

Ajna: Negotiating Forms in the Making of a Musical Cabinet

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ABSTRACT

Ajna is a musical cabinet made from a rich composition of acoustic materials and designed to perform digitally composed music. In this paper, we aim to unpack the design as well as key aspects of the design process that lead up to this unique artwork. We base our analysis on interviews with its two creators as well as on observations of Ajna performing in different contexts. From the perspective of interaction design, we first analyse the process of its making through the negotiations between physical form, temporal form, and the interactive gestalts. Lastly, we place these negotiations in a larger picture of *bricolage* as a design approach. Based on this we then discuss the qualities of bricolage in interaction design.

Author Keywords

Materiality, temporal form, physical form, interaction gestalt, form-giving, bricolage, music, instrument, acoustic

ACM Classification Keywords

H.5.1. Information interfaces and presentation: Multimedia Information Systems: Audio input/output

INTRODUCTION

Interaction design is expanding its vocabulary of expressions and purposes, with several recent works discussing richer material and technological variations in play with digital possibilities [12-14; 32]. We also see an increasing interest from academia in works of designers and artists who use interactive technologies in new and thought-provoking ways [1; 2; 5; 10; 28; 29].

In this paper we will present Ajna, an example of one such artistic project. Ajna is a human-sized interactive musical object created by the art- and music collective *I Skogen Ibland*. Ajna takes the form of an obscure, musical bricolage, made from a heterogeneous collection of parts including electromechanical devices, old musical instruments, microcontrollers, wood, feathers, skin, motors,

potentiometers – all hosted within the frame of a vintage rococo cabinet. Ajna is controlled via midi signals sent from a laptop and it can perform as part of an orchestra playing composed music, or be engaged with directly through different interactive setups. Ajna's versatility and cultural relevance is indicated by its opening performances both at an electronic music festival and at a folk music festival during the summer of 2013. Further, Ajna has been showcased at several music scenes and art galleries, and has also achieved some media attention by cultural commentaries. Ajna's rich materiality, form language, and complex interaction gestalts, we believe, has something to offer also to the interaction design community.

Our study is based on observations of Ajna in various performance settings, our own experiences playing with it, as well as interviews with the artists. We will give a detailed description of Ajna through the lens of Vallgård's [30] trinity of forms. Further, we will analyse the process of its making through examples of the negotiations between its physical form, temporal form and interaction gestalt. We will show how these negotiations was necessitated by the complexity of Ajna as well illustrate how they also enabled the artists to maintain their artistic integrity. With these analyses we aim to convey the aesthetic qualities that Ajna represents, but also some of the struggles that the artists went through since leaving the realm of stable homogenous materials and well-tested technologies. Lastly, we look at how the making of Ajna in essence was carried out as a *bricolage* [22]. That, while the individual elements of Ajna was not all ready-at-hand, the artists' negotiations show a high degree of receptiveness to the heterogeneity of the materials, technologies, and interactions they work with. We end with a short discussion of bricolage as a design

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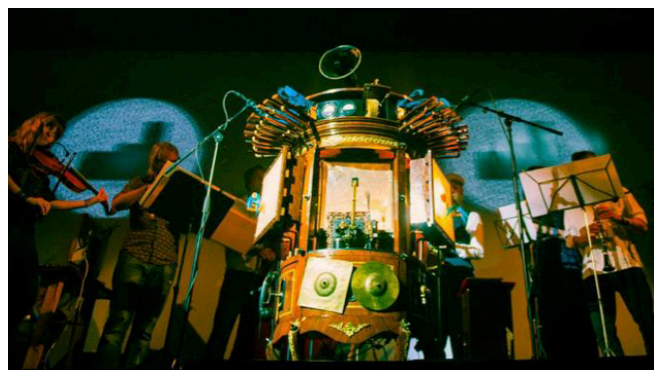


Figure 1. A picture of Ajna center stage surrounded by an orchestra.

approach for interaction design as means to develop a practice that can contribute to a continued sophistication of interactive artefacts and environments.

BACKGROUND

The current expansion in diversity we see in the expression and purpose of interactive artefacts stems from a combination of trends. One is the increased interest in learning from artistic and critical practice within the field of interaction design [1; 5; 10; 14]. Another is the introduction of physical computing [27], and more general design trends within post-industrial culture [7; 8; 23]. A third reason, which can be seen as a consequence of the above, is a more theoretically oriented line of work based on the conceptualisation of the computer as a material [31].

Artistic practices concerning the production and study of interactive artworks is gaining increased acknowledgement in our research field, with several keynote speakers and art exhibitions at main conferences in recent years [e.g. CHI, DIS, TEI]. Research around such projects are often based on intimate collaborations between practitioners with disparate backgrounds, who collectively explore how the art setting can inform knowledge around aspects such as design methods, participant behaviour, and new interaction technologies [5]. Artistic research can also serve a more conceptual role in bringing up issues that are otherwise neglected or under-discussed in a particular research area. By analysing 25 exhibited ArtBots installations, Jacobsson *et al.* [19] highlighted how common themes in mainstream robotic discourse were addressed and challenged in the works of artists, including the notions of robustness, intelligence, the aesthetics of mass production, autonomy, and anthropomorphism. These works thereby served to make critical statements, rather than exploring a specific research question per se. In this context it is important to recognize that the vast majority of interactive artworks and installations are probably created without much direct influence from researchers in HCI.

Introducing physical computing [27] through Arduino and other microprocessor platforms, combined with cheap and accessible electronics, has fostered not only new expressions but also new practices of tinkering [3; 9; 15; 18]. It has become easier and more common to experiment with new materials and new forms of interaction. Initially perhaps more on a hobby and DIY level, but now we also see professional and highly sophisticated fabrication [6]. The result is an ever-growing variety of locally produced interactive artifacts, ranging from sophisticated interactive artworks to simplistic amateur designs. An important shared characteristic is that the physical and the digital components are designed together and in a very tight interplay.

Ajna belongs within a stream of works that ultimately concerns the design of new digitally controlled and autonomously playing musical instruments. Examples in this field include exotic instruments from the early industrial day, such as the self-playing Pianola and the

barrel organ. More contemporary examples include a variety of physical drum machines [20; 34] or robotic percussionists, which are designed to combine some of the qualities of digital music making and control with the acoustic qualities of real instruments. Shimon, the robotic marimba player [16] and Haile [33] are two examples in this family, which are physical robots that are both able to perform with people on ordinary musical instruments.

One project with more direct similarities to Ajna is the Bestiari mechanical orchestra [4], presented at the art exhibition of the TEI'13 conference. Like Bestiari, Ajna plays rhythmical music using a large number of robotically controlled parts, put together in a bricolage fashion [22]. The resulting soundscape is shaped partly by a digitally controlled composition and partly by the material structure of the physical parts involved. The curious visual appearance of the moving parts, together with strong musical qualities, make these installations belong more closely to the area of digitally controlled kinetic artworks, in the artistic tradition of Jean Tinguely [29] and others. However, instead of a spatially distributed collection of seemingly self-playing objects, Ajna takes the shape of a contained body and is designed ultimately for human interaction in music performances.

Both Ajna and Bestiari are formed around the physical crafting of musical elements, which means that the design not only concerns the electro-mechanical control of moving parts on existing instruments, but also a more direct engagement with acoustic materials. This means that they also draw on the long historical practice and making of traditional instruments. The fact that they also include several instruments in one, further adds to the complexity in terms of control. However, the idea of designs that allow one musician to play more than one instrument at a time is not entirely new. A Barker's Stick, for instance, typically used by troubadours and in carnivals throughout Europe since the Middle Ages, is a stick that is usually mounted with a combination of bells, cymbals, and a string over a drum. This way, a single person can play a whole rhythm section. Like with kinetic artworks, the design of musical instruments involves the design of complex dynamic activity, interaction, and expression, although not necessarily driven by a computer. These types of works represent an aesthetic and a dynamic complexity that is rarely presented in the context of our research field, why we find it relevant to explore them further from a design practice perspective.

GETTING TO KNOW AJNA: METHOD

Our first encounter with the Ajna project was in a documentary programme about 'Analogue Longings' on national television [21]. The programme revealed a rhythmic interactive music sculpture, with what seemed like an endless amount of mechanical parts. It was a mixture of curious objects from the past, like a phone receiver, and ringing bells, as well as drums, blue feathers and pieces of

old furniture. The construction was obviously controlled digitally, but the overall expression consisted of a complex physical form and an analogue musical soundscape.

After we got in contact with the artists they agreed to set up a public exhibition and performance, which together with interviews became the basis for our study. Thus, our comprehension of Ajna stems from multiple encounters as audiences of live performances, from our own interaction with it, approx. four hours of observing others interacting with it, numerous informal conversations with the artists, as well as a 90 minutes semi-structured interview with both artists together. The themes of the interview were their intentions and philosophies as well as their design process.

As means to grasp and convey the complexity of Ajna both as an artifact and as a design practices we use Vallgård's trinity of forms [30]. The trinity of forms comprise the physical form, the temporal form, and the interaction gestalt. The physical form refers to the material expression and construction; the temporal form refers to designed patterns of computations (algorithms) resulting in animations, sounds and other expressed state changes, The interaction gestalt refers to set of human actions involved in using it and the context in which they happen. This framework was developed as a lens to understand the key aesthetic aspects of interaction design. It is especially suited as a lens to understand works designed using the computer's properties and qualities to achieve certain expressions and functions rather than works designed as interfaces to computers in a known forms (e.g. laptops or smart phones) [30]. Indeed, the three forms lend us the means to focus on Ajna's material expression and construction, its musical qualities, and how the musicians as well as the visitors/audience interact with it. Further, by making the division into the three forms we are able to analyse the crucial negotiations that took place between them in the making of Ajna.

AJNA

Ajna is the result of collaboration between two artists. One has a background as a music composer and percussionist in an orchestra (C); the other is a computer engineer and break-dancer (D). They conceived the idea of Ajna three and a half years ago as an informal discussion between two



Figure 2. Ajna: Initial sketch (left) and appearance of Ajna in exhibition setting (right)

close friends. They wanted to make a unique musical object that would enable them to play musical rhythms on the border of the acoustic and the digital. A musical object that would allow the composer to script more elaborate rhythms than a real percussionist or drummer would be able to perform in an orchestra, while at the same time make up for the shortcomings of digital drum machines. The project is thus largely produced as an autobiographical practice [24].

Central to the vision was an aesthetic expression that would represent what they call 'heavy' or 'wicked', both in terms of sounds and music and in terms of visual appearance (see Figure 2 for an early sketch of Ajna). They made a 'mood board' to build up a shared sense of what expression they were aiming for. This comprised a selection of video clips of various types of drum-based music, and images of curious objects from a combination of Voodoo culture, Thor Heyerdahl's Kon-Tiki, futuristic art, old school mechanical machinery. Some things changed in the process of building Ajna as we will see below, but much of the overall appearance stayed aligned with the initial vision. After receiving a small culture grant they started the actual making process, which took about a year.

Somewhere along the way this stout creature needed a name. The artists had begun to talk about it as a 'she' and after little discussion the choice fell on "Ajna." *"Ajna is a beautiful Finish name – it is a name with suitable meanings. Ajna – a nickname for the police in Swedish. Ajna is also the third eye. Ajna is a mirror in Turkish. The name is a hefty lady. She looks like an Ajna."*(C)

Physical form

The physical frame of Ajna consists of a re-purposed old rococo vitrine cabinet made from mahogany and bought on an online auction early on in the process (see figure 3). Within this frame a range of mechanical parts are fitted, including three drums, two cymbals, one marimba-style instrument with 20 wooden bars, one sampler, two maracas, two bells, one murmur machine, and one horn. All these parts are digitally controlled mechanical systems, some previously served the purpose of start engines in cars, one used to be a shoe shining machine and even others are handcrafted structures. The original form factors of the cabinet shape the layout of the musical components. The large drums, for instance, are fitted in what once used to be the main doors of the cabinet, using the space behind for the sound to resonate.

The drums. There are three squared drums in different sizes and with different sound qualities. At the front is the main bass drum, which also works as a surface for back projections. On each side are two smaller drums whose design is based on traditional African drums. The drumsticks are each attached to a solenoid repurposed from two automobile start engines. They have been modified to achieve the desired strength in their punch. The drumhead is made from natural skin and thus is sensitive to the humidity in the room. The drumsticks on the sides are



Figure 4. Parts of Ajna. From left to right: overview image, left side of Aajnophone, the murmur machine, one of the maracas, the horn, the one of the side drums, the main drum with projection, the sampler, the cymbals, the bells, and mixing panel.

ornamented with blue feathers. The visual association of the bass drum is that of a belly.

The cymbals. At the lower front of the cabinet are two brass cymbals, one square, and one round. Both are played from behind thus their mechanics are invisible to the audience. They are also controlled with solenoids albeit smaller than the drums.

The Aajnophone. The Aajnophone is a marimba-style instrument with 20 wooden bars that runs across the cabinet in the upper part. A small metal stick with a (spherical) plastic head driven by a motorized slider potentiometer and underlined by a blue feather plays each bar. The feather serves as a visual expression but also to dampen the vibration of the metal stick when it springs back. The visual association of the Aajnophone is that of shoulders or the top of a dress.

The maracas. At the very top of the cabinet are two egg shakers that each can move back and forth at different speed along a slot, controlled by servomotors. These are both decorated with a small spray of green feathers and give the distinct impression of being Ajna's eyes.

The telesampler. At the lower left side of the cabinet is an old school telephone receiver, which can be used to record a short sound sample, which is then replayed through the horn loudspeaker on top of the cabinet. Both recording and playback can be controlled either by pressing a physical button on the handset base or via midi.

The horn. At the top of the cabinet is a big horn from an old school gramophone. This horn is used to amplify some of the sounds or as output for digital music played directly from the computer.

The murmur machine. At the top right side is a wheel shaped brush traditionally used for shining shoes. It can be put to motion along with the lowering of a scraping plate, which via a contact microphone generates a whooshing sound that is then played through a speaker driver (mounted on a piece of pipe from a hookah). This device is used to generate a sound similar to the white noise that sometimes comes along when making digital recordings on amateur equipment.

The bells. Two alarm clock bells of brass are located at the lower right side, to make lower ringing sounds.

Each musical component hosts its own microprocessor. A larger computer, placed outside Ajna, communicates with the individual musical components through three midi channels: one for all the drums, cymbals, the sampler, and the murmur machine, one for the maracas, and one for the Aajnophone.

As a final mark on the physical form, Ajna is always modified and improved in-between performances, but on stage and in shows it is finished. There are no visible cables or electronics. This gives an appearance of being whole, yet mysterious: *We didn't want to have something that looked like a prototype or was more of a concept. It had to be a working whole.*" (D)

Temporal forms

In its static form Ajna is an interesting artifact to look at, however, its construction is all about action and activity. Ajna's temporal form comes in two if not three forms, one auditory and two are visual and kinetic. The perhaps most notable is the auditory, meaning the sounds it can make and how these are arranged musically. The music was also the main driver behind the whole project. As stated by the composer, with an edge of irony to emphasise his

frustrations with conventional drumming: “I was a drummer but not a good one. I was the worst in the bands I played in. Then I thought we could build something here that I could excel in. [...] That is what is so nice about Ajna, I can avoid feeling embarrassed!” (C). The loud sounds that Ajna produces are all calibrated to enable a varied and complex musical soundscape. The sounds from each instrument are made up from a combination of mechanical and computational controls. The computational control is formed from sequences arranged in standard music composition software, which are triggered based on user interactions, and sent to Ajna through three different MIDI signals. Thus some of the instruments are controlled via the same signal. Each signal is parsed through a separate microcontroller board in Ajna from which it is transformed to mechanical movements in the instruments via various actuators and transducers.

This design enables Ajna to keep a constant tempo, to perform quick sequences of complex manoeuvres with many parallel actions, and to follow scripted notes in a flawless manner. It also gives Ajna a high level of flexibility in adjusting each musical component both mechanically and digitally while performing coherent musical pieces. The result is a musical object that provides digital control without the confinements of an electronic soundscape – an object that can make complex rhythms with an acoustic richness and a performance presence, without missing a beat. A central aspect of this is of course also the actual music, which is composed in a style that has been described as “a blend of vanguard waltzes, limping outsider chamber and esoteric melancholic folk” [25].

The kinetic movements of the instruments is what generates the music, but the visual appearance of these animated parts also serves to complement the musical expression in a form of rhythmic dance. These movements are in several cases further augmented with feathers or other ornaments, which underlines the visual dimension of this temporal form. Apart from providing function and mere decoration, the details of these animated parts also give a strong sense of artistic imagination. Whether Ajna responds directly to interaction or to scripted music, it is easy as an audience to get carried away with the impression of autonomous movement, of Ajna being ‘live’. Lastly, the animated back projection displayed on the surface of the main drum is an independent form designed to further enhance the dynamic visual expression of Ajna, adding an additional narrative to the temporal form.

Interaction Gestalts

Ajna was initially designed to perform professionally composed music in orchestra settings, however, the artists have since added a couple of ways in which an audience can interact with it in, for instance, a gallery setting.

Thus the combined interaction gestalts comprises:

- Composing music for Ajna

- Playing with Ajna in a live orchestra
- Interfaces for participant performance in exhibitions

Interaction Gestalt 1: Composing music for Ajna

The composer writes the music by hand or directly on the computer using custom-built software along with the commercial Ableton suite (See figure 5, left). Here, composing music for Ajna is not too different to composing for an orchestra with other instruments:

“You have an idea, play it out on the guitar or the piano, and then you enter it into some sheet music software and then you transcribe it and then you print it and hook it up with a musician who in turn plays it” [...] “the tricky bit is really how to put it together musically, to make it work with musicians. But in a way that is like writing music to any musician, you just send it to Ajna instead.” (C)

The main difference when including Ajna in the composition is that you have control over a larger arsenal of sounds in one body. Yet, compared to an entire electronic music composition, the range of sounds is of course limited to the physical components of Ajna. This fact adds an interesting dimension, which makes it essentially different to other forms of electronic music making. *“There is something in it that is the same thing, but still a huge difference to making music that is entirely computer-based, it is transferred another step... back to an analogue world again...”(C)* One example of how Ajna’s physicality and analogue sound makes it a different process is that Ajna is very loud and have little in terms of volume control, so when working on a composition and depending on the acoustics of the room, earmuffs or other hearing protection is normally needed. Moreover, since Ajna cannot be easily transported, these activities are always tied to the physical setting of the studio.

Interaction Gestalt 2: Ajna playing in a live orchestra

Ajna plays in different orchestras, from improvised and contemporary folk music ensembles to full symphonies. The most common gig is with a seven-person orchestra including organ, viola, bass, woodwind, and brass. This is the setup for which most of the music is written. In this setting Ajna is always located centrally on stage to benefit both musicians and audience. The musicians need to be able

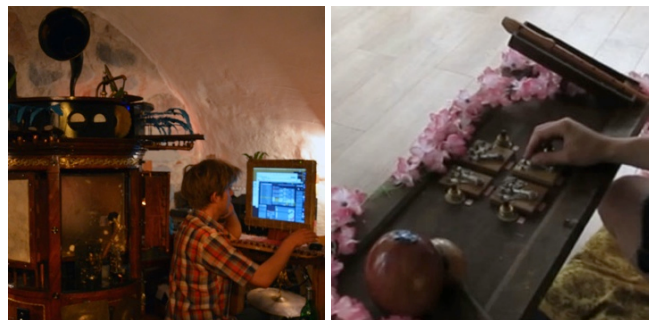


Figure 5. Setups for composing versus live mixing by visitors in exhibition context.

to see as well as hear the movements in order to keep the beat. *“The other musicians must pay attention to her movements and not just the sounds she makes. And in that sense she is a musician – although she does not really pay so much attention to the others... A deaf musician.”* (C) Like with any new member of the orchestra, they need some time of practice together before they are ready to perform a new set. Since Ajna in this setting is driven by predetermined midi-sequences, and is not responsive to the performances of its co-players, Ajna automatically takes on the role of the lead instrument or the conductor.

While on stage the artists sits in the background off to the side keeping an eye on how Ajna proceeds. Between pieces they can adjust the latency in the signals sent to Ajna ensuring it is always internally on beat. They also play small sound bites introducing the next number, thanking for applause etc. Underlining Ajna as the Diva of the show.

Interaction Gestalt 3: Playing with Ajna in exhibition settings
On several recent occasions, Ajna’s interaction gestalt has been adapted to function as a standalone interactive music sculpture in gallery settings. So far Ajna has been equipped with two different such modes of interaction: as a full body dancing experience, and the other as a DJ-like mixing situation.

In the first setting, Ajna is controlled from an interactive carpet on which people could walk, dance, and step in order to trigger different sounds and music loops. The carpet is made from 16 squares of Persian rug. Initially, it was designed so each part of the carpet would trigger individual tones. This resulted in a very direct mode of interaction, but it also meant that it was difficult to achieve a satisfying musical expression (i.e., if not jumping constantly on the carpet in rhythmic sequences). Thus, the artists developed another version where each square triggered a short musical loop sequence for a subset of the instruments. With a grid of 4x4 loops, possible to play in parallel, a player could create 625 different musical combinations by stepping and dancing on the carpet. The loops are always arranged in synch so that they begin at the right beat, which adds further depth to the interaction, as you can quickly switch on and off a beat, and thereby create even more rhythms.

In the second setting, Ajna is played via a control panel made from four brass telephone switches and push buttons (see figure 5, right). The four switches, each with three to four states, control musical loops with groups of instruments. The groups are labelled next to each panel as ‘Ajnophone’, ‘drums’, ‘cymbals’, and ‘shakers’. The four push buttons each turn a group of instruments on or off. People can thus shift between the three or four musical loops per instrument group with the freedom of 399 possible compositions.

These interaction modes highlight Ajna’s versatility as an interactive object, as well as its overall intentions towards public and artistic performance. Notably, these interaction

modes are both specifically made for audience’s participation and social play in semi-public cultural settings, where they also have been much appreciated.

NEGOTIATING PHYSICAL AND TEMPORAL FORMS IN RELATION TO INTERACTION GESTALTS

The different interaction gestalts that Ajna affords does inevitable involve variations both in the temporal and physical forms. It changes in expression from the pre-scripted composed music, to the playful experimentation with beats and the danced interaction. Characteristic for all of them, however, is a tight interplay between physical materials, temporal behaviour, and the means for control and interaction.

Obviously, this coupling of physical materials and digital control was not easily achieved. The vision of Ajna might seem to have been clear from the start, but the road to realizing it involved *“long rather frustrating periods of tinkering, thinking, and searching.”* (D) An important activity was the collection suitable parts to use in Ajna, and also to figure out how to use them. Ajna is not built from off-the-shelf components but rather from old acoustic instruments and mechanical structures re-purposed and rebuilt to form a particular aesthetics both acoustically and visually. For instance, the choice of hosting all instruments in one cabinet had serious consequences both in complexity and acoustics: *“generally, all the instruments sounded better when they were standing on their own.”* (D) Yet, this was an important choice the artists had to make because anything else would not have given the impression of the stout lady on the stage. *“It was a negotiation. Something might sound good, but if it looks bad we had to change it and vice versa.”* (D) The drums, cymbals, marimbas, shakers, and horns all required different physical conditions to fit in terms of acoustics and visual expression.

Therefore, the design process involved constant negotiations of the physical forms, the temporal forms, and the interaction gestalts. Below, three examples from the design process will be used to illustrate how the artists addressed these types of negotiations.

Exploring the materiality of mechanical drumming

Ajna is to large part a rhythmic body, and thus the drums are a central part of the construction. An important aesthetic decision was that these *“shouldn’t just replace a drum set or a drummer but rather have their own soundscape.”* (D) Thus, designing them demanded thorough explorations into materials, mechanics, and shapes as different means to achieve this. They also relied on the expertise of a drum workshop located in the city.

Inspired by the sound and the look of West African square drums made from skin on a wooden frame the artists wanted to make something similar for Ajna. Since a square drum has a larger variety in how the skin is stretched than a round one it also has a larger vocabulary of resonances. This way they were able to work with drum sounds

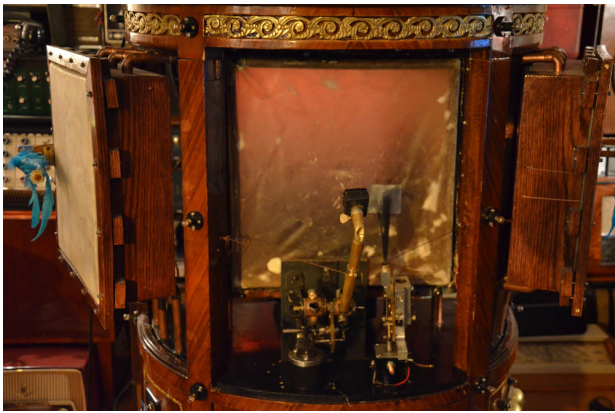


Figure 6. The main drum. Without back projection the sensitivity of the drum skin becomes more apparent. Notice the patched section where the brush hits.

different from “a robot playing on an ordinary drum kit.” (D) However, where a West African square drum is handheld and typically played with bare hands, the Ajna drums would be fixed in the cabinet and operated by a stick and thereby risk resembling an ordinary drum set more. The challenge was thus to combine material, mechanics, and control while maintaining an overall aesthetic expression - visually as well as in terms of acoustics.

One important choice here was the drumhead, which would have a strong impact both on the sound and the visual appearance. They chose natural veal skin and experimented with different viscosities. When working with natural skin it is important that there is a mechanism for tightening it up as skin changes its elasticity, and thereby the sound, with wear and tear, and also with changes in temperature and humidity. In some cases it was for instance necessary to use a heat gun or hair dryer to help tighten the skin.

A second important choice was the drumsticks and how they were operated. For the drumsticks on the side drums the artists tested different kinds of wood, length and breadth of the stick. However, it was only really possible to test the sound in combination with the force of the steering arm. Thus finding the right drumstick material, length, and the right force had to happen through a process of iterative testing. “*Variations in the density of the wood would result in completely different sounds. How the drumstick will hit the drumhead. How fast it should go back. The materials. The arms, how they spring back.*” (C) This was an on-going negotiation between the physical and the temporal form as means to achieve the desired expression. The side drums are operated with sticks, while the main drum is hit with a large metal hammer and also with a brush (see figure 6).

A third important choice was to find the right force of the drumstick and decide whether and how that should be adjustable. The force was controlled in a distribution between the mechanics and electronics. The force control for each drumstick was built with a solenoid from an old car start engine and combined with a mechanical gearing to



Figure 7. The Ajnophone and its feathers.

help slow it down. In the beginning it was so forceful that the drumstick broke the skin. It was possible to adjust the force through mechanical gearing and the amount of power sent to the solenoid. After testing different ways of controlling the drumstick they decided that even if the beats had some musical variations they were not substantial enough build in this extra layer of control. They decided to stay with one force of beat per drum and instead focus on getting the most optimal sound for each drum.

Combining visual expression and mechanical function

The musical component on Ajna that provides the most melody is the Ajnophone (see figure 7). While it is also a percussion instrument the qualities of the wooden bars enables different tunes to be played. The challenge in designing the impact is essentially the same for the Ajnophone as for the drums; however, here a bit more precision and a little less force is needed. One thing is to move a stick towards an impact from a certain point, another is to make sure the stick is going back to that same point afterwards so the motion can be repeated and repeated rapidly. The solution on the Ajnophone was to attach a brake-wire over the stick so it would never go further back than that. However, the problem was that the force with which the stick swung back created a resonance in the wire that in itself would make an unwanted sound. This fostered a series of tests of the force to see if it was possible to find a balance between the wanted sound and the unwanted noise from the brake-wire. Part of the solution came from another challenge.

When an orchestra plays there is a constant sensing of where the others currently are and will be in a second. This is what makes it possible to keep a rhythm. Ajna is not responsive to other players but has a significant role in the music composed for the whole orchestra. Thus, playing with Ajna will put a larger challenge on the rest of the orchestra to stay on beat. “*Everyone has to notice her presence just like you look at your fellow musicians and can see when they take a deep breath.*” (C) The artists also wanted to make the movements easier to see for the audience at a distance. In order to achieve this the artists decided to ornament some of the moving parts with

feathers. The shakers got green plastic feathers, the drumsticks on the side drum got blue bird feathers and so did all the 20 sticks on the Ajnophone. The choice of feathers and their colours were made to fit with the cultural references of a Voodoo altar and Thor Heyerdahl's Kon-Tiki. The feathers on the Ajnophone would now form a half circle on the upper-part of Ajna underlining not only the movements of the music but Ajna as a 'lady'.

The feathers also had the fortunate aerodynamic effect of minimizing the fall back resonance in the sticks playing the Ajnophone. Combined with some felt adjustments on the brake-wire the artists were now able to find an appropriate balance to achieve a clear impact tune with no additional noise.

Negotiating expression through software

The digital control is what gives Ajna its advantages over human percussionists, and what makes it possible to perform scripted music. *"It gives an enormous amount of possibilities to have the control digital rather than all mechanical. It would have been difficult to make it sound good. Just to make it sound sharp would be impossible without the digital adjustments."* (C)

However, the types of materials used in the instruments of Ajna are not typical in a digital context – they are all somewhat unstable. They change with environmental factors like humidity and temperature; they change with wear and tear. The drumheads, for instance, are highly sensible to the humidity in the room as they are made from veal skin. High humidity will result in a softer skin and thus in a slight delay in the beat as well as in a different sound. In the hot summer days of our study, the humidity in the air was high, and between performances the artists were drying up the drum skins using hairdryers, to make sure the sound quality would be perfect. Thus the same composition sent from the external computer might not always result in a coherent rhythm when Ajna plays it. Still, it is exactly these types of materials that enable Ajna's kind of music as well as its visual appearance.

The combination of this many musical components, each built from different materials, patched together electronically is bound to be a little out of sync – especially since the different instruments already from the beginning have different length in time between signal and sound, due to their physical parts moving in different speed and length. Most of the materials are also highly sensitive to wear, tear, temperature, and humidity. Some of this dissonance can be remedied by mechanical tweaking. To get all instruments perfectly in sync, however, the artists had to develop AjnaDelay. AjnaDelay is a software patch in which each instrument is assigned a digital delay. This way Ajna could be "tuned" before each performance. *"In order to make sure everything is in sync that latency needs to be controlled via the computational part of Ajna. It was a bit of a tricky part from the beginning to solve this problem. We had an ambition to measure the latency in real-time and adjust for it while playing – but that was a bit too complicated."* (D) In

that sense AjnaDelay is the bridge between the physical form and the temporal form – and what makes a digitally arranged piece of music execute as intended.

DISCUSSION

With its unusual combination of rococo, voodoo and steampunk, Ajna is a fusion of cultural and historical references that may be difficult to decode at first encounter. What we found immediately fascinating about Ajna was the material richness, its unmistakable presence, the strong aesthetic identity, and the almost magical autonomy we experienced during the performances. The drums and the murmur machine represent different ends of an aesthetic spectrum, as do the start engine mechanics and the blue feathers – albeit a different spectrum. Ajna can thus be seen to represent the opposite to interactive artefacts made from a stance of simplicity, ease of use, or 'flatness'. Also the process of its making draws on practices far from those prescribed in any traditional HCI context (e.g. user centred design methods or common prototyping techniques).

As shown in the beginning of the paper Ajna is not alone in representing this type of aesthetic complexity [4; 6; 29], however, research on this type of work is still fairly limited. And while the interaction design community begin to embrace more complex interactive structures [11; 26] we are still struggling with ways of coping with it in a design practice. Hazlewood et al. have argued that the *"unpredictable set of challenges of going 'big' and 'physical' requires, concomitantly, other nonuser-centered skills, steps and decision-making processes"* [15, p. 1]. As a result they propose a combination of 'bricolage' and 'consultation' to augment existing design practice [15]. They introduce bricolage as one out of many methods, however, the making of Ajna compels us to see bricolage as a self-contained method or design philosophy.

Louridas [22] propose that all design is a matter of bricolage; yet, we would argue that some works, such as Ajna, represents this practice more literally, closer to the artistic sense of the term. Still, we rely on Louridas' and thus Lévi-Strauss' interpretations of bricolage and the role of the bricoleur. Here, three elements are key: First, the bricoleur works from a finite set of tools and materials for each project *"the rule of his game is to always make do with 'what's available'"* [22, p. 518]. Second,, the bricoleur *"interrogates all the heterogeneous objects that constitute his treasury, he asks them to understand what each one of them could 'signify', thus contributing to the definition of a set to be realised"* [22, p. 519]. Third, *"the bricoleur does not need the equipment and the knowledge of all trades and professions"* [22, p. 518], but operates based on interpretations of the relation between the materials and tools before him/her. A bricolage in this sense thus comes out as a carefully negotiated patchwork or *meshwork* [cf., 17] of material expressions. In case of interaction design those material expressions are extended to also include the temporal form and the interaction gestalt. Bricolage in interaction design

thus can be seen as a negotiated patchwork of the trinity of forms.

While Ajna is not the result of bricolage in a dogmatic sense, the underlying philosophy is still present throughout. Most parts were purchased for specific purposes through the process and not part of an already existing inventory, however, found objects and recycled/repurposed objects did play a very prominent role in its form-giving (e.g. the vintage rococo cabinet). Each found object has its own history, function, form and cultural connotations, which in itself created meaning and purpose. The many negotiations of forms, from which Ajna was made, were all done on the premises of the chosen materials and with gradually developed mutual understanding of the artistic ideal. Ajna is thus the result of constant tinkering with materials, forms, texture, scale, mechanics, electronics, software, and interaction. The artists often described this process as a form of ‘puzzle solving,’ which sometimes even appeared as a means in itself.

Further, the artists were not inclined to compromise on the aesthetic ideals, as that would render the whole project superfluous. They stated that there was not a single form element that preceded the others. The physical form was just as important to the temporal form as were the means of interaction and control. The drums, for example, would have been much easier to tune had they been round. Yet their untraditional form, the cultural reference to West Africa, and the physical fitting into a given space in the cabinet, was important for the artists to maintain. The deliberate choice to work with rare vintage objects was a means to make something unique, but also to help cater for qualitative expressions akin to those of a live orchestra performance. A more conventional (electronic) product design aesthetic would most likely make a less elegant fit into this interactive context.

Indeed, Ajna would simply not be possible to design in a CAD program and then make. It could hardly be mass-produced in its current form simply because there is no blueprint and all the small tweaks have been carefully tuned through hands-on experimentation. Ajna was never meant to be generalized – on the contrary. This sense of artistic intention, as well as authorship, becomes perhaps most evident in terms of the temporal and interactive properties. No matter what interactive mode Ajna is set for, the program it performs is crafted in its entirety by a human composer and as part of a musical performance context. All interaction modes and all music is composed based on firm knowledge about musical instruments, the specific sounds they produce, and an overall artistic intention.

A final aspect that we would like to highlight is how Ajna is largely constructed on an ‘amateur’ basis, with limited funding, no clear customer, and no academic training in many of the practices involved in the process, including interaction design. Yet, compared to other explorative interactive artefacts presented in research contexts, Ajna

appears very professionally made. While the artists did consult experts in the process (e.g. they consulted a drum maker to learn about possible ways to construct drums), the envisioning, design, and construction of Ajna took place in a trail and error dialogue with the specific materials and objects at hand, as well as between the two artists. Indeed, the prominent role that found objects took in this form-giving process also meant that initial sketches could only be made on a rather abstract level, and in turn that there were never a possibility of outsourcing the actual construction to someone else. This practice can be seen in contrast to most interactive art projects in our research field, in which the standard setup has been described as collaborations between ‘artists’ and ‘technicians’, and where these roles are explicitly separated [6]. Although the artists had different backgrounds and consequently there were some divisions of labour, the roles could not be easily divided in terms of technological investment as separable from artistic authorship. This, again, points to a type of design process in which material negotiations and hands-on experimentation were central to achieving the overall result, as an interactive functioning object as well as musically and visually.

CONCLUSION

We have presented the design of Ajna, a complex interactive music sculpture, and further reflected on its design process based on interviews with its creators. Importantly, making the analysis based on interviews with practitioners outside of the HCI research field, in this case became an exercise in looking beyond design intentions and desires expressed as research problems, to instead value the explorations more readily as a progression towards an overall aesthetic goal. Clearly, this project represents a very unique type of exploration, which cannot easily be copied or transferred to mainstream practices of interaction design. However, there are some characteristics that could be related to other settings than the artistic, e.g. the values of aesthetic intentions, the explorative design process, and the many negotiations between different types of form factors. In particular, we have through Ajna given an account of bricolage as an open-ended design practice that demands a hands-on approach to the process, and which forms a way to work with and allow for more complex designs. Indeed, bricolage in this type of projects demands courage to engage with materials, technologies, and modes of interaction that are not necessarily familiar ground. However, we see substantial qualities to be found in the rich material vocabulary that this project represents, and which until now has been largely unexplored as a topic of interaction design.

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