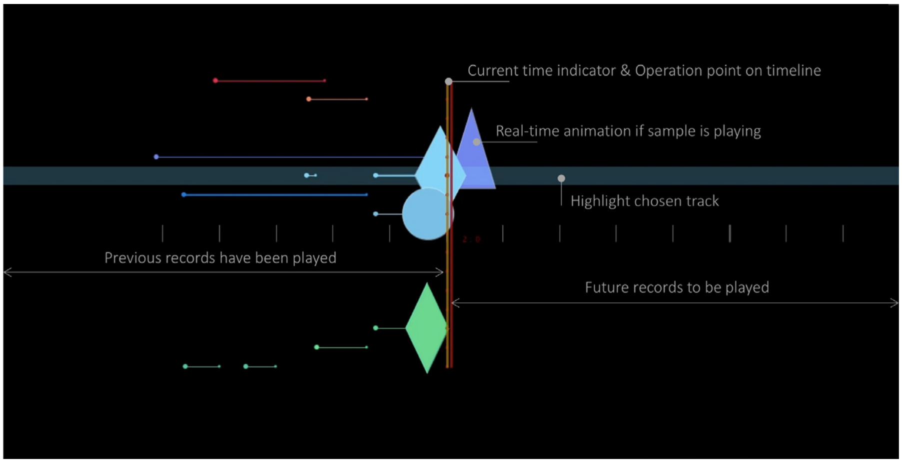

Fig. 2. Timeline interface: current playback position.

M_{nn} is designed with non-changeable playing point and non-editable records, aimed at triggering the musicking mode that is similar to improvising with an instrument. M_{ne} is designed with non-changeable playing point and editable records, aimed at triggering the music mode of comprovising that allows editing on previous records, such as live coding. M_{cn} is designed with changeable playing point and non-editable records, aimed at triggering the music mode of comprovising that allows replaying previous creation, such as playing with a Launchpad. M_{ce} is designed with changeable playing point and editable records, aimed at triggering the music mode that is similar to composing with Logic.

Table 1
MTBox versions.

	Non-editable records	Editable records
Non-changeable playing point	M_{nn}	M_{ne}
Changeable playing point	M_{cn}	M_{ce}
Participant Group	Group 1	Group 2

3.4. Implementation

MTBox has three main components. First, the hardware interface such as buttons, rotary knob and LEDs were integrated with a micro-controller board, *Arduino Mega* (Arduino Mega). Second, the timeline interface was programmed in *Processing* (Processing). Third, the sound interface was built in *Pure Data* (Pure data).

A working setup of MTBox included a MacBook Pro. The Processing and Pure Data were running on the MacBook Pro. The iPod embedded in MTBox was connected with it via USB and was used as a screen extension to display the timeline interface via *Splashtop* software (spl), which was set in full-screen mode with no other user interface objects visible or accessible. Arduino Mega was also connected with the MacBook Pro for power supply and data transfer. The user interaction data was transfered from Arduino Mega to Processing. After processing, the data was then transfered to Pure Data to control the state of the samples, and also back to Arduino Mega to control the state of LED lights. A technical set up of MTBox please see Fig. 4.

4. Experiment design

4.1. Independent variables

To examine the effects of the four modes of MTBox that addressed different musicking features, we conducted a cross comparison between two groups of participants. In addition to this, we built on the two tasks used by Rozendaal et al. (2007) and O'Brien (2010) to examine the effect of task motivation on online users' flow and engagement: (i) experiential motivation versus (ii) utilitarian motivation. We use these two task motivations to examine the effects of the task motivations on non-musician's creative engagement. The first motivation is an exploratory task to encourage participants to explore the MTBox in their own way. This is to give participants an experiential goal that aims for a hedonic experience. The second is a creative task to encourage

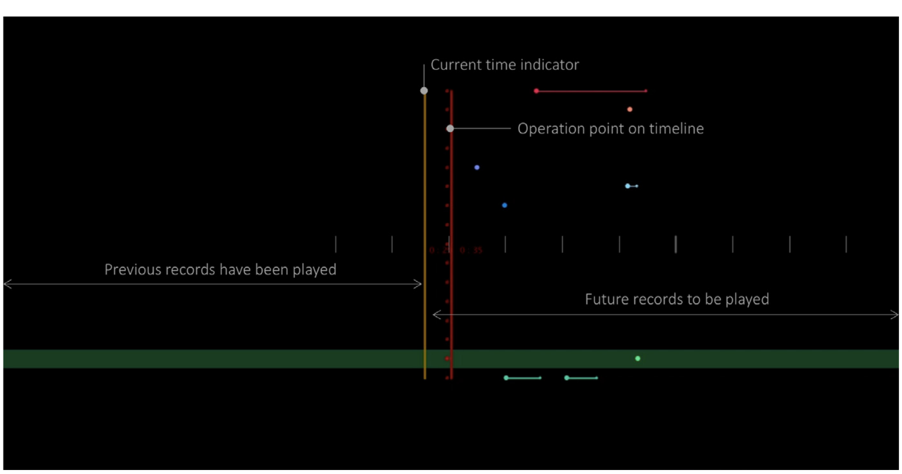

Fig. 3. Timeline interface: scrolled to previous.

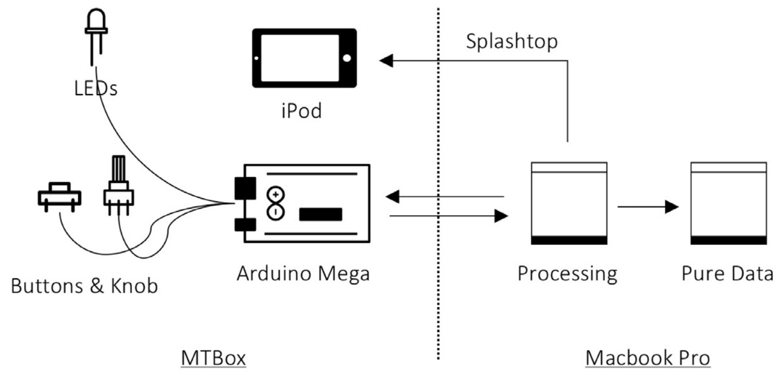

Fig. 4. Diagram of the technical set up.

participants to create a piece of music with MTBox. This is to give participants an explicit utilitarian goal that aims for a concrete creative result.

In total, three independent variables were manipulated in the experiment. For how they are related to two groups of participants please see Table 1.

- A within-subjects factor (repeated) of two task sessions (exploration and creation) – whether or not a participant is asked to play the prototype with a utilitarian goal for creative output.
- A within-subjects factor (repeated) of changeable playing point – whether or not a participant is able to start playing from the previous or the future records on the timeline.
- A between-subjects factor (non-repeated) of editable records – whether or not a participant is able to edit (to cut off or extend) the previous and the future records on the timeline.

4.2. Hypothesis

According to Sawyer, expert musicians are usually motivated by a utilitarian goal for creative output, and most of the great music was created after engaged in long periods of preparation and frequent revision (Sawyer, 2011). We hypotheses that creative engagement when using MTBox will be greater when non-musicians are involved in the composition mode with the ability to replay (with changeable playing point) and revise records (with editable records), or when participants are given an explicit utilitarian goal to create a piece of music. Therefore we developed three hypotheses relating to the independent variables:

- *H1:* Creative engagement will be greater with an explicit utilitarian goal for the creative output.
- *H2:* Creative engagement will be greater with the prototypes with changeable playing point.
- *H3:* Creative engagement will be greater with prototypes with editable records.

4.3. Dependent variables

Candy and Bilda proposed two indicators for assessing creative engagement in the context of interactive art: (i) the conceptual change, when there is a shift in participant's intentionality and expectation with the system; and (ii) the behavioral change, which is often observed before and after an unexpected change in the system (Candy and Bilda, 2009). According to them, the observed behavioral change needs to be confirmed participants' retrospective reports. This involves observation of participants' behaviour and analysis of participants' feedback, demanding a huge amount of work on data interpretation, and also bringing with it a risk of missing points due to superficial interviews, especially when the interaction process is long. However, in contrast to the context of interactive art, where the audience's behaviour change is usually caused by the unexpected change in the system, the behaviour change in the scope of this study is usually initiated by the player themselves. Therefore it is difficult to determine participants' behaviour change via video recordings in the context of our study. Instead we propose using survey methods as the main method to assess the conceptual change based on a set of creative engagement factors, and collecting interaction logs as a complementary source for analyzing behaviour change during the interaction process. We developed two categories of dependent measures to assess participants' creative engagement: i) participant feedback (agreement on interval scale statements) and ii) activity assessment (what participants did).

4.3.1. Participant feedback

Attributes of user engagement (O'Brien and Toms, 2008; 2010) and the factors that are used to evaluate CSTs (Carroll, 2013; Carroll et al., 2009) informed the design of survey questions used in this study. Attributes of user engagement include: focused attention, perceived usability, endurability, novelty, aesthetics, and felt involvement (O'Brien and Toms, 2010). The factors that are used to evaluate CST include results worth effort, expressiveness, exploration, immersion, enjoyment, and collaboration (Carroll et al., 2009).

We also drew on a previous study on non-musicians' creative process with musical interfaces (Wu and Bryan-Kinns, 2017) to inform the design of the survey questions. This study indicated that the factors such as the learnability of system and whether or not the system helps to structure the composition and support planning ahead are also crucial for non-musicians' creative engagement.

Therefore we combined and merged the above factors into a single set of factors to evaluate the level of creative engagement of our participants. These factors include Interest, Aesthetics, Learnability, Feedback, Structure Composition, Plan Ahead, Enjoyment, Exploration, Expressiveness, Challenge, Control, Focused Attention, Results Worth Effort. As this paper is focused on the individual creative process rather than a collaborative process, we exclude the factor that addresses collaboration. Table 2 illustrated the origins of the factor, and how they are integrated into the questionnaire statements.

The questionnaire used in this study to access participants' Creative Engagement (referred to as the CEQ) is based on the factors discussed above. It is necessary to note that this questionnaire is not proposed as a validated instrument for measurement of creative engagement, instead it is used to explore the feedback on factors that relate to creative engagement. The CEQ has two parts: The first part was a list of statements addressing factors on creative engagement. Participants were asked to rate their agreement for each statement on a seven-point Likert scale from 1 (Strongly disagree) to 7 (Strongly agree). There were three separate lists of statements: initial self-assessment on music creativity, statements for explore session (ES) and statements for create session

Table 2
Factors of creative engagement.

Factors	Definition	Source	Survey
Interest	User's interest in the prototype or task	Engagement	ES1, CS1
Aesthetics	Perceived visual beauty	Engagement	ES2
Learnability	The easiness of learning	Timeline	ES3
Feedback	System response according to interaction	Engagement	ES4, CS5
Composition	Support on structuring the composition	Timeline	CS2
Readiness time	Support on planning future events	Timeline	CS3
Enjoyment	Perceived pleasingness	Creativity	CS8
Exploration	The easiness of explore new ideas	Creativity	ES5, CS6
Expressiveness	The ability to perform various outcomes	Creativity	ES6, CS10
Challenge	The amount of effort put in interaction	Engagement	ES7, CS4
Control	How in charge user feels in interaction	Engagement	ES8, CS7
Focus attention	The concentration on the task	Both E&C	ES9, CS9
Result worth effort	Perceive value of the result	Creativity	ES10, CS11

Table 3
Survey statements for exploration session (ES) and creation session (CS).

ES0.	I am very creative to create a piece of music.
ES1.	I was curious about the prototype.
ES2.	This prototype was aesthetically appealing.
ES3.	I found this prototype confusing to learn.
ES4.	The timeline helps me to understand my interaction.
ES5.	I have found different ways of playing with the prototype.
ES6.	It was easy for me to explore many different musical ideas, possibilities, or outcomes, using this musical box.
ES7.	I felt frustrated while playing with this musical box.*
ES8.	I could not do some of the things I wanted to do on this prototype.*
ES9.	When I was playing with the prototype, I lost track of the world around me.
ES10.	Playing with this musical box was worthwhile.
CS1.	I was curious about the creation task.
CS2.	The timeline helped me to organize my composition.
CS3.	I had enough time to plan what I want to play.
CS4.	I felt frustrated while creating with this prototype.*
CS5.	The timeline offered support to implement different music ideas and possibilities.
CS6.	I kept finding new ways of playing with the sound in this prototype.
CS7.	I could not do some of the things I needed to do on this prototype.*
CS8.	I was very creative with the music.
CS9.	When I was creating with the music box, I lost track of the world around me.
CS10.	The prototype allowed me to be expressive on music.
CS11.	I think I produced a piece of music with good quality.

(CS), see Table 3. There were eight paired statements in ES and CS addressing the same factors: interest(ES1, CS1), feedback(ES4, CS5), exploration(ES5, CS6), expressiveness(ES6, CS10), challenge (ES7, CS4), control(ES8, CS7), focused attention(ES9, CS9), results worth effort (ES10, CS11). The paired statements addressing the same factors were aimed at offering comparisons between the task sessions. The statements marked with the symbol * were coded in a negative way.

In the second part of CEQ, participants were asked to choose one option that is most appropriate for a set of statements from the two given MTBox modes. With the comparisons between MTBox modes, we were able to capture participants' opinions on the six factors of creative engagement: (1) Enjoyment: I enjoyed my self most; (2) Exploration: I explored more music ideas; (3) Expressiveness: I felt I was more expressive; (4) Challenge: The interface was frustrating; (5) Creativity: I felt more creative with; (6) Results worth effort: I felt more satisfied with the result.

Table 4
Coded interaction.

Interaction type	Coded interaction
s	Switch sample
f	Scroll to future timeline
p	Scroll to previous timeline
b	Back to current playing point
c	Change playing point to previous timeline
d	Change playing point to future timeline
r	Start pause
n	Stop pause
a	Add a new ON point
e	Edit an ON point
i	Insert an ON point in the records
o	Add a new OFF point
m	Edit an OFF point

4.3.2. *Activity assessment*

Each interaction with the buttons and timeline controls on MTBox, was logged with a coded interaction type and time, see Table 4. Numerical measures of the interaction with MTBox can be derived from analysis of these logs of participants' activity with the user interface. We focused on activity with the timeline and compute the ratio of time each participant spent on the timeline, both in the future timeline (f-duration) and in the previous timeline (p-duration).

4.4. *Qualitative interview assessment*

In addition to the quantitative data collection of logs and questionnaires, a semi-structured interview was conducted to collect supplementary qualitative feedback in order to understand the participants' subjective experience with MTBox. Interview questions were designed based on the task sessions. Questions include: *Did you find different ways of playing the prototype? What feature of the prototype do you think allows you to be more exploratory? Which feature of the timeline do you think is more useful for creation? What feature of the prototype do you think helps you to be more creative? Did you get frustrated when you were creating?*

4.5. *Procedure*

Twenty-four participants (12 male, 12 female) who considered themselves to be non-musicians were recruited to take part. The average age of the participants was 25 ($SD = 5.247$). The participants were a mixture of undergraduate students, graduate students, and non-students. They signed a consent form and were informed that they could leave at any time. Each participant received £10 (GBP) as compensation.

Before starting to play with the MTBox, the participants were asked to complete a pre-questionnaire to self-assess their musical creativity. Participants were divided into two groups: Group 1 and group 2. In the study they interacted with two UI modes separately. Group 1 interacted with M_{nn} and M_{cn}, and group 2 interacted with M_{ne} and M_{ce}, see Table 1. To eliminate the influence of the sequence of exposure to UI mode, the order of the UI modes was randomly assigned for participants. With each prototype there were 4 sessions:

- *Guided Learning (15 min)* The participants were guided in learning all the functions of the prototype and then encouraged to try out MTBox for a while based on the given introduction. They could ask questions if they were confused about the functions. The initial trial with MTBox was limited to 5 minutes. The buttons of MTBox were left unlabeled because we wanted the participants to learn to use MTBox without the need to refer to labels.
- *Exploration (10 min)* The participants were encouraged to explore it in their own way and were told that they could play whatever they

wanted. There was no requirement given for a minimum number of samples that should be used or outcome to be produced. The participant was reminded after 10 minutes of interaction and they could continue if they wanted. Afterwards they were asked to fill in the questionnaire (ES). Interview questions were then asked to get an understanding of the participant's exploration process.

- *Creation (10 min)* The participants were encouraged to create a piece of music with the prototype and were told that final records on the timeline will be treated as the result of their creation. There was no requirement given about the length of the piece or the minimum number of samples to be used. The participant was reminded after 10 minutes of interaction that they can continue if they wanted. Afterwards the participant was asked to fill in the questionnaire (CS). Interview questions were asked to understand their creative process.
- *Semi-Structured interview (5 min)* The participants were then interviewed to collect their feedback on the experience and the user interface.

5. Results

5.1. Questionnaire feedback

Three analyses were carried out on the questionnaire data: (i) comparison of the paired factors of creative engagement was conducted to examine the effects of task motivations; (ii) comparison by MTBox modes; and (iii) comparison by dependent variables were conducted to examine the effects of prototype modes.

5.1.1. Comparison on paired factors of creative engagement

A three-way mixed ANOVA was conducted to investigate the impact of three independent variables (playing point, record, and task) on the agreement on the paired factors of creative engagement in the questionnaire. There is a significant three-way interaction between the three variables for the factor of feedback ($F(1,22) = 6.480$, $p = .018$). There is also a significant two-way interaction ($F(1,22) = 8.000$, $p = .010$) between the playing point and task.

There is a significant main effect of task on the agreement on the paired factor of expressiveness ($F(1,22) = 8.469$, $p = .008$), with a higher agreement ($M = 4.979$) on the expressiveness of the prototypes when assigned an exploratory task, compared with the creative task ($M = 4.438$). There is also a significant main effect of task on the agreement on the paired factor of results worth effort ($F(1,22) = 55.640$, $p < .001$), with a higher agreement ($M = 6.250$) on the result worth effort of the prototype when assigned with an exploratory task, compared with the creative task ($M = 4.250$). A summary is presented in Part 2 of Table 5.

Table 5
Significant differences on participants' agreement on creative engagement factors.

Session	Factor	Agreement mean
1. Comparison on creativity by stages		
M_{ce}	Creativity	ES0 < CS8
2. Comparison by task session		
	Expressiveness (ES6, CS10)	Explore > Create
	Result worth effort (ES10, CS11)	Explore > Create
3. Comparison by prototype modes		
Explore	Aesthetics (ES2)	$M_{ce} < M_{ne}$
Create	Creativity (CS8)	$M_{ce} > M_{ne}$
Create	Focus Attention (CS9)	$M_{cn} > M_{ne}$
4. Comparison by independent variables		
Create	Feedback (CS5)	M_{nn} and $M_{ne} < M_{cn}$ and M_{ce}
Create	Focus Attention (CS9)	M_{nn} and $M_{ne} < M_{cn}$ and M_{ce}

5.1.2. Comparison by MTBox modes

A paired samples t-test was conducted to compare the difference between the agreement on ES0 and CS8 with all prototypes. There was no statistically significant difference between the initial self-assessment of music creativity and creativity with MTBox modes including M_{nn}, M_{ne} and M_{cn}. However, participants' ratings on their creativity with M_{ce}($M = 4.50$) is statistically significantly higher ($t(11) = -3.095$, $p = .010$) than their initial self-assessment of music creativity ($M = 3.0$), see Part 1 in Table 5.

For each statement in the questionnaire, a *t*-test was conducted to compare with MTBox modes. A summary of significant differences is presented in Part 3 of Table 5. A paired samples *t*-test indicates that the agreement on ES2 ("This prototype was aesthetically appealing.") with M_{ce} ($M = 5.50$, $SD = .905$) in exploration session is statistically significantly lower ($t(11) = -2.419$, $p = .039$) than that of M_{ne} ($M = 5.83$, $SD = .718$). A paired samples *t*-test indicates that the agreement on CS8("I was very creative with the music.") with M_{ce} ($M = 4.50$, $SD = 1.087$) in creation session is statistically significantly higher ($t(11) = 2.345$, $p = .034$) than that of M_{ne} ($M = 3.67$, $SD = 1.231$). An independent samples *t*-test finds that the agreement on CS9("When I was improvising with the music box, I lost track of the world around me.") with M_{cn} ($M = 5.92$, $SD = .996$) in creation session is statistically significantly higher ($t(22) = -2.328$, $p = .030$) than that of M_{ne} ($M = 4.83$, $SD = 1.267$).

Table 6 details the results of the prototype comparison questionnaire (second part of CEQ) with significantly different results highlighted in bold using a Chi test. Between the M_{nn} and M_{cn} comparison, there is no significant difference between the enjoyment, creativity and results worth effort, but significant differences are found in the factor exploration ($X^2 = 10.667$, $p = 0.001$), expressiveness ($X^2 = 6.000$, $p = 0.014$), and challenge ($X^2 = 6.000$, $p = 0.014$). Between the M_{ne} and M_{ce} comparison, there is no significant difference between the enjoyment, expressiveness, challenge, and results worth effort. However, significant differences are found in the factors of exploration($X^2 = 16.667$, $p < 0.001$) and creativity ($X^2 = 10.667$, $p = 0.001$).

5.1.3. Comparison by independent variables

The data of M_{nn} and M_{cn} was combined to compare these results with the data of M_{ne} and M_{ce}, in order to examine the effects of editable records. An independent sample *T*-test was conducted on the agreement of questionnaire statements for two different task sessions. There was no statistical difference in any of the data between these two groups.

Similarly, the data of M_{nn} and M_{ne} was combined to compare it with the data of M_{cn} and M_{ce}, in order to examine the effects of changeable playing point. A Paired sample T-test was conducted on the agreement of questionnaire statements for two different task sessions. In the creation session, the agreement on CS5 ("The timeline offers support to implement different music ideas and possibilities") with prototype M_{nn} and M_{ne} ($M = 4.67$, $SD = 1.373$) is statistically significantly lower ($t(23) = -2.228$, $p = .036$) than that of M_{cn} and M_{ce} ($M = 5.25$, $SD = 1.260$). The agreement on CS9 ("When I was improvising with the music box, I lost track of the world around me") with prototype M_{nn} and

Table 6
Prototype comparison table.

Playing point Records	No change No edit M_{nn}	Changeable No edit M_{cn}	No change Editable M_{ne}	Changeable Editable M_{ce}
Enjoyment	5	7	4	8
Exploration	**2**	**10**	**1**	**11**
Expressiveness	**3**	**9**	4	8
Challenge	**9**	**3**	5	7
Creativity	5	7	**2**	**10**
Results worth effort	5	7	7	5

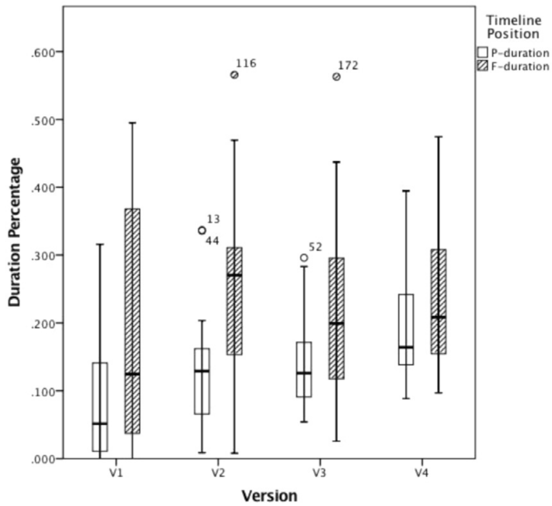

Fig. 5. P-duration and F-duration.

M_{ne} (M = 5.17, SD = 1.239) is statistically significantly lower (t (23) = -2.632, p = .015) than that of M_{cn} and M_{ce} (M = 5.58, SD = 1.248). A summary of significant difference is presented in the Part 4 of Table 5.

5.2. Timeline activity

The percentage of time a participant spent on the previous records of the timeline (p-duration) and on the future records of the timeline (f-duration) was calculated, illustrated in Fig. 5 based on MTBox modes. A summary of significant differences is presented in Table 7.

A paired samples t-test indicates that participants spent significantly more time ($p < .001$) on the future records of the timeline than on the previous records of the timeline. There is also a significant strong positive correlation (r = .599, n = 96, $p < .001$) between the p-duration and f-duration according to Pearson correlation. A three-way mixed ANOVA was conducted to investigate the impact of changeable playing point (within subjects), editable record (between subjects) and task (within subjects) on p-duration and on f-duration. There is a significant main effect ($F(1,22)$ = 19.370, $p < .001$) of playing point on p-duration, with higher percentage time spent on p-duration with changeable playing point prototypes (M = .167, SD = .093), compared to that with non-changeable playing point prototypes (M = .110, SD = .076).

A Pearson correlation was conducted to determine the relationship between f-duration and p-duration and agreement on statements in two sessions. There is no correlation between p-duration and agreement on statements in the exploration session. However, in the creation session, there are statistically significant positive correlations between f-duration and CS2 (The timeline helps me to organize my composition) (r = .322, n = 48, p = .026), and between p-duration and CS5 (The timeline offers support to implement different music ideas and possibilities) (r = .297, n = 48, p = .040).

5.2.1. Summary

To summarize, with **motivation** we found significantly higher agreement on prototype **expressiveness** and **satisfaction with the result** when assigned with the exploratory task, as compared to the creative task.

With the **timeline feature of changeable playing point** we found:

- When exploring, M_{ne} was **more visually appealing** than M_{ce}
- Creating with M_{ce} was **more creative** than with M_{ne}.
- Participants reported **more focus** when creating with M_{cn} than with M_{ne}.
- M_{cn} and M_{ce} gave **better feedback** than M_{nn} and M_{ne}.
- Participants reported **more focus** with M_{cn} and M_{ce} than M_{nn} and M_{ne}.
- M_{cn} and M_{ce} were **more exploratory** than M_{nn} and M_{ne}.
- M_{cn} was **more expressive** than M_{nn}.
- M_{cn} was **less challenging** than M_{nn}.
- M_{ce} was **more creative** than M_{ne}.

In terms of **timeline activity** we found:

- Significantly **less time** was spent on previous records than in future records.
- With a changeable playing point, **more time** was spent on previous records than on the future records of the timeline.
- Positive correlation between f-duration and CS2 suggesting that the more time spent on future records, the higher the agreement on the timeline helped on **structure composition**.
- Positive correlation between p-duration and CS5 suggesting that the more time spent on previous records, the higher the agreement on the timeline offered enough **feedback**.

Table 7
Significant statistical analysis on timeline activity.

Relation	Example
Significant difference	p-duration < f-duration
Main Effect on p-duration	Changeable playing point > Non-changeable playing point
Positive correlation	f-duration and CS2
Positive correlation	p-duration and CS5

5.3. Interview feedback

A bottom-up deductive thematic analysis (Braun and Clarke, 2006; Fereday and Muir-Cochrane, 2006) was conducted to extract participants' ideas about the playing mode and task motivation. The themes are reported below with a representative quote from participants (Participant ID is included in brackets).

5.3.1. Skill set

"Because there are some skills involved, its the difference between say playing tennis and doing a crossword, like there is skill in a crossword, but you get the time to sit there and think about it, you don't have to do it in a hurry." (Participant 23)

In terms of the expertise of musical performance, two sets of skills, namely *mental* and *physical skills*, are required for expert musicians to articulate the music in their mind and express it through the instrument (Davidson and Coulam, 2006; Ericsson, 1998). Our data suggests a similar categorization for non-musicians' creative engagement with digital musical interfaces. Based on the feedback from all the participants, we identify *mental skills* which are concerned with various cognitive facts related to the conceptual understanding and creation of music. For example the strategies of idea exploration and generation, and the ability to shape sound structures(Webster and Ho, 1997), or the *mental representations* that help to plan and reason the actions, and to monitor the performance (Ericsson, 1998). *Physical skills* are concerned with the ability to execute the music ideas, similar to the concept of *craftsmanship* proposed by Webster (Webster and Ho, 1997).

It was more difficult for participants to play in the improvisational mode as several of them reported they can not 'think' or to 'concentrate' when music was playing. According to our participants, the most demanding mental skill was to memorize all the sounds, and to make decisions at the presence of the ongoing music. Some features of the timeline were reported to be conceptually helpful during the process, which will be discussed in later session. In terms of the physical skill, our participants reported that they found it hard to press the right button at the ‘right time’. Some participants suggested offering visual feedback when they achieved a synchronized action, or to have auto-synchronization embedded in system.

5.3.2. Structured records and plan

“It makes the structure more obvious, you know, of the music.”(Participant 23)

Participants spoke highly of the timeline as it helped to organize their records and to plan future music events in a structured way, which allowed them to store musical ideas for the future and helped to reduce the mental workload required for music making, e.g. “freed up to think about other things” (Participant 19). The records on the timeline also helped to remind user of the previous interactions and sound combinations they had made. Apart from offering an overview of the current events, e.g. “you can see which sound is on and off at each time” (Participant 16), the visual representations of the timeline enables non-musicians to approach music visually, e.g. “the reference of the timeline, which is a lot like a graph, and then the sounds” (Participant 23). The timeline was reported by participant to offer three parts of information: i) the previous records reminded participants of what was done; ii) the current status indicated what was going on; and iii) the future timeline helped participants to anticipate what was going to happen. The structured records and future ideas offer an easy trace back to previous success and mistakes, and free participants “to use their imagination’.

5.3.3. Improvise

“Then live playing is like, Im just making some music, its just there in the moment and then Im gonna throw it away I dont care anymore. So its like, yeah, just playing.” (Participant 10)

“In real time I have to use my senses, and my ability to react and press it when its supposed to be pressed.” (Participant 23)

Participants’ concept of improvisation was associated with the activity of playing live. The term *live* refers to play directly with the sound in real time with MTBox. This might or might not involve some planning ahead. According to participants’ feedback, there were two levels of playing live:

One is *experimenting live* with possible interactions, sound combinations and patterns in real-time. When playing in this mode, participants usually focus more on the music ideas and process rather than the results. Thus they reported less pressure as they worry less about the mistakes. Moreover, participants report playing experimentally is intuitive, engaging and responsive for beginners to learn and explore, because of the direct sound feedback from interactions.

The other level of playing live is *performing live*, using the interface as an instrument, performing music in real-time with the musical structures or ideas in mind. Contrary to the *experimenting* mode, *performing* mode is result oriented. Participants viewed the interaction process and its results as a whole output when playing in this mode. With the emphasis on the result and its quality, participants put more mental effort on musical aspects such as timing, structure planning, etc. Participants reported more pressure, felt less confident and encountered more barriers such as skill, readiness time, etc. in this level of playing live. They also reported great pleasure and fun when playing with this mode successfully as ‘I enjoy at the moment right now (Participant 5)’. Also, the function of planning ahead plays an important role in supporting participants’ live performing by providing enough readiness time to release the real-time pressure as the participants ‘didnt have to worry about playing the button at the right point (Participant 19)’.

5.3.4. Compose

“If I were to make a composition, I would actually want to go, like after Im done, sort of done, I want to go back and relisten to it, to change it, you know.”(Participant 10) “So its actually, so the start would be good as well as the end...... I was actually trying to make sounds...... So you feel its more secure, in some sense.” (Participant 16)

Participants viewed composing as an iterative process of building up a piece, creating, reflecting on and revising the previous records, from which they can learn and get inspirations from the success and mistakes. For example, one participant reported when he looked back on the mistakes he made, he thought to himself ‘I’m not gonna do that again’ (Participant 7). This is in keeping with the concept of composition in the traditional music context. Participants who enjoyed this mode reported its advantages, including offering more ‘freedom’, allowing them to modify mistakes, e.g. ‘I can correct it, so that will be much better.’ (Participant 5), requiring less physical skills and offering enough readiness time as they do not ‘have to be quicker’, producing less pressure for users as they felt ‘its more secure’, and ensuring good quality of results which ‘the start would be good as well as the end’. In terms of the two features of MTBox, replay and revise records, participants reported being able to replay records plays a more important for supporting composition, compared to being able to revise records. This is consistent with the results from the quantitative analysis.

In terms of the process of composition, most participants started with exploration on music ideas by randomly putting sounds together, and once they have accumulated enough music ideas, they would start building up a general structure for the whole piece, e.g. ‘with practice you could really layer up things’ (Participant 19). This process could be thought of as a bottom-up strategy (Roads, 2015). Contrary to the bottom-up strategy, one participant began with a general structure of music in mind, followed by exploring and creating sound ideas and then filling them into a structure. This could be thought of as a top-down strategy (ibid).

5.3.5. Motivational orientations

“It just really depends if I really want to create something, at the end I wanted to be good, probably the second one (M_{ce}). And if I really just want to playing live, like music flow, so would be the first one (M_{ne}).” (Participant 18)

“I could play, and just without having, to have a composition or something, just playing and listen to the sound, that was nice, and discover the sounds and stuff.” (Participant 3)

Given an explicit utilitarian goal for music output, participants preferred the composing mode as they reported ‘for actually creating a nice song, it would be really good to have the timeline and to be able to go back and forth’. Whilst with an exploratory task, participants were more likely to be engaged in the playing live as they enjoyed the responsive feedback of playing live, e.g. ‘its really easy to do at the current time, cause you can actually hear it.’(Participant 16) and reported being excited about the serendipity they encountered, e.g. ‘the experiment of possibly creating something is good.’ (Participant 24). Also because they did not have a goal for output, they reported being more relaxed, being less worried about the mistakes, and were more encouraged to explore more music ideas in this condition.

5.3.6. Inspiration source

“Im just put all the squares or all the circles and see if it sounds nice for some reason. But I think I like better to just mix, the shape.”(Participant 3)

“And the second one, more of a task that you have to, I guess helps to get different ideas. Cause you know you have this limit.”(Participant 8)

From the feedback there were primarily three sources for inspirations in musicking. The primary source was participants’ previous interactions and the music events recorded on the timeline, including the general music structure, and the sound ideas, combinations or patterns. These allowed participants to evaluate and to ‘learn from’ the previous success and failures, e.g. learn ‘how they work together’ (Participant

16), decide 'what needs to be changed' (Participant 11), and thus build on the previous creations. Another source was the visual clues. Graphic information such as the shape, color, length of the graphic representations inspired participants on sound combinations and patterns 'cause you can see which one is playing with which, with the other one' (Participant 16) so you 'know which one to cut and extend' (Participant 24). Finally, constraints were another source for inspiration. Although participants reported they felt frustrated when interacted with prototypes that had non-changeable playing points or non-editable records, it turned out that these constraints triggered the exploratory behaviors, and lead to more creative music ideas, e.g. 'a task that you have to, I guess it helps to get different ideas. Cause you know you have this limit.' (Participant 8).

6. Discussion

The hypothesis H1 (*Creative engagement will be greater with an explicit utilitarian goal for the creative output*) was not supported by our results. Given an exploratory task, participants' rating of expressiveness of the prototype (ES6 and CS10) and satisfaction with the results (ES10 and CS11) were significantly higher than when they were given a utilitarian goal. This suggests that an experiential goal has more potential than a utilitarian goal to increase the positive experience in terms of perception of expressiveness of the prototype and satisfaction with results. This may be because when participants were given an experiential goal they were more willing to explore more musical expressions and were encouraged to employ divergent thinking (Sawyer, 2011), while the pressure of a utilitarian goal may have limited divergent thinking and the exploration of musical ideas.

Interestingly, participants' rating of the aesthetic appeal of M_{ne} was significantly higher than M_{ce} in the exploration session. In another word, participants found the prototype without changeable playing point to be more appealing than the prototype with changeable playing point when playing with an exploratory task. This may be because M_{ne} has fewer functions than M_{ce}, and it's simpler to learn and to play when given an exploratory task. In this condition players were not obliged to create anything in particular and so they may not have needed the functionality of a changeable playing point resulting in it becoming a cognitive burden that affects the perceived aesthetic of MTBox. This is contrary to the results that changeable playing point mode received higher agreement on creativity ($M_{ce} > M_{ne}$), focus attention ($M_{cn} > M_{ne}$) and feedback (M_{cn} and $M_{ce} > M_{nn}$ and M_{ne}) when playing with a creative task. From the above discussions, we infer that the task motivations largely affect the need for the changeable playing point on MTBox.

The hypothesis H2 (*Creative engagement will be greater with prototypes with changeable playing point*) was supported by our findings. Firstly, participants' rating for feedback (CS5) and focus attention (CS9) were higher with prototype M_{cn} and M_{ce} (which both had changeable playing point) than M_{nn} and M_{ne}. These higher ratings for feedback suggest that the interface with changeable playing point better supports creative engagement in keeping with findings by O'Brien and Toms who propose feedback as a key element of engagement (O'Brien and Toms, 2008).

Secondly, participants rated their attention as significantly more focused with M_{cn} (has changeable playing point only) than with M_{ne} (has editable records and no changeable playing point). Higher ratings for focused attention suggest deeper level of creative engagement - focused attention is proposed as a key element of engagement (O'Brien and Toms, 2008) and factor contributing to creativity (Carroll et al., 2009).

Thirdly, in Table 6 significantly more people reported that M_{nn} was more challenging than M_{cn} but no difference between M_{ne} and M_{ce}, and significantly more people reported that M_{ne} was less creative than M_{ce} but no difference between M_{nn} and M_{cn}. Also, both M_{cn} and M_{ce} were rated to be more exploratory than M_{nn} and M_{ne}. Both of these results indicate that a changeable playing point contributes to increased reporting of factors of creative engagement. Moreover, the ratings of creativity with M_{ce} were significantly higher than with M_{ne}, indicating that the changeable playing point increased perceived creativity.

Finally, the findings that when playing with a changeable playing point there was significantly more time spent on the previous timeline, and that the more time participants spent on the previous timeline the better feedback they gained from the timeline, suggest that the changeable playing point increased participants positive experience of the prototype.

Hypothesis H3 (*Creative engagement will be greater with prototypes with editable records*) is partially supported by our findings. There is no significant difference between the participants' responses between non-editable prototypes (M_{nn} and M_{cn}) and editable prototypes (M_{ne} and M_{ce}). This suggests that the edit-ability of content does not have a direct effect on people's perception of their creativity. Or, more generally the findings suggest that there was no perceived difference in support for creativity from a prototype which was designed more for improvisation (non-editable) and one which aimed to support composition (editable). This may be due to the musicking tasks given to participants which were purposefully vague (e.g. "explore" or "create"), or possibly because the participants were non-musicians who had a (relatively) short time to learn to use the system, or it could be because the comparison between editable and non-editable prototypes was between group as subjective Likert scales are compromised because of different reference groups (Heine et al., 2002).

However, participants' ratings of focus attention with M_{cn} are significantly higher than with M_{ne}, and the ratings of the creativity with M_{ce} are significantly higher than with M_{ne}. This indicates that when both features (editable records and changeable playing point) are available, creative engagement is higher as elements of creativity are rated higher.

Interestingly, the results also seem to indicate that the feature of changeable playing point may be more crucial to non-musicians' creative engagement with musical interfaces than the feature of editable records. The ratings of expressiveness and challenge are significantly different between M_{nn} and M_{cn}, but there is no significant difference between M_{ne} and M_{ce}. Whilst ratings of creativity are significantly different between M_{ne} and M_{ce}, but no significant difference between M_{nn} and M_{cn}. This indicates that whilst support for editing has some effect on ratings of expressiveness, challenge, and creativity, the primary effect is due to whether there is a changeable playing point or not. These results suggest that the effect of the feature of changeable playing point is enhanced by the addition of the feature of editable records.

6.1. Timeline activity

We found that when playing with a changeable playing point, there was a higher percentage of time percentage spent on the previous timeline. We also found a strong positive correlation between f-duration and p-duration. These two findings allow us to claim that the usage of both previous and future timeline is higher with the prototype that has a changeable playing point than with a non-changeable playing point. Players did use the previous and future zone of the timeline, and these activities were correlated with positive feedback on factors such as feedback and support for composition.

Wu and Bryan-Kinns (2017) showed that non-musicians reported more creative engagement when they had more time to prepare and to implement their musical ideas. Our finding that the more time spent on the previous and future timeline the better feedback and support on composition were gained from timeline also supports this claim that non-musicians' creative engagement increases when the musical interface provides functions for planning ahead. Together with the qualitative results discussed in the theme *compose*, we propose that replay and revision of the previous records helped non-musicians to learn, explore and implement music ideas. As presented in the theme *structured records and plan*, the timeline serves as a distributed cognitive tool for non-

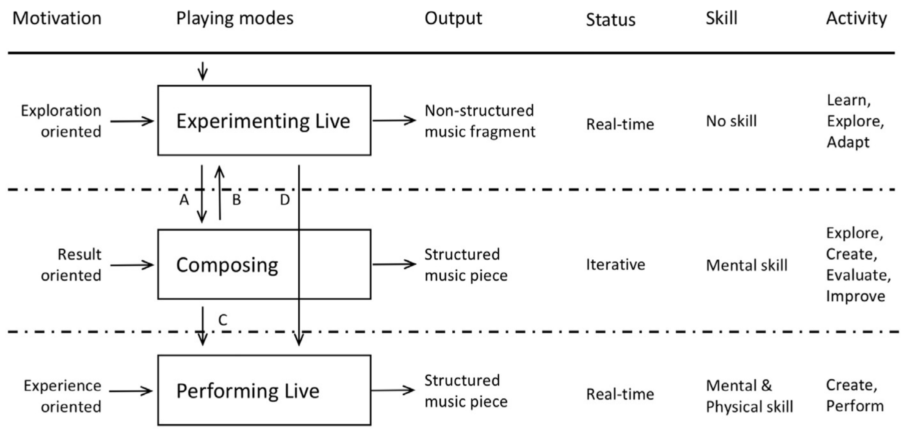

Fig. 6. Non-musician's creative engagement model with musical interface.

musicians as it allows them to store knowledge and ideas temporally in the system rather than in the memory (Hollan et al., 2000), and offload tasks and cognitive process on to environment or tools (Davis et al., 2013a). We emphasize the importance of providing a **structured** records and plan. It's with a structured resource, the records could possibly serve a better use. As novices need to learn from mistakes (Kim et al., 2015), a structured records allows them to trace back efficiently and to recall previous mistakes and success easily. Moreover, a structured records/plan could also contribute to a clear representation of the overall music structure, supporting users to create a structured piece of music.

6.2. A Descriptive model for creative engagement

We propose a descriptive model of non-musician's creative engagement with musical interfaces from the qualitative analysis of participants' feedback, see Fig. 6. The rationale for developing a descriptive model is to offer a structured and generalized description on creative engagement with IMSs and interactive systems that involves real-time activities. In this model we describe creative engagement based on six factors: (i) the motivation of playing; (ii) the playing modes; (iii) the output; (iv) the status; (v) the skills required, and (vi) the activities involved. There are three modes of playing progression from *experimenting live* to *compose* and on to *performing live*. Each mode is driven by a different motivations, and demands a different set of skills. There are different activities involved in these modes. We propose that there is an increasing level of difficulty between the three modes outlined below from the easiest mode to the more advanced mode. And the output of each mode is with a progressive quality.

Experimenting live is when a player is focusing on experimenting in real-time with possible musical ideas such as rhythmic patterns, typically using a trial and error approach. This playing mode requires no skill and the output is non-structured musical fragments. It is usually the first mode of play adopted by novices, of which the main purpose is to learn and incubate ideas for later creation (Sawyer, 2011). As has no conceptual and technical requirements, it encourages players to play in the initial stages We propose when playing with this mode the players are in the very first level of creative engagement. It is oriented to exploration and involves behaviors such as learn, explore, and adapt to the system (Bilda et al., 2008).

Compose is an iterative process of building up a structured piece and involves behaviors such as exploring, creating, listening, evaluating, improving, and recreating. It requires cognitive skills and the output is a structured piece of music, which is similar to the musicking mode of composition discussed in Section 2.3. It is usually adopted at the second stage of the interaction process after players reach a deeper understanding of the system (Bilda et al., 2008), and when the player has an explicit utilitarian goal for producing good results. In this proposed framework it acts as a *sustainer* (Edmonds et al., 2006) to keep the player engaged after the initial encounter. We propose when playing with this mode player is in the second level of creative engagement.

Performing live is implementing musical ideas in a structured way in real-time and involves create and perform behaviors. It requires both mental and physical skills and the resultant output is a structured piece of music, which is similar to the mode of comprovisation and improvisation discussed in Section 2.3. It is usually adopted at the final stage of the interaction process when the player is pursuing the enjoyment of playing as well as a good result, and when the player is getting more confident with their mental and physical skill, and starting to play fluently (Hansen et al., 2011) with the interface. This mode encourages the relationship between the system and the player continues to grow We propose this mode is a more advanced level of creative engagement, and also the desired phase of creative engagement.

With MTBox, the most common trajectory of modes starts with *experimenting live* followed by *compose*, similar to a bottoms-up strategy of composing proposed in Roads (2015). In contrast to this, one participant reported starting with a general musical structure in mind and experimenting live with musical ideas to fill it in, which is similar to a top-down strategy of composing proposed in (Roads, 2015). The trajectory towards *performing live* such as C and D, illustrated by a dotted line, was reported as being more difficult to handle, however it was more enjoyable. Therefore, the trajectory of modes progressing towards performing live is the optimal trajectory of creative engagement we would like to propose, as it offers challenges as well as joy cf. (Csikszentmihalyi, 2014).

6.2.1. Barriers and catalysts

The barriers inhibiting non-musicians' creative engagement with IMSs include limits of cognitive skills, i.e. working memory, multitasking, and physical skills, i.e. synchronized or real-time action, and their lack of confidence and experience, i.e. pressure to produce a good quality result, and ease of becoming fixated without knowing what to do next. User interfaces could be designed to provide scaffolding to overcome these aspects. In our case, the timeline supported planning ahead and allowed players to save working memory and reduce the amount of multitasking required. The ability to change the playing point supported real-time activities by allowing access to records in real-time, which is an important feature of comprovisation discussed in Section 2.3. In terms of participants becoming fixated without knowing what to do next, the visual representations on the timeline helped to inspire participants to create more musical expressions.

From our data, we propose several potential external and internal catalysts that could trigger further levels of creative engagement. External catalysts include constraints and social pressure. For example, as presented in the theme *inspiration source*, when the prototype has limited control, the constraint may trigger participants to explore more possibilities. Alternatively, some participants reported that they were thinking about audiences when playing, which led them to explore and create. Internal catalysts include motivation and serendipity. When the motivation shifted from an experiential goal to a utilitarian goal, we found that players typically changed to different playing modes. Or when participant found unexpected or surprising ideas, they were encouraged to explore more possibilities, as presented in the theme *inspiration source*. These catalysts are different to those reported in studies of interactive art which suggest that participants start of engage in creative pursuits when their intentionality and expectation are not achieved (Bilda et al., 2008), or when the system initiates an unexpected change (Candy and Bilda, 2009).

6.3. Design implications

To break the barriers to creative engagement for non-musicians, and to support their activities in the process, a list of design implications are discussed in detail below based on motivation, mental workload, insights and real-time activities. These design implications will have direct implications for the design of similar musical systems for non-musicians in NIME (Jensenius and Lyons, 2017), or systems that aim to engage novices creatively in HCI.

1. Design for progressive layers of motivation. Designing motivations in different stages of interaction is a good way to catalyze novices in an optimal trajectory of creative engagement. According to the descriptive model of creative engagement, applying different motivations could catalyze users towards different levels of creative engagement. It could be achieved by promoting experiential exploratory goals by designing stepwise functions to be discovered stage by stage, or by promoting utilitarian creative goals by encouraging participants to share the musical outcome to their social networks. This is in line with the proposal to foster and enhance motivation by setting stages and context for creative works (Selker, 2005b). It suggests an integration of different motivations into a single system, and differs from the previous practices that focused on design only for experiential motivations (Bengler and Bryan-Kinns, 2013; Hansen et al., 2011; Robson, 2002) or utilitarian motivations (Benedetti et al., 2014; Bonnardel and Marmèche, 2004; Davis et al., 2013b).

2. Design to support cognitive skills. As discussed earlier, non-musicians are not skilled at music making which puts greater demands on their working memory and multi-tasking than experts. There are two practical implications to reduce novices' cognitive workload in the creative process.

- Offer ***controllable structured records***. Structured records of content and interactions offer an easy way to trace back to previous success and mistakes (Kim et al., 2015), which supports self-evaluation of activities and contributes to iterative improvement. This is in keeping with the call for rich history-keeping mechanisms and compositional structures suggested in (Carroll et al., 2009; Franco et al., 2004; Shneiderman, 2007). However, we emphasize the mechanism to control and manipulate the records at a global level rather than merely organize or visualize the data. Being able to be reused or changed the records could become resources for learning as well as content for further creative processes. This supports the activities of learn, explore, create, improve as well as perform. In our case the ability to revisit and replay previous records in real-time allowed players to use the previous records as content to create the whole piece. In the music domain this could be as simple as a timeline storing the information about melodic contour and rhythmic patterns, similar to the traditional music score.

3. Design to stimulate insights. Novices can easily get fixated on previous ideas (Kerne et al., 2014). It is necessary to provide mechanisms to support in gaining insights.

- Provide an ***inspiration source*** to foster insights, by offering valuable records, visual cues, or by employing certain constraints. More specifically, this could be achieved by providing the ability to evaluate records and to encourage users to learn from their evaluation (Carroll et al., 2009; Shneiderman, 2007). Or very simple graphic elements such as shape and color can potentially help users to get ideas for creating music combinations and patterns. This could stimulate *analogical thinking* that connects the content of analogies across domains to support selective comparison in a creative process (Bonnardel, 1999; Sternberg and Kaufman, 2010). This is similar to the strategy for supporting serendipity by providing users with unexpected and valuable content that they might not have otherwise think of or come across (Kerne et al., 2014; Makri et al., 2014). It could also be achieved simply by employing limited control to drive users to explore the limit of the system to trigger their creativity. As discussed by Sternberg, constraints do not necessarily harm creative potential, but may be built into the construction of creativity itself (Sternberg and Kaufman, 2010).

4. Design for real-time activities. For real-time interactions that require both cognitive and physical skills, it is difficult for novices to achieve good performance in a short time as it takes time to become fluent. Supporting real-time activities can be achieved through the following two practices.

- Support ***planning future events***. When pursuing outcomes with good quality in real time it is necessary to have a clear conceptual route for upcoming events and implementation methods. A mechanism allowing preparation of events in advance can reduce the amount of multi-tasking needed for real-time interactions, similar to the distributed creativity proposal to offload some of conceptual and technical tasks to tools (Davis et al., 2013b). This will greatly reduce the cognitive workload and offer a greater chance of participants having enough readiness time (Wu and Bryan-Kinns, 2017), thus imposing less pressure on participants and allowing for more confidence and chances for creativity (Gelineck and Serafin, 2010).
- Facilitate ***real-time physical skills***. Automatic solutions provided by systems e.g. auto synchronization and auto correction, help novices to achieve a satisfactory performance, and thus help to reduce pressure and build confidence (Nickerson, 1998). In our case, auto-synchronization might help non-musicians to trigger music samples at the right time. This is in keeping with the current design practices that use solutions such as auto synchronization to engage novices in entertainment experience (Shirokura et al., 2010; Weinberg, 2008).

6.4. Limitation and future work

There are some limitations to our work that might affect our results. MTBox was designed with a limited number of buttons and therefore offers limited sound choices. The samples were restricted to electronic sound genre. Moreover, the sound of MTBox was generated from the computer instead of MTBox itself or headphones. The monotony of expressiveness and disconnected sound might restrict players from becoming creatively engaged in the interaction, and thus affect their feedback. Future improvements need to be carried out to integrate the sound generation mechanism into MTBox.

One limitation of the study design is that the study was conducted in a controlled scenario within limited time. Even though a session was designed to provide guided learning and allow time for practicing it might still be that it is difficult for some participants to become confident with the prototype. Moreover, the study did not evaluate non-musicians' long-term creative engagement with the prototype, nor did it examine natural scenarios of use, or with multiple players, which could all be interesting to look at in future research, e.g. by conducting long-term studies with participants in real scenario, or design multiple MTBoxs to allow collaborative music making with multiple participants. In this study we did not include people who had musical experience. Even though MTBox was designed for non-musicians it would be interesting to see how experienced musicians' creative engagement might be influenced by the different modes of MTBox. The effects of user interface mode and design implications might be different as experts have better musical skills and knowledge compared to non-musicians.

The questionnaire which was designed based on a set of factors extracted from engagement attributes and evaluation factors for creativity support tools provided evidence about our hypothesis. The questionnaire could be useful as a set of criteria for evaluating creative engagement with interactive systems more generally, however this would need to be verified with further studies, and could be an exciting contribution to this field. From the very brief analysis of the interaction log data we find the potential to examine states of creative engagement with evidence extracted from interaction log data. More in-depth analysis methods such as data mining could be applied to detect patterns of activity or to quantify activity levels.

7. Conclusion

In this paper we explored the effects of task motivation and user interface features on non-musicians' creative engagement with interactive musical systems. Based on the results of an empirical study of twenty-four participants, we highlighted that an experiential motivation is better than a utilitarian motivation for creatively engaging non-musicians. We found that a replay feature is less important when a player has an experiential motivation compared to a utilitarian motivation. However, we also showed that supporting participants to replay previous musical ideas increased some aspects of their creative engagement. And when participants were able to edit their creations the increase in reported creative engagement was more pronounced. We also found that creative engagement increased when the musical interface provided features for planning ahead.

A descriptive model of non-musician's three levels of creative engagement was proposed with three playing modes. We highlighted the mode of performing live as the desired mode of playing and identified barriers and catalysts for non-musicians to achieve it. Design implications were proposed to inform future design for supporting novices creative engagement taking into consideration motivation, cognitive skills, insights and real-time activities.

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