Experiences with voice to design ceramics

Hansen, Flemming Tvede; Jensen, Kristoffer

Published in:
International Journal of Arts and Technology

DOI (link to publication from Publisher):
10.1504/IJART.2014.060939

Publication date:
2014

Document Version
Early version, also known as pre-print

Citation for published version (APA):
Hansen, F. T., & Jensen, K. (2014). Experiences with voice to design ceramics. *International Journal of Arts and Technology*, *7*(2/3), 163-184. https://doi.org/10.1504/IJART.2014.060939

Experiences with voice to design ceramics

Flemming Tvede Hansen*

The Royal Danish Academy of Fine Arts,
The School of Design,
Philip de LangesAllé 10,
1435 Copenhagen C, Denmark
E-mail: fth@kadk.dk
*Corresponding author

Kristoffer Jensen

Department of Architecture,
Design and Media Technology (AD:MT),
Aalborg University,
Esbjerg, NielsBohrsVej 8,
6700 Esbjerg, Denmark
E-mail: krist@create.aau.dk

Abstract: This article presents SoundShaping, a system to create ceramics from the human voice and thus how digital technology makes new possibilities in ceramic craft. The article is about how experiential knowledge that the craftsmen gains in a direct physical and tactile interaction with a responding material can be transformed and utilised in the use of digital technologies. SoundShaping is based on a generic audio feature extraction system and the principal component analysis to ensure that the pertinent information in the voice is used. Moreover, 3D shape is created using simple geometric rules. The shape is output to a 3D printer to make ceramic results. The system demonstrates the close connection between digital technology and craft practice. Several experiments and reflections demonstrate the validity of this work.

Keywords: interaction with audio features; generative 3D software; interaction with voice; audio features; ceramics; arts and technology; design; experiential knowledge.

Reference to this paper should be made as follows: Hansen, F.T. and Jensen, K. (2014) 'Experiences with voice to design ceramics', *Int. J. Arts and Technology*, Vol. 7, Nos. 2/3, pp.163–184.

Biographical notes: Flemming Tvede Hansen is a graduate student from the Danish Design School 1990–1995 specialised in ceramics and glass and subsequently trained in multimedia design 1999–2000 at The Multimedia Institute MMI at The School of Architecture in Copenhagen. His PhD scholar was delivered and defended in 2010 at The Danish Design School, Copenhagen and is about how experiential knowledge of crafts rooted in ceramics can be transformed and utilised in the use of digital technologies. His current research is about how experiential knowledge and the involvement of the body are being exploited in the use of digital technology. It can be hand gestures, body movement, or the voice, that forms the basis for an interaction with a digital responding system. He is currently working as a Postdoctoral Research Fellow at the The Royal Danish Academy of Fine Arts – The School of Design.

Kristoffer Jensen obtained his Master in 1988 in Computer Science at the Technical University of Lund, Sweden, and his DEA in Signal Processing in 1989 at the ENSEEIHT, Toulouse, France. His PhD was delivered and defended in 1999 at the Department of Computer Science, University of Copenhagen, Denmark, treating signal processing applied to music with a physical and perceptual point-of-view. His current research topic is signal processing with musical applications, and related fields, including perception, psychoacoustics, physical models and expression of music. He has chaired four major conferences, been the editor of six books and conference proceedings and published 182 papers, and he currently holds a position at the Institute of Architecture, Design and Media Technology, Aalborg University Esbjerg as an Associate Professor.

This paper is a revised and expanded version of a paper entitled 'Using the voice to design ceramics' presented at Second International Conference, ArtsIT 2011, Esbjerg, Denmark, December 2011.

1 Introduction

The approach in this study is driven by a desire to *humanise* the use of digital technology in the field of 3D design. By humanising we mean that the involvement of the body is being exploited in the use of digital technology – and that it is reflected in the product. It can be hand gestures, body movement, or as in this project, the voice, forming the basis for an interaction through digital technology. This is seen as in contrast to the predominantly use of mouse clicks and typing numbers, which does not utilise the body as a tool to accentuate the design with digital technology.

The project builds on McCullough's (1998) idea about a close connection between digital work and a crafts practice, and that the hand- and brain activities related to computer technology may be analogous to practical activities where tacit knowledge, according to Polanyi (1966) is involved. McCullough's research is based on studies of crafts; design processes and tools related to fundamental human activities. The results of these studies are related to the artist Leach's (1940) idea about crafting and execution as a unity that is intuitive and humanistic – *One Hand, One Brain*. Thus McCullough suggests that computer systems should be developed much more from the user's perspective (here, the designer) to utilise tacit knowledge.

The overall field of this research is about integration of digital technology in the field of 3D design, especially in fields rooted in arts and craft. In this case it is about how experiential knowledge of crafts rooted in ceramics is transformed and utilised in the use of digital technologies. Thus experiential knowledge represents the idea of an intuitive and humanistic crafting and tacit knowledge. Specifically, the project focuses on the development and exploration of a digital interactive design tool that uses voice as input and 3D physical form as output by rapid prototyping. As the voice is among the main communicative and expressive parts of the human, this project, which we call SoundShaping, is made to investigate what the voice is capable of creating in 3D ceramics.

While technology often seems to take us away from material (Dormer, 1994) the approach taken here enables the designer's body to be once again involved in the making of physical artefacts. Sandvik (2007) describes a similar process in media communication and development of computer games in which the industry's dehumanisation is being returned for re-humanisation through digital technology. He sees the interactive computer as a creative tool that makes people able to express themselves beyond the biological and mechanical functions.

Firstly, the present concept implies the study of the interaction between the designer using voice as input and a real time dynamic and responding 3D graphics. Secondly, it focuses on the output in 3D physical form, i.e., actual and real, a form that can be viewed, touched, and thus examined from different angles. This part is done with digital-based 3D printing in order to obtain ceramic items from the digital tool. The project distinguishes itself exactly by the combination of digital interaction and 3D tangible form, – and by being a tool to produce 3D artefacts and not a digital interactive installation (Paul, 2003). This work is situated in the general context of using the body in digital interactive processes in which experiential knowledge is used to create physical artefacts. Furthermore, the motivation is based on the idea that designers approach to, and empathy in designing, also can originate from other fields than traditional crafts. The designer can have experiential knowledge and empathy in singing, music, performance, etc., and that digital technology makes it possible to utilise, embed and translate such knowledge in the process of designing 3D objects.

The article reports from the first stage of the technically, artistically and experimentally development of this design tool. In Section 2, the article introduces the field of research. This is more specifically about integration of digital technology within the field of ceramics and how this approach is related to similar research and experiments in the field of 3D digital technology as such. Subsequently in Section 3 the article presents SoundShaping, which is a digital system to create ceramics from the human voice. In Section 4, the article will introduce some representative experiments and reflect on how SoundShaping makes new possibilities in ceramic craft. These experiments will be discussed in relation to a concrete design context. Lastly in Section 5 we present our conclusions.

2 Field of research

This section first describes the idea of experiential knowledge of craftsmen rooted in ceramics, which this study about integration of digital technology relies on. Secondly, the section describes the state of art in integration of digital technology within the field of 3D design rooted in arts and craft, and thirdly it introduce examples of contemporary use of digital technology within the field of art and design, which have inspired and are related to this study.

2.1 Material-driven designing

In this study the material is the pivotal point for the design process. The approach is focused on the experimental stage of sketching based on an exploratory use of material. Thus this approach does not initiate with practical functional solutions.

An example of such an approach is the design by the Danish ceramist Anne Tophøj (Figure 1). The pattern of the edges at the plates has appeared by centrifuging fluid porcelain. It has been possible for Anne Tophøj to intervene and control the way the dynamic pattern emerged at the very moment of shaping, – based on parameters such as changing centrifugation speed over time. Thus the design has appeared in interplay between the property of clay and centrifugation to design a pattern (NewDanishCeramics, 2008). The pattern of the edge is based on the basic structure of liquid clay, which can appear in a vast number of unpredictable and surprising versions depending on the values assigned to the parameters.

The architectural theorist Kwinter (2002) describes a dynamic and uncertain process that links what he calls a virtual component to an actual one. By virtual is not meant virtual reality or simulations created in the computer, but rather as a space of possibilities, – unlike the actual, which can be measured quantitatively in metric space (Rahim, 2006). To describe such a process, Sanford Kwinter refers to the kymatic images by Hans Jenny. These images are generated by sinus tones emitted across steel plates covered by a mixture of sand and superfine lycopodium powder. The mixture is transported by the sinus tones into a pattern. The sinus tones, the steel plates and the mixture of powder and sand make up the virtual component, and the pattern makes up the actual component.

Figure 1 Plates by Anne Tophøj with edges that appears by centrifuging fluid porcelain (see online version for colours)

In a similar way the originality of the design process by Anne Tophøj can be described. This approach, that Hansen (2010) in a design context calls *interactive material-driven designing*, is characterised by two levels, forming a whole. First, one level is to discover, identify or develop a potential of a material. In this example it is the dynamic potential of the liquid porcelain to create patterns when centrifuged. This level Hansen calls *first level of interactive material driven designing*. Secondly, another level is to explore and realise the potential by producing a number of representative 3D examples of what can be done and how. This is about an intimate interplay between the designer and the material at the very moment of giving form by interventions. This level Hansen calls *second level of interactive material driven designing*. These are two coherent and interrelated levels, which are reflected as a unique artistic fingerprint in the final artefact.

The idea of *interactive material driven designing* is not based on predictability, but rather on unpredictable results generated by playfully interventions in a material and being attentive to the response. By the interventions an understanding of the responding material is obtained. That means a certain control of the material but in a dialogue on the premises of the material. Thus the material works as a partner in the process of the making.

Landa (2002) describes it as "…a form that we tease out of those materials as we allow them to have their say in the structures we create", and Leach (1940) as "….a living embodiment of the intention…".

That process enables the designer to obtain experiential knowledge. This is not an approach meant for a particular material, but rather a design methodology. It is by this approach to the design process this study investigates how experiential knowledge is transformed and utilised in the use of digital technologies.

2.2 Integration of digital technology

The overall field of research about integration of digital technology within the field rooted in arts and craft is characterised by creative use of equipment within digital technologies. An example is the research by the research cluster Autonomatic (2011). Autonomatic explores the use of digital manufacturing technologies in the creative process of designing and making 3D objects. One example is Masterton's (2005) intense process of testing CNC milling, adjusting large segments of machine code and changing or making tools for the machine to use (Figure 2). This work is seen as a transformation of how a silversmith might use a range of hammers and stakes to create a certain form or texture (Bunnell, 2004). Another example is Tavs Jørgensen's use of CAD programmes that enable production of flat patterns from which prototype models are constructed. This method is similar to that used for traditional origami models, but the complexity of the shapes means that they could never have been realised without the use of IT tools (Figure 3). The complexity of the shapes is contrasted by the simplicity of the plaster moulds used to cast the ceramics pieces (Jørgensen, 2009).

Figure 2 Drummond Masterton, patterns applied to three dimensional forms through the process of CNC milling (see online version for colours)

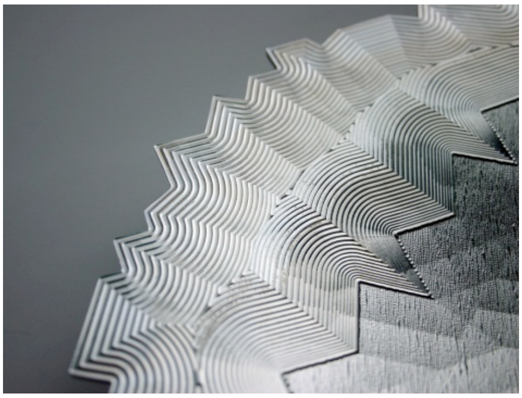
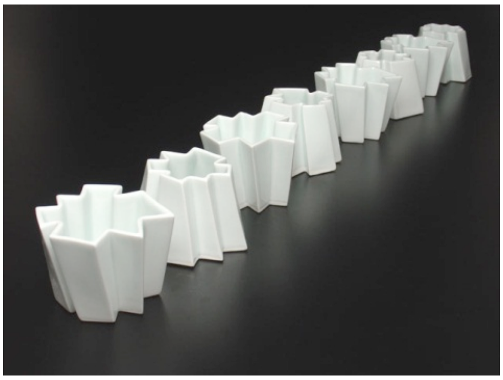


Figure 3 Tavs Jørgensen, origami cups, porcelain (see online version for colours)



These are examples that integrate manufacturing with digital technologies in a way that builds on craft tradition. However these examples have an analytical approach, which do not reflect what Hansen (2010) calls the *interactive material-driven designing*. The examples are not about an intimate relationship between the designer and the material at the very moment of giving form by interventions, but rather about a conceptually complexity within design and form, in which realisation is dependent on digital technology. The example by Anne Tophøj displayed such an intimate interplay with a responding material, thus experiential knowledge. It is such experiential knowledge of craftsmen that Hansen argues can be transformed and utilised by the use of digital technologies and is thus relevant to this study.

Hansen's conclusion is that such an approach to designing is utilised with digital technology when the designer develops his/her (or develops own) own digital *material*. If the designer is not able to develop his/her own digital *material*, he/she should collaborate with relevant specialists to make this possible. This study constitutes such collaboration since the authors' research backgrounds originate from the field of ceramic craft and computer science respectively.

2.3 Interactive generative digital technology and related works

A parallel to the idea of a responding material can be found in the generative potential within digital technologies. It means that the computer is able to produce results based on input. Important development in this field of design can be referred to in the animation techniques introduced by Greg Lynn and the experimental use of diagrams introduced by Peter Eisenman during the nineties [according to Sevaldson (2005)]. This is also about a focus on how interrelated forces in a complex dynamic system work as a kind of *abstract machine* (Deleuze and Guattari, 1988) which is utilised as part of the design process.

The aspect of interaction within digital technologies with such a generative potential is well known in the field of event-based productions such as computer games, interactive art installations, performances, etc.

The US-based artist Camilla Utterback has designed an interactive generative system, which can be explored by the audience (Figure 4).

> "Untitled 5 is the fifth interactive installation in the External Measures Series, which Utterback has been developing since 2001. The goal of these works is to create an aesthetic system which responds fluidly and intriguingly to physical movement in the exhibit space." (Utterback, 2004)

Another and related example is the interactive dance-architecture Sea Unsea (Thomsen, 2007), which takes place on an interactive stage informed by a camera interface (by motion capture). The performers' movements affect a sonorous field of sound and exploring, attracting, repulsing and entwining their bodies and voices within an evolving patterns of a swirling hypnotic synthetic sea (CITA, 2006). A third example is *Intersecting Lines* by Dulic and Hamel (2009). *Intersecting Lines* are visual music instruments, based on the idea of performing correlated audio-visual imagery. Thus it is a real time improvisatory performance instrument that can transform an input coming from the performer both in aural and visual domains. The input in *Intersecting Lines* is based on the performer's gestures.

Figure 4 'Untitled 5' by Camille Utterback (see online version for colours)

Note: A changing wall projection in response to the activities in the space.

On one hand, such use employs digital technology as part of its own medium and makes up a clear distinction when compared to a digital design tool (Paul, 2003); the purpose of this project. On the other hand such event-based productions form the basis for and are related to experiments in this study, because it is about connecting the aspect of interaction with a generative material by the use of digital technology. Thus this is about an intimate relationship between the designer and the material in the very moment of giving form that utilises experiential knowledge according to the idea of *interactive material-driven designing*. This is what we call humanising the digital technology.

In parallel to event-based productions experiments have also headed in the direction of independent works of art. *Reflection* by Maus and Fischer (2008) is an example of such. *Reflection* is a data sculpture, which was inspired by and derived from a musical piece. A FFT frequency spectrum analysis was performed on the audio clips and arranged in a 3D coordinate system consisting of frequency and time. The final sculpture was created with a CNC milling machine. Another example is *Sound Surface – 3D printed pots* by Keep (2012) which represents a series of pots generated from sound data based on musical pieces, and computer code using the processing programming language to create 3D digital surface texture. The captured digital files were following 3D printed in clay.

On one hand these two examples make up a clear distinction by using musical pieces compared to the idea of *interactive material-driven designing*. Thus these examples are not about an intimate interplay by interventions between the designer and the material. On the other hand both examples deal with an experimental development of the designers own generative digital material (as described in Section 2.2) based on an audio input, and an output to a 3D rapid prototyping techniques to make 3D result. Thus it is about a tool to produce 3D artefacts. That is quite related to present project. In short, the present project is, firstly, a study about an experimental development of the designers own generative digital material and interventions by the use of the body as in the above mentioned events-based examples (in this case the voice). Secondly, it is about an output in 3D tangible form as in the examples of the above-mentioned examples of independent art works. The project distinguishes itself exactly by the combination of digital interaction and 3D tangible form. Thus it is a tool to produce 3D artefacts and not a digital interactive installation.

3 SoundShaping

This section presents SoundShaping, a system to create ceramics from the human voice. Sound is invisible, but when it hits the ear membrane, it is *translated* into intelligible sound by the brain using neuronal signals. We are in this study interested in the idea of a translation of the audio, but a subjective translation to a three-dimensional form, which can be seen and touched as a kind of physical memory and that reflects the audio experience. The subjective translation is viewed as an artistic fingerprint, which motivates the interactive process and the artistic intention. The translation is seen as a responding generative 3D graphic that transforms the designer's audio input. Interaction is an unpredictable and surprising process that motivates an exploratory and experimental process for the designers and researchers.

In this research we employ the *research through design* methodology (Frayling, 1993) which for our purpose is defined as an experimental design practice that is part of the design research and contributes empirical data. The method is explorative and experimental, which in this study means that the research questions and empirical series of experiments are produced and developed in the process of research. This approach is seen as a *reflection on action* similar to Schön's (1983) ideas. The method begins with a definition of a frame for carrying out experiments, which is defined by the overall research question. This approach is inspired by Binder and Redström's (2006) notion of *exemplary design research*:

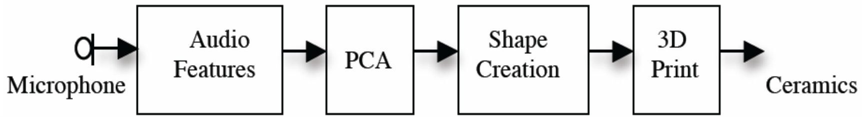
> "It is 'exemplary' in the sense that it enables critical dissemination primarily by creating examples of what could be done and how, i.e. examples that both express the possibilities of the design program as well as more general suggestions about a (change to) design practice."

The intention with this paper is to give an insight into experiments in this frame and the potential it exhibits.

3.1 Overview

The SoundShaping system overview can be seen in Figure 5. It consists of an *audio feature* estimation module, a principal component analysis (PCA) module to extract the most important information from the audio features, a *shape creation* module, and the *3D print* module.

Figure 5 Overview of the SoundShaping system



In this work, we consider the voice as an expression of information through the use of vowels and consonants (Fant, 1970), and as an expression of emotions (Pittam and Scherer, 1993) through the prosody, i.e., the use of mainly pitch and loudness contours. The *audio feature* module extracts intuitive features with a clear relationship to humans, such as pitch and loudness, but also less intuitive features, such as spectrum. In the case of a craftsman using such a system that uses a limited number of intuitive features, two situations may arise,

1 the craftsman uses intuitive features, such as pitch/loudness, e.g., by singing

2 the craftsman does not use these features, but expresses the voice differently, e.g., whispering.

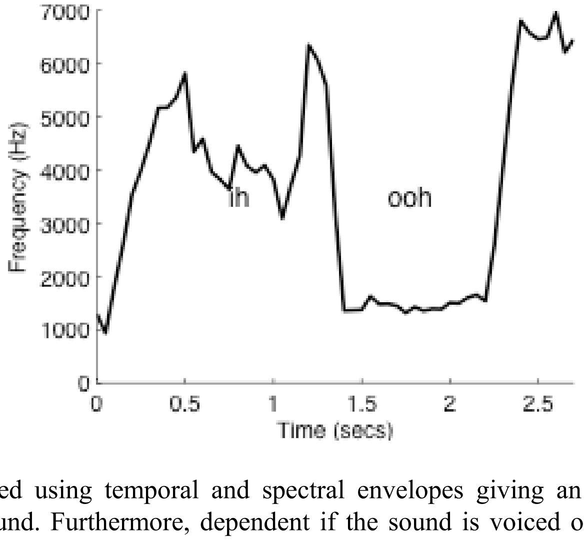
If (1) then the craftsman has potential for conscious control of the shape that is created (by e.g., using the pitch when singing), but in the case of (2), the craftsman has lost the conscious control of the system, because the system does not respond to the category of non-intuitive features used. In order to increase the potential for utilising any expression of the voice as well as retaining the possibility of a conscious control of the system, the PCA (Pearson, 1901) module is introduced. This module extracts pertinent information from the voice, which may be expressed differently from time to time, but the output of the PCA is supposed to reflect the intent of the craftsman, no matter how he or she expresses the voice. In this way, the system is not preconfigured to a specific set of features, but instead it selects the most pertinent features (using the PCA) after each utterance. Thus, if the craftsman uses intuitive features, such as the pitch, the PCA selects these features, but if instead, the craftsman uses other, non-intuitive features the PCA will select these instead.

To decide what the resulting shape has to fulfil, it is needed to look at the purpose. In this research we want to investigate the use of 3D digital designing in ceramics. The 3D print technique is based on the use of a Z Corp 3D powder printer (ZCorporation, 2011), which is changed to use ceramic powder. This technique allows us to print the 3D geometry directly in ceramics. Thus the 3D print has to fulfil the general requirement for firing a ceramic artefact. A ceramic artefact needs to have strong walls, which can resist the heat since the ceramics softens during firing. At the same time the walls should not be too thick since this produces cracks during firing. Thus it is a matter of the construction. The artefact should not be too curved and have a certain strength to support itself, a hollow inside with walls is useful. These requirements had to be fulfilled in the shape creation module.

3.2 Audio features

It is necessary to know which features that are usable to describe the audio. It is on the basis of the audio features an idiom and a dynamic interactive graphics is developed and programmed. In this section we will specify and give insight into the extensive and high amount of audio input that are used for SoundShaping. This will provide understanding of the complexity and dynamic utilised in the generative system and in the 3D geometry that the system produces. The high amount of audio features provided by the voice at a time is exceptional. Thus we will describe and illustrate the audio input used for SoundShaping.

Figure 6 Spectral centroid (very related to the perception of brightness) values obtained from voice



Audio is described using temporal and spectral envelopes giving an overview of the quality of the sound. Furthermore, dependent if the sound is voiced or unvoiced, more parameters are used to describe the sound in detail. In this work, the MIR toolbox (Lartillot and Toiviainen, 2007) is used as the basis for audio feature extraction. The *spectral centroid* (very related to the perception of brightness), *roughness*, and RMS (loudness) features are used to capture the specific features, and the *chromagram* is used to capture pitch information. These features capture mainly the prosody – emotional expressions (Pittam and Scherer, 1993) of the voice. The *spectrum* captures detailed spectral information, and the *MFCC* captures the spectral overview, the spectral envelope. These features capture mainly the information expressed by the consonants and vowels (Fant, 1970). A frame length of *50 ms* seems to work well in this context. The prosody features are shown below in Figure 6 (spectral centroid), Figure 7 (RMS), Figure 8 (roughness) and Figure 9 (chromagram) from a short voice extract saying approximately *ih ooh*. In all figures, the x-axis denotes the time in seconds, and the y-axis denotes the specific feature. In the case of the chromagram, all notes are possible, and each note has a weight denoted by a colour code for each time step, in which light denotes stronger. It is clear the brightness is higher for the *ih* part of the voice, compared to the *ooh*. The *ooh* segment has higher loudness (rms) and roughness. There is also a clear evolution in the pitch, as can be seen in the chromagram.

Figure 7 RMS values obtained from voice

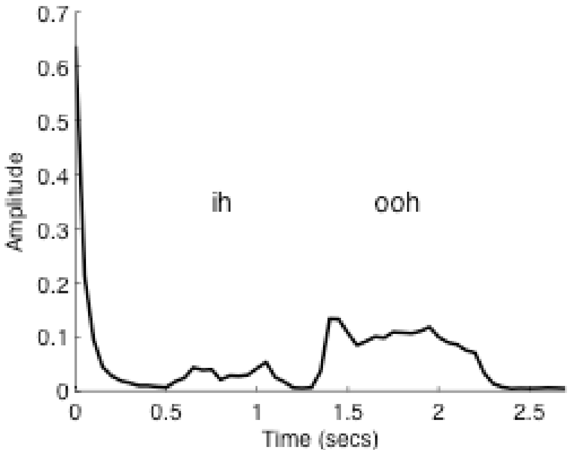


Figure 8 Roughness values obtained from voice

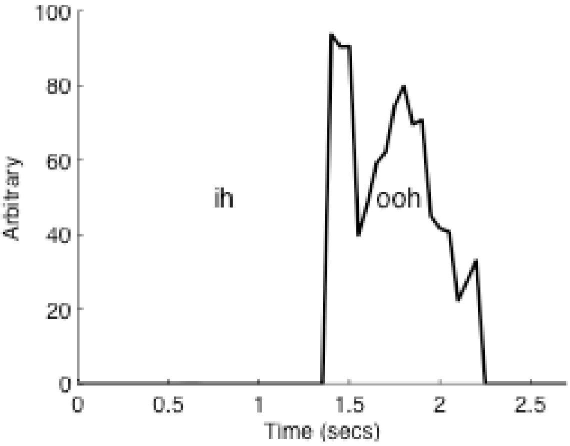
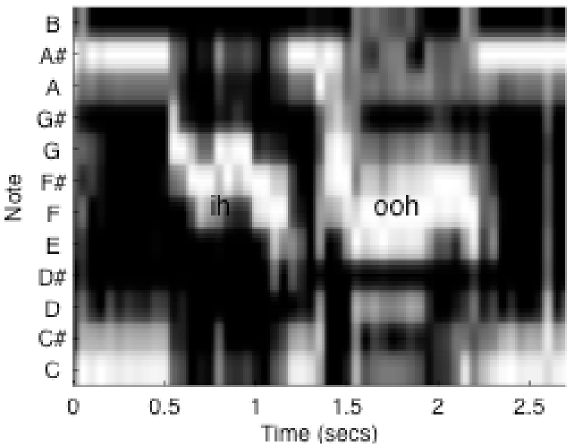


Figure 9 Chromagram from voice



The spectral features, spectrum and MFCC are shown in Figures 10 and 11, respectively. It is clear from the spectrum that the voice segment (*ih ooh*) consists of two separate vowels. That it is vowels is seen from the rather long homogenous segment, with lines indicating voiced content, in addition to the stronger frequency contents, corresponding to the formants that can be seen in both vowels. This is not as clear from the MFCC, however, this representation is believed to be more machine-readable, as it is commonly used in automatic speech recognition.

All in all, the audio features consist of a many values for each frame (time step). In order to obtain the wanted (lower) number of features, and to ensure that the most pertinent information from the audio is used, the PCA (Pearson, 1901) is used on the audio features. This ensures that the output components are uncorrelated and account for as much of the variability of the voice as possible. In addition, the principal components are arranged so that the first components accounts for as much of the variance as possible.

Figure 10 Spectrum from the voice

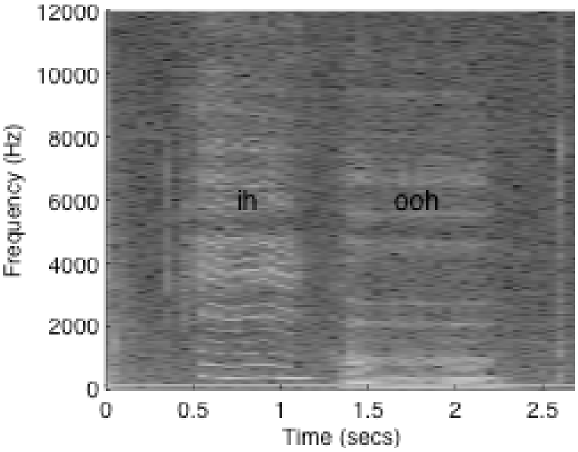
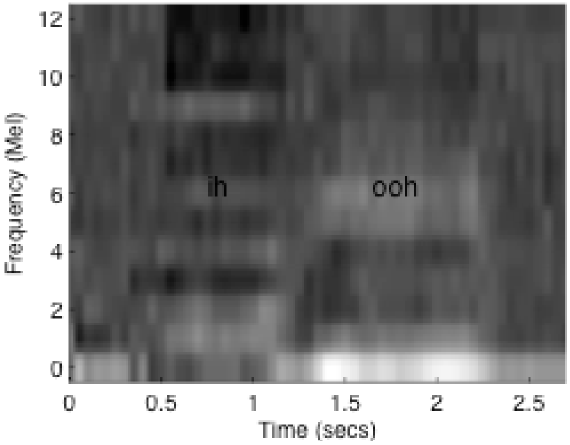


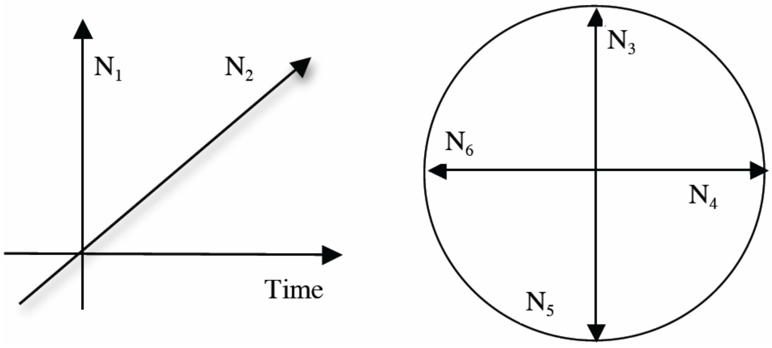
Figure 11 MFCC from the voice



3.3 3D graphic

The use of PCA makes it possible to reduce down the audio features to an arbitrary number of components. This experiment is based on six variables (N) in addition to time. The 3D digital geometry is seen as one object, which evolves in the length over time. The position of the centre is determined by two components and time [Figure 12(a)]. The cross section is determined by four components [Figure 12(b)], which are connected with a parameterised curve. To make sure there is variation in all shape dimensions, the variables (output of the PCA) are normalised in order to have equal standard deviations. The SoundShaping allows for a free configuration of which components to use to which geometry parameter.

Figure 12 (a) The position of the evolving 3D geometry is determined by two components (N_1 and N_2) and time, and (b) the cross section of the 3D geometry is determined by four components (N_3 to N_6)

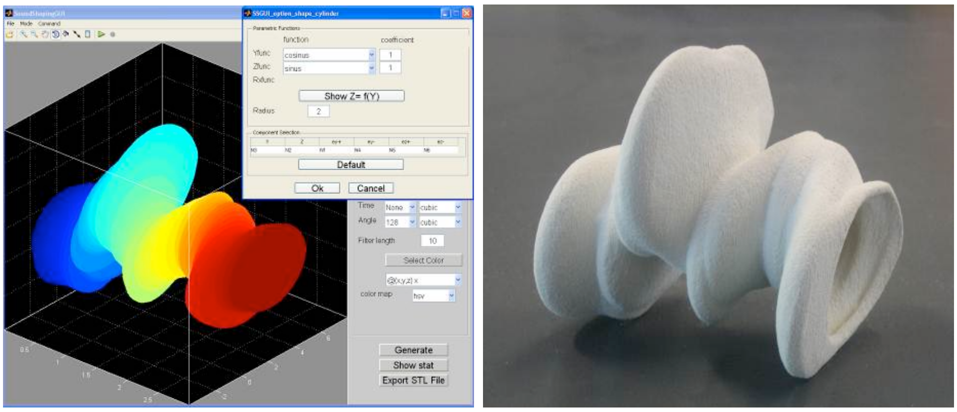


(a) (b)

As the voice is a very expressive organ, the resulting shape can be very different at each utterance. Thus this geometric solution sometimes fulfils our requirements, but sometimes showed a too curved or thin shape. Therefore, many possibilities of parameterisation are included, that adjust the resulting rendering. This is utilised to explore and specify the idiom in different categories of sound, e.g., screaming, babbling, talking, singing, etc., and at the same time fulfil the realisable requirements. The options include *frame size*, choice of *audio features*, order of PCA *variables*, *smoothing* length, and *curve* parameters. Figure 13(a) shows a 3D object with smoothing and the order of PCA *variables* and *curve* parameters options. In Figure 13(b) the same shape is shown as created in ceramics by the use of a 3D powder printer from ZCorp (ZCorporation, 2011). The recipe for utilising ceramics powder in the 3D printer is based on the research by University of Washington Department of Mechanical Engineering in Seattle, Washington (Ganter et al., 2009).

The development with parameters makes up an excellent basis to investigate the responding aspect. The exploration of the introductory responding generative system allows adjusting the shape with the voice. At this stage the SoundShaping system creates one object at a time. Each time the PCA is recalculated it creates a shape based on a responding generative system inherent in a complexity within audio features. Thus, with time, the designer explores and obtains the behaviour of the PCA as experiential knowledge. This enables the designer to explore the voice in an individual way and reflects the designers fingerprint in the design. Such an approach is based on the designer's and the researcher's experiential knowledge, which this project relies on, and permits examining the potential of the material by interacting with it and be attentive to its response.

Figure 13 (a) The SoundShaping interface, including curve parameterisation and PCA variable order options (b) The same object created in ceramics (see online version for colours)



Yfunc cosinus 1
Zfunc sinus 1
Radius 2
Time None cubic
Angle 128 cubic
Filter length 10
@(x,y,z) x
color map hsv

(a) (b)

4 Experiments, experiences and examples

As mentioned in Section 2 this research about integration of digital technology relies on experiential knowledge and thus the idea of *interactive material-driven designing*. According to the idea of *interactive material-driven designing* the design process is characterised by two levels that form a whole. The first level is to discover and identify a potential in a material. In this experiment we have done that and made up an excellent basis by the development of SoundShaping (the responding digital material). The second level of material driven designing is about interventions with the material – in this case by the voice – and being attentive to the response. This enables to actualise the potential within SoundShaping in a number of representative examples.

4.1 Interventions, control and limitations

To investigate what is possible and how, we will in this section examine some interventions to understand the nature and potential of the responding system: SoundShaping. Thus we will discuss how to obtain a certain control and understanding of the responding system. By control we do not mean to foreseen the exact shape, but as earlier mentioned in Section 2 to obtain a certain understanding on the premises of the material by interventions and being attentive to the response, and thus obtain experiential knowledge. We have done several experiments regarding this issue and will in this article examine a few, however we find these representative for our findings at this stage.

Figure 14 The three geometries in the top and bottom (shown in side-view) are representing different examples of the voice extract saying *ih* and *ooh* respectively

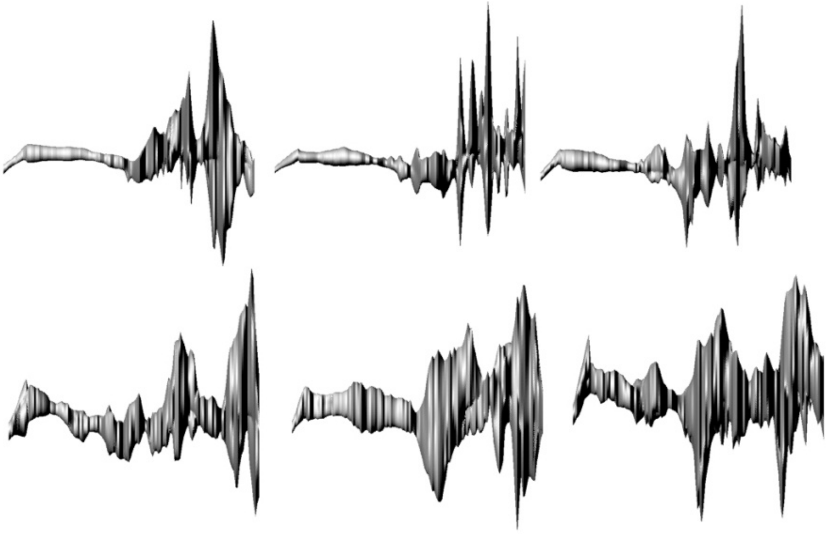


Figure 15 The three geometries in the top and bottom (shown in top-view) are representing different examples of the voice extract saying *ih* and *ooh* respectively

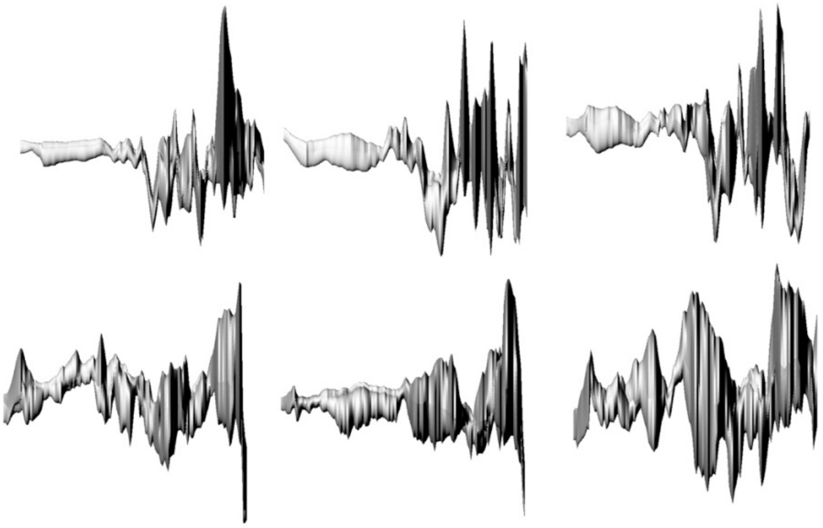


Figure 16 The geometries in the top and bottom (shown in front-view) are representing examples of the voice extract saying *ih* and *ooh* respectively

The following interventions are based on two contrasting audio inputs by a short voice extract saying approximately *ih* and *ooh* respectively ascending in volume. The difference in the audio output will show some aspect of the nature of SoundShaping. To be sure about the quality of the result the audio input was repeated three times. The results are shown in Figures 14 to 16. Figures 14 and 15 are showing the same shapes, but seen from two different angles; from the side-view and top-view respectively. The three geometries in the top of each figure are representing the three different examples of the voice extract saying *ih* and the three geometries in the bottom of each figure are representing the three different examples of the voice extract saying *ooh*. Figure 16 shows the geometries viewed from a front-view.

Based on the results shown in Figures 14 and 15, it is obvious on the outline of the geometries that SoundShaping responds to the voice over time. The outline grows depending on that. This may be referred to the loudness (rms) described in Section 3.2 (shown in Figure 7). Also it can be seen that the voice extract saying *ooh* is showing a larger volume in the geometry than the voice extract saying *ih*. This may be referred to roughness features described in Section 3.2 (shown in Figure 8), since the *ih* represents a brighter tone than the *ooh*. In this case the volume of the geometry seems to grow depending on the loudness (rms) and roughness features. This knowledge gives the impression that some control can be obtained and thus experiential knowledge. In other words, in some cases, it seems possible to control the geometry using the loudness of the voice.

The shapes at Figure 16 summarises the differences between the top view and side view at Figures 14 and 15 respectively. Figure 16 refer to the geometric model explained in Section 3.3 and reflects a complexity that is hard to see through. It is difficult to see why the values of the variables are stronger at some points than others and to refer them to e.g., the features based on the MIR toolbox explained in Section 3.2. This seems to reflect the influence of the PCA. As explained in Sections 3.1 and 3.2 the PCA extracts pertinent information from the voice. Each time, this may be different features depending on how the utterance is made. Since the information from the voice may be expressed differently from time to time, it is hard to see through this regarding the aspect of control. Thus a limitations, since the results produced by SoundShaping consist of a considerable degree of unpredictability or apparent randomness.

Nevertheless it is interesting to consider this complexity and randomness in a design tool as a design quality?

4.2 A random pattern or random compound object

The complexity and randomness produced by the PCA, can be utilised as a random pattern or for designing a random compound object. We will investigate and explore this issue with the help of the parameterisation in SoundShaping. Firstly we will investigate the idea of a random pattern by the use of the radius parameter. Secondly we will investigate the idea of a random compound object.

The parameterisation in SoundShaping makes it possible to change the radius settings (see Figure 13). Originally, this setting was made to prevent too thin shapes, but it is also useful to enable patterns on objects. Figure 17 shows the first utterances with the voice extract *ih* and *ohh* respectively from Figure 16, but with different diameters. The larger the diameter is the more the 3D shape based on the PCA components becomes a pattern on a basic shape; in this case a tube. While the apparent randomness decreases with increasing diameter, each object is still different even at high diameters. Figure 18 shows the examples with the two largest diameters. These examples show the parameterisation utilised for making random patterns. The examples appear as drafts for e.g., cups with different patterns based on different voice extracts; *ih* and *ohh* respectively.

Figure 17 The voice extract *ih* and *ohh* respectively with different diameters

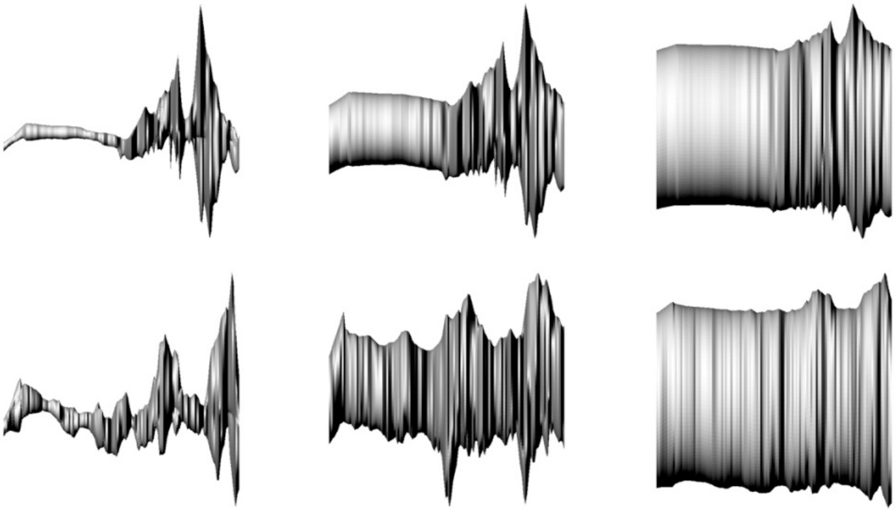
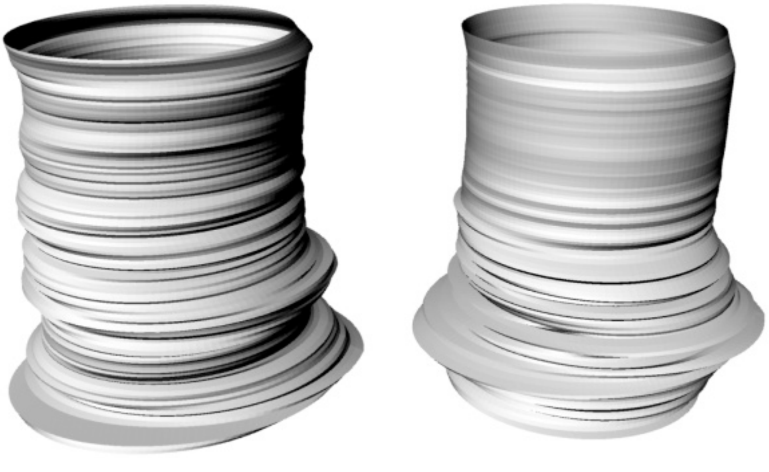


Figure 18 Drafts for e.g., cups with different patterns based on different voice extracts; *ih* and *ohh* respectively



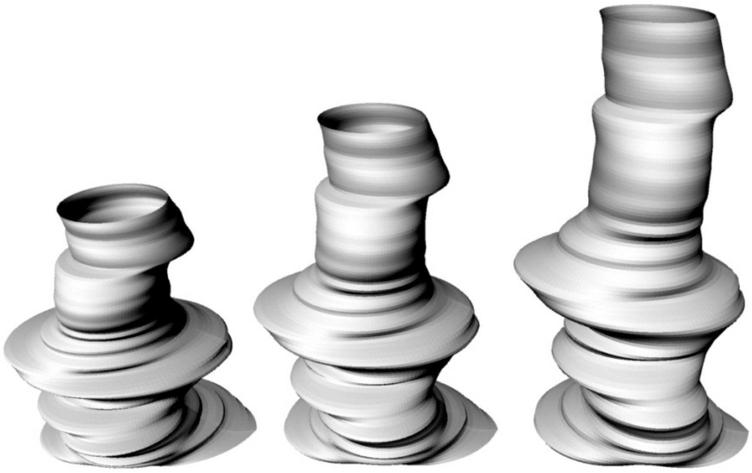
Secondly we will investigate the idea of a random compound object. We will explore this by changing the frame length (time step). The geometry to the left at Figure 19 shows the example based on the voice extract *ohh* with the medium diameter in Figure 17 (the example in the middle and at the bottom). Figure 19 shows the geometries based on a frame length of 50, 100 and 150-ms. respectively. The geometry based on 150-ms seems to work because it changes the pattern into a compound object. This tendency is further developed in Figure 20, which shows the geometry based on the frame length of 150-ms scaled in the height with 0%, 50% and 100% respectively. These latter examples show the parameterisation utilised for making random compound objects. The geometries appear as drafts for e.g., vases or jugs.

Figure 19 The *ohh* voice extract produced by SoundShaping with a frame length of 50, 100 and 150-ms respectively

4.3 Reflections and further development

The experiments with SoundShaping we presented in Section 4.1 showed a considerable degree of randomness. We have explored how to utilise this in Section 4.2 for making 3D design, specifically for making patterns and compound objects.

Figure 20 The *ohh* voice extract with a frame length of 150-m. scaled in the height 0%, 50% and 100% respectively



Note: The geometries appear as drafts for e.g., vases or jugs.

The considerable degree of randomness makes it difficult to obtain experiential knowledge according to the idea of *interactive material-driven designing*. In this case it is relevant to consider the workflow with SoundShaping. As earlier mentioned in Section 3.3 SoundShaping creates one object at a time. It means the audio is first recorded and then the PCA is calculated and a shape created. That workflow makes it difficult to obtain the intimate relationship between the designer and the material, according to the idea of *interactive material-driven designing* explained in Section 2.3, because of the high degree of randomness. The workflow becomes less intuitive and more analytical, e.g., compared to an interactive generative system such as Camille

Utterback's shown in Section 2.3, which for this purpose can be termed as real-time interaction.

Thus the purpose of a further development of SoundShaping is to obtain a higher degree of experiential knowledge. On one hand this can be obtained by a higher control by lower down the number of audio input. On the other hand it can be obtained by the development of a higher degree of real time interaction. The latter is to prefer because it firstly keeps the intent of an audio input that accounts for the main part of the voice expression and secondly it support the idea to obtain the intimate relationship between the designer and the material, according to the idea of *interactive material-driven designing*.

5 Conclusions

We have in this article introduced an approach to integration of digital technology in the field of 3D designing, especially in fields rooted in arts and craft such as ceramics. The approach is characterised by an interaction and a responding 3D graphic that has proven useful to explore and to experiment by interacting with the voice. We have exemplified and discussed this issue based on experiments.

The experiments were based on the development and use of the generative system *SoundShaping* that converts audio into features, and variables (based on PCA) that accounts for the main part of the voice expression. The use of PCA ensures that the craftsman expresses the voice in any manner while still being sure that the output – the 3D object – reflects his/her intent.

In the experiments we found that some control can be obtained, but also a considerable degree of randomness was found. Nevertheless we have shown that the randomness can be artistically utilised for making form, specifically for making patterns and compound objects.

Regarding randomness we have discussed and reflected on the further development of SoundShaping. The workflow may prevent the intimate relationship between the designer and the material in the very moment of giving form, and thus to obtain experiential knowledge according to the idea of *interactive material-driven designing*. In order to keep the high amount of audio input that accounts for the main part of the voice expression the further development of SoundShaping requires investigation on real-time interaction.

References

Autonomatic (2011) [online] http://www.autonomatic.org.uk/ (accessed 3 October 2011).

Binder, T. and Redström, J. (2006) *Exemplary Design Research*, Wonderground Proceedings Book, Lissabon, Portugal.

Bunnell, K. (2004) 'Craft and digital technology', Paper presented at the *World Crafts Council 40th Anniversary Conference*, Metsovo, Greece.

CITA (2006) 'Sea Unsea' [online] http://cita.karch.dk (accessed 5 March 2010).

Deleuze, G. and Guattari, F. (1988) *A Thousand Plateaus: Capitalism and Schizophrenia*, Athlone Press, London.

Dormer, P. (1994) *The Art of the Maker*, Thames and Hudson, London.

Dulic, A. and Hamel, K. (2009) 'Visual music instrument', *Genève: International Journal of Arts and Technology*, Vol. 2, Nos. 1/2, pp.22–39.

Fant, G. (1970) *Acoustic Theory of Speech Production*, Mouton De Gruyter, The Hague.

Frayling, C. (1993) 'Research in art and design', Royal College of Art Research Papers, Vol. 1, pp.1–5.

Ganter, M., Storti, D. and Utela, B. (2009) 'The printed pot', Ceramic Arts Daily, Westerville [online] http://ceramicartsdaily.org/methods-techniques/the-printed-pot/?floater=99 (accessed 12 September 2011).

Hansen, F.T. (2010) *Materialedreven 3D digital formgivning: Eksperimenterende brug og integration af det digitale medie i det keramiske fagomrade*, PhD-report, The Danish Design School Press, Copenhagen.

Jørgensen, T. (2009) 'Oktavius' [online] http://www.oktavius.co.uk/ceramic_origami.html (accessed 1 March 2009).

Keep, J. (2012) '3D printing' [online] http://www.keep-art.co.uk/journal_1.html (accessed 1 March 2012).

Kwinter, S. (2002) *Architectures of Time: Toward a Theory of the Event in Modernist Culture*, MIT Press, Cambridge.

Landa, M.d. (2002) *Material Complexity*, Paper presented at the *Digital Tectonics*, University of Bath Department of Architecture and Civil Engineering, Bath.

Lartillot, O. and Toiviainen, P. (2007) 'A Matlab toolbox for musical feature extraction from audio', *International Conference on Digital Audio Effect*, Springer, Bordeaux.

Leach, B. (1940) *A Potter's Book*, Faber and Faber, London.

Masterton, D. (2005) 'The hunt for complexity', Paper presented at the *Autonomatic 1 Symposium*, University College Falmouth, Falmouth.

Maus, B. and Fischer, A. (2008) *Reflection* [online] http://old.allesblinkt.com/project/reflection (accessed 11 November 2011).

McCullough, M. (1998) *Abstracting Craft. The Practiced Digital Hand*, MIT Press, Chicago.

NewDanishCeramics (2008) *Statistics >< Ceramics*, NewDanishCeramics, Exhibition Catalogue, Copenhagen.

Paul, C. (2003) *Digital Art*, Thames & Hudson, London.

Pearson, K. (1901) 'On lines and planes of closest fit to systems of points in space', *Philosophical Magazine*, Vol. 2,No. 6, pp.559–572, Taylor and Francis, London.

Pittam, J. and Scherer, K.R. (1993) 'Vocal expression and communication of emotion', in M. Lewis and J.M. Haviland (Eds.): *Handbook of Emotions*, The Guilford Press, New York, London.

Polanyi, M. (1966) *The Tacit Dimension*, The University of Chicago Press, USA.

Rahim, A. (2006) *Catalytic Formations. Architecture and Digital Design*, Taylor & Francis, New York.

Sandvik, K. (2007) 'Magt, oplevelsesøkonomi og Web 2.0 – en forandringsfortælling', *Ordet*, Copenhagen [online] http://tidsskriftetordet.blogspot.com/2007/12/magt-magt-oplevelseskonomi-og-web-20-en.html (accessed 21 January 2011).

Schön, D. (1983) *The Reflective Practitioner. How Professionals Think in Action*, New York: Basic Books, New York.

Sevaldson, B. (2005) *Developing Digital Design Techniques. Investigations on Creative Design Computing*, Oslo School of Architecture and Design, Oslo.

Thomsen, R. (2007) *Sea Unsea*, Arkitekten, Copenhagen, No. 6, p.47.

Utterback, C. (2004) 'Untitled 5' [online] http://www.camilleutterback.com (accessed 2 December 2009).

ZCorporation (2011) '3D printers' [online] http://www.zcorp.com/en/Products/3D-Printers/spage.aspx (accessed 3 October 2011).