Investigating How To Design For Systems Through Designing A Group Music Improvisation System

Bart Hengeveld*, Joep Frens*, Mathias Funk**

** DQI group, Dept. of Industrial Design, Eindhoven University of Technology, The Netherlands*
*** DI group, Dept. of Industrial Design, Eindhoven University of Technology, The Netherlands,*
B.J.Hengeveld@tue.nl, J.W.Frens@tue.nl, M.Funk@tue.nl

Abstract: In this paper we describe one of our studies aimed at gaining insight in how to design for systems, which we see as the current challenge in industrial design. We observe that the methods, tools and techniques that were developed for 'traditional' industrial design and, more recently, interaction design, fall short when designing networked, highly dynamic and open systems. To get more grip on this challenge, we set up a design challenge at our Department of Industrial Design, aimed at designing a Group Music Improvisation System. All participating students were asked to design part of the system, in the form of a novel interactive musical instrument that had its own behaviour but also allowed other instruments to influence its behaviour. This design challenge was explored with 20 undergraduate students during one semester. At the end of the semester all students had to present their work in a group performance. In this paper we describe our theoretical foundations, our starting points, the setup and results of the project, and discuss our most prominent findings and future steps.

Key words: Design, Interaction design, System design, Music, Improvisation, Co-creation

1. Introduction

Coming from the traditional craft of 'designing for appearance' we—designers—are currently moving through a paradigm of 'designing for interaction' towards 'designing for systems' [6], where we see systems as an open structure of technological and human interactions; in other words, any node in this structure, whether technological or human, can interact with another and both add meaningful structure to the system. In our experience this type of design is one of the more prominent upcoming challenges for the field of industrial design, which still builds on the two earlier paradigms. We feel that designing for systems not only calls for new design tools and skills, but even for new methodological approaches and trans-disciplinary communication. We elaborate on this in section 2.

To explore 'how to design for systems' we set up a design challenge in our department of Industrial Design. We centered this project on the subject of improvised music, which we see, like many others (e.g., [16]) as an inspirational source of insight. What makes improvised music particularly interesting for us in the context of designing for systems is that improvised music already has systemic characteristics on a social level so as to infuse the design challenge with relevant insights. For example, when we think about jazz music the rendition of a composition—which is in essence a musical design—is highly dependent on factors that lie outside the reach of the composer: the size of the performing band, the people in the band bringing their individual musical backgrounds, even the type of gig or venue all influence the outcome [2]. Nonetheless, as a system a jazz band functions really well; the whole is more than the sum of the parts. Yet, improvised music as we know it, does not form a system as we just defined it, as the technological aspects are underexposed.

It is however possible to create a system of novel musical instruments that could benefit from the advance of embedded and networked technology, which allow us to take on a different approach to group music; one where the instruments themselves can take on a more active role. This may not only result in a new expressive musical aesthetics, but might also inform us on how to design for such open systems where meaning is co-created.

We discuss the design challenge in this paper. We elaborate on our starting points, describe the results and discuss lessons learned in order to shape the upcoming iteration of this research. In the next two sections we first discuss systems design and (improvised) musical performance, before moving towards the actual design challenge itself.

2. Designing for systems

We are interested in systems design, which we perceive as the new frontier of design [6]. Where design has always favored a 'one person – one product' pattern, systems design breaks this pattern by introducing many, distributed (interactive) products, or 'nodes', that are connected to each other through informational ties. In our view theses systems are woven into the social fabric of our lives; they comprise of artefactual nodes (both of physical and digital nature) and human nodes. Following this, a system is both a technological and a social construct following the rules and mores of both.

Comparing systems with the interactive products of before we identify that an interesting aspect of systems is that they can grow and are therefore open: it is difficult to define the boundaries of a system and the functionality of a system is emergent and therefore subject to change. Not only is the functionality of a system necessarily a resultant of the configuration of a system in terms of artefactual and human nodes, in a system new people and new nodes can join, thereby altering the structure of the system. This means that the 'functionality' of a system changes as well, as it is, at least partly, dependent on the configuration of the system. Adding to this a system will not be static in time, new nodes will be added, and as always, these new nodes will offer new and unforeseen functionality.

Naturally this has consequences for the design process. Product design always had solid demarcations of what to include and what to exclude in a given product, in systems design these demarcations are less defined, blurrier. The systems design challenge is an open challenge where the designer needs to anticipate on new people, new nodes or new uses that he cannot know on beforehand. This makes systems complex and unpredictable and as a result designing for them as well. The classic design tools and methods do not suffice.

One of the ways of dealing with the openness and resulting complexity and unpredictability of systems is to take an experiential approach in designing. By trying out and experiencing the complexity of systems, personally but also holistically [7], a feel is created for the width and breadth of the solution domain and the direction that has promise. The design process has to be taken our of the 'head' of a single designer and into the 'hands' of a team of designers, essentially giving the design process systemic characteristics as well.

3. Group music improvisation

As said, we see similarities between systems as we have described them above, and improvised music. For example, considering a jazz quartet: this configuration of musicians does not only contain artefactual and human nodes, it acts as a system as well, as its organization is largely dependent self-directed: within stylistic and compositional boundaries a jazz quartet can fluently improvise without a predetermined goal. We elaborate on this in this section, discussing: (1) the act of performing music, (2) group improvisation in music, and (3) the influence that systemic technology can have on this.

3.1 The act of performing music

In our view (and experience) the activity of playing a musical instrument is not trivial; it involves multiple simultaneous feedback loops of musical expression [1] as shown in Figure 1, making that playing music demands a musician to be sensitive to and expressive in different settings at the same time. We do not see these feedback loops as unique to improvised music, but rather as universal attributes to any kind of musical expression, whether played from sheet music (e.g., in a classical orchestra) or without (e.g., in a jazz quartet). We explain these loops first, before illustrating how technology can impact them, potentially leading to a new musical aesthetics.

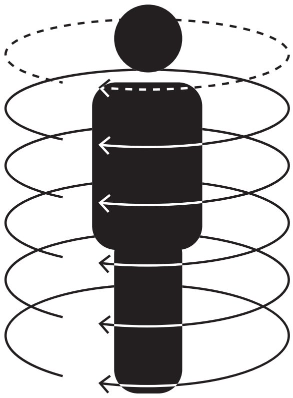

Figure 1. Different layers of feedback loops in musical performance

The *first* feedback loop, no matter the musical setting or situation, originates from a musician interacting with his musical instrument: the musician plays the instrument, which in turn generates a sound, to which the musician can respond (e.g., in intonation or expression). This feedback loop is at the core of playing music.

Secondly, in any setting involving musical interaction (e.g., multiple musicians together or a single musician and a play-along CD) a musician can belong to a section. For example, a drummer and a bass player both belong to a rhythm section. All musicians within a section have to sound well together, which adds a feedback loop to the aforementioned one.

The *third* feedback loop originates when sections start belonging to a larger musical body. For example, a cellist (who is acting in the first feedback loop with his cello) in a classical orchestra belongs to the cello section (feedback loop two), but also to the string section (consisting of the first and second violins, violas, cellos and basses, feedback loop three). In all feedback loops the cellist will have to sound well, whether this is determined by his individual musical expression or his collaborative performance of sounding 'together'. On top of this, the string section belongs to an even larger body: the orchestra.

To keep all these sections musically aligned, orchestras have a conductor who imposes his interpretation on the orchestra. This adds a *fourth* feedback loop. In jazz bands the role of the conductor often moves from musician to musician within a single piece of music. In jazz bands the musician playing a solo largely determines the musical direction, but initiatives from other band members can result in shifts in direction as well.

The *fifth* feedback loop we identify is the one involving the audience: when the audience 'connects' to the performers, they typically perform better.

A *sixth* feedback loop is less direct, but a feedback loop nonetheless: delayed feedback on your performance through sales, downloads, streams, Facebook likes, Tweets, etcetera. Clearly this feedback loop is of a different character than the previous five, as its effect on a musician's performance is less instantaneous, but we can see how it can influence elements such as the musician's motivation. We also foresee this sixth feedback loop becoming more influential in the near future, with the rapid developments in social networking and crowd funding.

3.2 Group improvisation in music

Although we do not consider these feedback loops unique for improvised group music, as stated in the previous section, they nonetheless intrigue us in that particular setting from a design perspective. What interests us most in group music improvisation is how the aforementioned feedback loops are dependent on self-organization. Let us explain this.

Transcribed music has a clear organizing factor: the sheet music. Despite the openness for music interpretation or the relativity of tempi (*allegro ma non troppo*) or expressions (*crescendo poco a poco*) sheet music gives a common direction to all involved musicians. In improvised music much (not all) of this direction is absent; often music originates 'on the fly', depending on factors such as the group composition, the setting, the musical backgrounds of the group members, and more. This makes that a single musical design (e.g., a jazz standard) will sound differently each time. Individual musicians can play with the musical boundaries of their joint effort, exploring melodic, harmonic and rhythmic variations, responding to each of the group members' idiosyncratic contribution, all for the benefit of the musical creation of the whole.

From an interaction design perspective we find this highly interesting as we see self-organization as one of the key mechanisms in systems design; the systems we are dealing with nowadays are simply to vast to be able to design every tiny aspect. For example, many online systems such as Wikipedia cannot be managed by a single modifier but rely on self-organizing principles.

3.3 The influence of systemic technology on performing music

The principle described in the previous section could open up a new domain of musical instruments, along with a new musical aesthetics based on technological mediation. We elaborate on this here.

The feedback loops described in the previous section are largely unidirectional and depend highly on social processes: interaction between players usually happens non-verbally using body language, gestures, mimics, and such, directed by listening to other instruments and watching other players play their instruments. In this process any player can only perceive sound coming from another player's instrument, but only influence it indirectly by influencing the other player (see Figure 2, left); or as we described this in the previous section: influence from other members of the musical body takes place in feedback loop two, three and four, limiting the direct influence to each member's individual first feedback loop. There has been quite some related work in this, as the history of interactive, electronic musical instruments in general is rich. Typically the Theremin and the Moog synthesizer are seen as pivotal milestones in this history, but recent work is superfluous and compelling. For example, Bevilacqua et. al. explore digitally enhanced bow gestures in their "Augmented String Quartet" [3], IRCAM's MO project [15] offers a modular system allowing for the exploration of gestural interfaces for musical expressions, while other extend to mimics [8].

However, what if a player could also influence the instruments of other players, or in other words, break into the first feedback loop? We find inspiration here in projects that shift the interaction to collaborative object [9], for instance, reacTable [13], which is a widely acclaimed interactive music tabletop. Another objective in this project was to open access to improvisation [11] as well as extending the control of musical instrument operation [5]. However, we want to take a step beyond 'multiple players playing a modular instrument' and strive for a situation in which the modularity is taken to a higher level, one in which any constellation of players and instruments form a self-organizing musical body. As one can see from Figure 2 (right), which shows a visualization of this new principle, the network of connections between players and instruments is denser and entirely bi-directional: players interact both with their own instruments, other players, and their instruments.

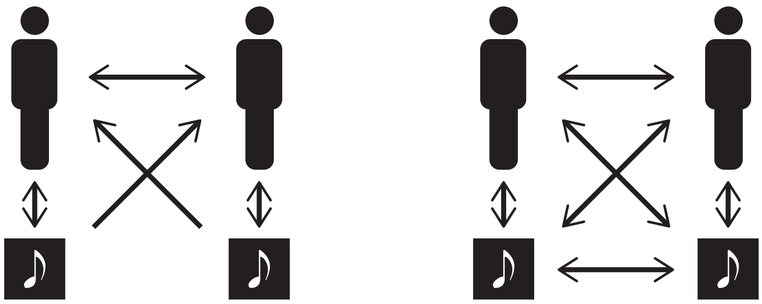

Figure 2. Interaction modes in traditional music performance settings (left side) and in the proposed new setting (right side). Human players at the top interaction with each other, but also with their instruments, here visualized as black boxes in both images.

This new interaction creates richer feedback loops, and necessarily adds to the complexity of the performance. In addition, this interaction mode changes how players perceive the setting of the performance: there is less a strong and exclusive bond between players and their own instruments. Instead, instruments become shared artifacts [14].

4. Designing for Group Music Improvisation

4.1 Design challenge

To explore this we formulated the aforementioned design challenge, as follows: 'design a musical instrument dedicated for use in improvised music that allows for musical expression but that grows in expressivity by technologically influencing the other instruments when used in an improvised, co-creating performance'. We implemented this design challenge in our educational curriculum as a 5-month-long design project carried out by

20 Industrial Design undergraduate students. The goal was to come to a Group Music Improvisation System that would support expression by any combination of instruments and instrumentalists.

4.2 Project setup

Although the project was initially framed as a project about designing for systems, stating it as such would not properly capture its complexity: it was rather a setting, in which *multiple designers collaboratively design a multi-user system consisting of multiple (radically) different and unique devices acting individually and as a whole*. To streamline the project as much as possible we stimulated all students to act as much as they could as a self-organizing system themselves, in order to have them co-shape the project and get grip on (musical) group dynamics. We organized weekly and bi-weekly coaching sessions, as well as regular jam sessions during which students could collaboratively try out experiential mock-ups and prototypes of their designs. In addition to these activities several workshops and invited talks were organized, for example involving a designer and maker of traditional musical instruments, and a composer and performer of contemporary electronic music.

5. Results

The challenge resulted in 16 designs, all detailed to the level experienceable, functional prototypes. The designs can be roughly organized along three dimensions as visualized in **Figure 3**.

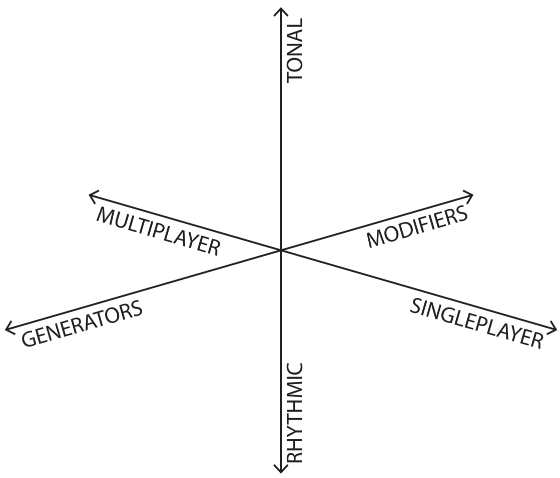

Figure 3. Solution domain of the resulting designs.

Two clear clusters of designs could be identified: one consisting of music *generators*, and one consisting of music *modifiers*. The former cluster can be considered as a collection of musical instruments (in the broadest interpretation of the word) using either elements from traditional music—capitalizing on aspects such as melody, harmony and rhythm—or from soundscapes. A few of the designs built on traditional musical instruments, while the majority used synthesizing technologies connected to tactile sensor input (as can be seen in Figure 4). The latter cluster contained designs aimed at modifying sound, for example that generated by the former cluster. Many designs used microphones and live sampling techniques to acquire sound input, which in turn could be processed and emitted again. Other modifiers used tangible interaction to shape the sound such as shown in Figure 5.

Some of the designs were only suitable for single player use, while the majority aimed at facilitating multiple user interactions. Also, two clear clusters could be made according to the type of sound output: i.e., centered on rhythmic or on tonal qualities.

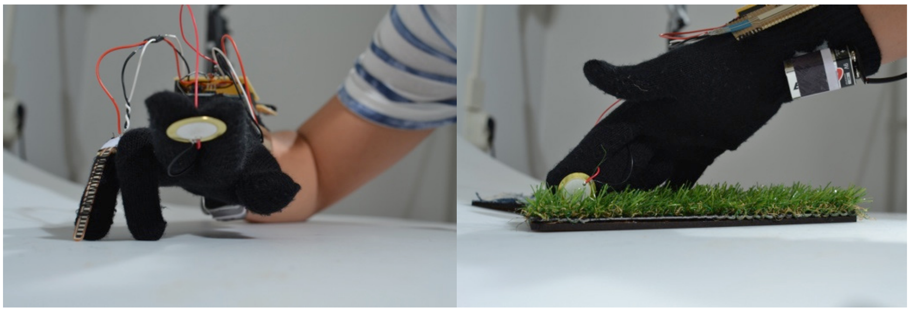

Figure 4. Glove sound generator. Sound is generated by touching and stroking different textures.

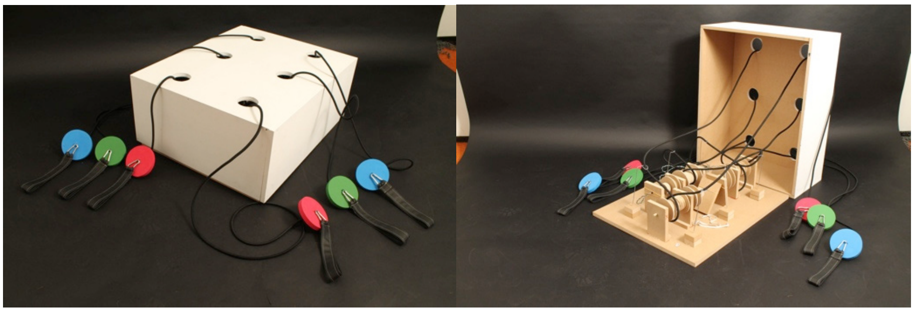

Figure 5. Multiplayer sound modifier, which uses tension on ropes attached to (or simply grabbed by) different players to modify sound. Handles with matching colours have a mutual influence.

Although the challenge resulted in many very appealing interactive musical instruments, only one of the results actually embodied the networked situation we visualized in Figure 2 (right). This student designed a very interesting set of instruments—one augmented percussive instrument and a two-stringed tonal synthesizer, see Figure 6—in a 3D surround sound setting, where both instruments had their own behavior but were also open for one behavior modification by the other instrument. This meant that the percussive instrument could influence the pitch of the tonal instrument, and the tonal instrument the attack of the percussive instrument. The output of the tonal instrument was omnidirectional, but the percussive instrument moved around randomly in the 3D surround sound space, which added an intriguing additional feedback loop to those mentioned in Figure 1. Both instruments had a learning curve, which kept them interesting and challenging for instrumentalists.

Figure 6. One design combined an augmented percussive instrument (left) with a two-stringed tonal synthesizer (right), set in a 3D surround sound space. Each of the instruments could influence one sound aspect of the other.

6. Observations

Although this was the first time we have run this project—which we should consider a pilot as such—some preliminary findings are evident.

Firstly, it is significant that only one student managed to truly create a networked setting as we envisioned it, building two instruments that with reciprocal influence, and setting up he infrastructure for adding more instruments. Most of the other concepts and prototypes however did not work as intended, i.e. in a systematic way. Many instruments did not work out that well due to various reasons, most prominently (human) communication problems, unlike problems we have encountered before. The design students found it hard to switch between micro and macro levels in their process, i.e. designing a musical instrument *individually*, while designing a system *together*. This called not only for another perspective on design responsibility in the students, but also for a willingness to self-sacrifice: designing as a system demands individual designers to acknowledge that they are themselves not a sum of the parts, but parts of a whole. This requires them to allow other designers to 'interfere' with their individual decisions for the sake of the whole. Many students found this difficult to cope with.

However, as deadlines were approaching, more and more students discovered the necessity to self-organize, understanding that influencing each other would not only be a huge technical challenge, but also not produce the intended sonic results. Consequently, their design tracks more or less converged, resulting in jointly created instruments that could influence each other on a conceptual level and that produced sound complementary in pitch, tone, volume, rhythm, and texture. Communication changed in terms of focus, from technology and prototyping, to what the students actually wanted to achieve in terms of music and experience. Self-organization at group level helped to focus on different aspects of the experience, such as sound generation and sound modification.

We observed this process as a series of rapid swings in terms of ideas, scopes, and technical foundations. As with any other explorative process, the swings are large in the beginning when most explorative action happens, and only over time processes stabilize until the point a narrow project is scoped and can be followed-through with minor changes. The problem arose when the design processes and swings of multiple designers were not synchronized and would not converge in the end (see Figure 7, left). When reaching the final stage of the process, the processes should continue in parallel (see Figure 7, right), which was what we had envisioned when setting up the design project. Unfortunately this could hardly be observed.

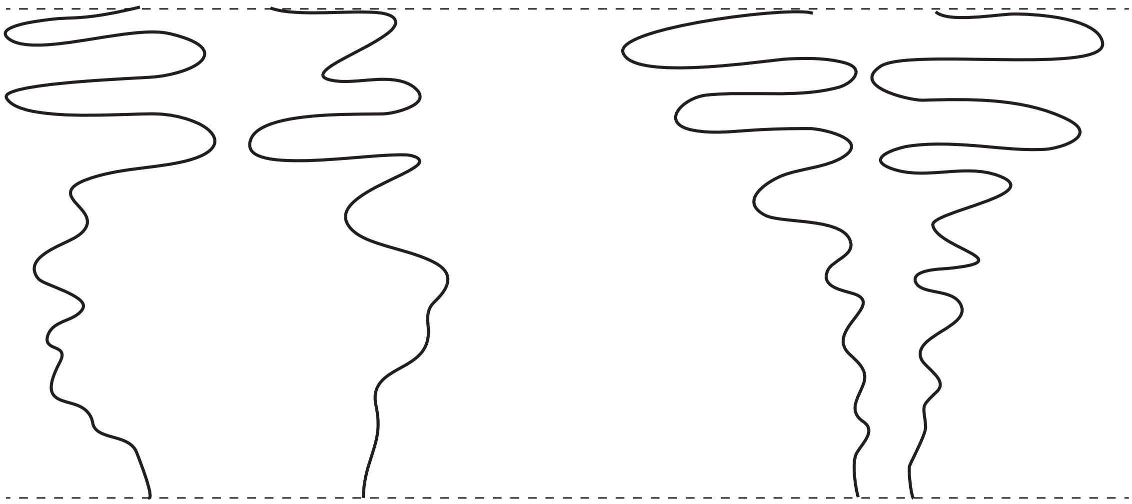

Figure 7. The observed process of students (left), showing individuality and only few moments of convergence, and our intended process (right) in which we aimed for more touching points and more convergence.

7. Lessons learned

Based on this pilot study we can only conclude that designing for systems is easier said than done. One profound difficulty seems to be that we cannot simply transfer our 'designing for interaction methods and tools' to this new paradigm. We attribute this to several reasons. Firstly, designing for systems is relatively uncharted territory in industrial design, which means that we don't know whether existing approaches from other disciplines—roughly speaking, a bottom-up or top-down approach—can be applied. Recent studies in systems design from an industrial design perspective seem to suggest a hybrid top-down/bottom-up approach [10] in which first- and third-person perspectives should be taken into account [7] in a highly dynamic design process [12]. Secondly, the fact that the systems we are aiming at are targeted at highly heterogeneous user-groups too heterogeneous does not help either. Traditionally, processes in industrial design have always had a focus on quantifying user needs into measurable design requirements, but these processes run into their limitations when there is no clear user but rather a group of them. Thirdly, the interaction with systems appears to be different than with traditional interactive standalone products, as systems are more focused on facilitating opportunities for behavior rather than on disclosing functionalities. In our experience (not only in this project but over the last few years), behaviour itself cannot be designed, it can only be designed *for*. This means that designers can tweak the circumstances in order to elicit a particular behaviour [17], but one can never be sure. This effect magnifies when designing for large groups of people.

The major struggle for the students appeared to be the openness of the systems design challenge; the influencing part. It gave the students very little traction to move forward in the design process. They were prone to postpone taking decisions to advance the process, because they felt unable to do so for lack of founded reasons. They did not seem to realize that taking (preliminary) decisions was simply crucial in order to progress their insights. One prominent obstructing mechanism we observed was that the students seemed afraid to bring things to the physical: until very late in the process they only brought existing instruments to our coaching jam-sessions, rather than bringing their own designs on an experienceable level. Consequently they missed opportunities to explore the effects of their own design decisions and to explore, in a group setting, the effect of interconnected instruments that influenced each other.

The design challenge that we formulated, designing for group music improvisation, was rather often interpreted as designing a group instrument for music improvisation. Despite our coaching efforts many students refused to let go of the control that this alternative interpretation offered as the alternative contained the openness. The students that best tackled the openness of the challenge, were those who worked in close cooperation and thus *contained* the openness to levels they could handle.

Finally, we observed time and again that students struggled with the notion of improvisation and expressivity. Or more exactly: they found it difficult to design *for* improvisation and expressivity. This had two reasons: *firstly*, some students did not have a musical background themselves which made that they needed to invest a lot in music essentials in order to make the conceptual step into improvisation. This limited their solution domain significantly. *Secondly*, most of the students had difficulties dealing with the dichotomy of the world of improvisation (which is continuous) and the world of interaction design (which is discrete).

8. Future steps

We are currently running a second iteration of the project described in this paper. Several changes were made to the content and setup:

- We have started this iteration with a concert on the successful instruments of the first iteration (see Figure 6). We hope this will provide students with more grip on the abstract character of open systems design, improvisation and expressivity.
- To be able to compare our current findings better we have extended the challenge with a lighting track, in which students design networked light objects that should be able to share and exchange behaviour. We expect that this additional design track will enable us to identify difficulties that are typical to music, in order to interpret our current findings better.
- In order to stimulate students to take decisions we have planned three interim design presentations, where they present two-minute videos demonstrations of their design concepts. By doing this stimulate them to 'take their design out of their head' and explore their design in a more experiential way; as videos are dynamic media, students simply are forced to think in terms of interactive loops of expressive input and output.
- We have explained less about music improvisation, as we observed that it restricted the students without a musical background of their own. Instead of explaining the fundamentals of music and improvisation as we did before, we extended the notion of music to include soundscapes as well. We hope that this allows students more time to invest in exploring expressivity on a level they can grasp, resulting in more natural designs.

9. Notes

We would like to point out that the authors of this paper have a combined background in Industrial Design and Computer Science, as well as in music. One of the authors studied double bass at the conservatory of music, while another is an award-winning drummer. Both compose music.

The student who designed the system depicted in Figure 6 worked on the project for his Bachelor internship. Consequently he had twice as much time to spend. Interestingly though, he did not have any musical background.

10. Acknowledgments

The authors would like to thank all students and coaches in the "Designing A Group Music Improvisation System" project that took place in the Out of Control Theme at the Department of Industrial Design of the Technische Universiteit Eindhoven in Fall 2012. Special thanks go to Vleer Doing for his outstanding work and to all our guests who gave workshops.

11. References

[1.] Bahn, C., Hahn, T., Trueman, D. (2001) Physicality and feedback: a focus on the body in the performance of electronic music. Proceedings of the International Computer Music Conference. pp. 44–51.

[2.] Bailey, D. (1993) Improvisation-Its Nature and Practice in Music. Da Capo Press, USA

[3.] Bevilacqua, F., Baschet, F., Lemouton, S. (2012) The Augmented String Quartet: Experiments and Gesture Following. Journal of New Music Research. 41, 103–119.

[4.] Bryan-Kinns, N., Healey, P. (2006) Decay in Collaborative Music Making. In: Schnell, N. and Bevilacqua, F. (eds.) Interfaces. pp. 114–117. New York: ACM Press.

[5.] Cappelen, B. (2011) Expanding the role of the instrument. Proceedings of the International Conference on New Interfaces for Musical Expression. 511–514.

[6.] Frens, J.W. & Overbeeke, C.J. (2009). Setting the stage for the design of highly interactive systems. Proceedings of International Association of Societies of Design Research 2009 - IASDR'09, (pp. 1-10). Seoul, Korea: Korean Society of Design Science.

[7.] Frens, J.W., Tomico Plasencia, O. & Zimmerman, J. (2012). Designing for Social Systems:Experiential Approaches. In T. Jachna, Y.Y. Lam & S Tzvetanova Yung (Eds.), Proceeding of the Proceedings of DesignEd Asia Conference 2012, (pp. 344-358). Hong Kong: DesignEd Asia Conference Secretariat.

[8.] Funk, M., Kuwabara, K., Lyons, M.J. (2005) Sonification of Facial Actions for Musical Expression. Design. 127–131.

[9.] Heinz, S., Modhrain, S.O. (2010) Designing a shareable musical TUI. Technology. 26, 339–342.

[10.] Hengeveld, B.J. (2011) Designing LinguaBytes: A Tangible Language Learning System for Non- Or Hardly Speaking Toddlers. Doctoral Thesis. Eindhoven University of Technology.

[11.] Hsu, W. (2007) Design issues in interaction modeling for free improvisation. In: Parkinson, C., D'Arcangelo, G., and Singer, E. (eds.) Proceedings of the 7th international conference on New interfaces for musical expression - NIME '07. p. 367. ACM Press, New York, New York, USA.

[12.] Hummels, C., Frens, J. (2009) The reflective transformative design process. Proceedings of the 27th international conference extended abstracts on Human factors in computing systems CHI EA 09. 2655–2658.

[13.] Jordà, S., Geiger, G., Alonso, M., Kaltenbrunner, M. (2007) The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. Proceedings of the 1st international conference on Tangible and embedded interaction. pp. 139–146. ACM, New York, NY, USA.

[14.] Nacsa, J., Barakova, E., Frens, J. (2011) Sharing meaning and physical activity through a tangible interactive lighting object. Procedings of the Second Conference on Creativity and Innovation in Design - DESIRE '11. pp. 227–230. ACM Press, New York, New York, USA.

[15.] Rasamimanana, N., Bevilacqua, F., Schnell, N., Guedy, F., Flety, E., Maestracci, C., Zamborlin, B., Frechin, J.-L., Petrevski, U. (2011) Modular musical objects towards embodied control of digital music. Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction. pp. 9–12. ACM, New York, NY, USA.

[16.] Root-Bernstein, R.S. (2001) Music, Creativity and Scientific Thinking. Leonardo, 34, 1, pp.63-68. MIT Press, USA.

[17.] Ross, P.R. (2008) Ethics and aesthetics in intelligent product and system design. Doctoral Thesis. Eindhoven University of Technology.