THE HYPERTENSION SINGING BOWL: RESEARCH THROUGH DESIGN IN ACOUSTIC SONIFICATION

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1. INTRODUCTION

The Hypertension Singing Bowl was digitally shaped from a year of blood pressure readings, and 3D printed in stainless steel. This digital singing bowl rings just like a traditional hand-crafted bowl when it is rubbed with a 'Puja' stick. The mapping of the blood pressure data onto the shape also maps the data onto the sound it produces. Just as antique bowls are sought out for their unique sounds, the effect of the personal dataset on the shape and acoustics gives each digital bowl a unique sound too.

![Hypertension Singing Bowl](image)

Figure 1: Hypertension Singing Bowl.

The Hypertension Singing Bowl is an early example of an Acoustic Sonification [6]. It is also an early example of Design Research in the field of data sonification. Design Research was proposed in the 1960’s, and developed through academic programmes in Architecture, Industrial design and Engineering in the 1980’s [7]. Bruce Archer distinguished design research from scientific methods by stating that 'there exists a designerly way of thinking and communicating that is both different from scientific and scholarly ways of thinking and communicating, and as powerful as scientific and scholarly methods of enquiry when applied to its own kinds of problems' [3].

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2. RESEARCH THROUGH DESIGN

Design has gained increasing importance in high-tech products such as computers, phones and tablets, where interfaces, graphics and physical form have become important differentiating features. William Gaver describes how the influx of designers in the culture of "scientism" in the Computer Human Interaction (CHI) research community led to concerns about the "rigour" of practice-based research, and questions about what should be considered as “good” research [9]. Gaver argues for practice-based research through design for discovery and the advancement of knowledge in Computer Human Interaction. Design through research is a generative process of exploration, speculation, particularization and diversification that leads to the proliferation of new realities. Results are provisional, contingent, and aspirational, allowing richer and more situated understandings than those produced through analytic methods. Knowledge is manifested in artifacts that have much more detail than any written or diagrammatic documentation.

3. ANNOTATED PORTFOLIOS

An artifact can be thought of as occupying a particular point in a design space. Designs that establish a design space around themselves are known as "ultimate particulars". Design spaces can be explored by moving around a particular point, or by moving away from it along understood dimensions. A collection of related designs establishes an extended domain in design space. Multiple examples help tease apart configurations of choices, and identify dimensions of variation and invariance among them. Gaver proposes that the comparison of collections of related designs in "annotated portfolios" may serve as an alternative to formalised theory. The annotation of individual examples can identify ideas and issues that connect and differentiate them. This is the converse of the generalisation of regularities from repeated designs in Design Patterns [1][2][4].

"Most fundamentally, annotated portfolios respect the 'ultimate particular' of the designed artifact, rather than abstracting across instances as pattern languages do, while allowing for the 'extensibility and verifiability' for which some of the HCI design community have called." [9].

4. HYPERTENSION SINGING BOWL AS AN ULTIMATE PARTICULAR

The Hypertension Singing Bowl is an artifact that that opens up a design space of Acoustic Sonification around it. It is the most recent iteration in a series of artifacts that began with a small plastic prototype of a singing bowl. The second iteration was printed in stainless steel at a larger size to test whether it would ring. In the third iteration, blood pressure data was mapped onto the shape of the bowl. Blood pressure data consists of two readings known as diastolic and systolic pressure. Diastolic is the pressure in the arteries when the heart contracts. Systolic is the pressure when the heart is resting between beats.

The complete data set consists of 120 readings taken over a one year period. The diastolic reading was mapped to the outer...
thickness of the bowl, and the systolic to the inner, resulting in a bowl with varying thickness at each radius from top to bottom. The resulting bowl was too thick and did not ring. The amplitude of the mapping was reduced and the bowl was reprinted in titanium, which is very strong and very light. This version did not ring well either. A reflection on the results led to a redesign of the mapping to vertical tines that encode the data points as changes in thickness. This version of the bell rings just like a traditional singing bowl, even though it looks radically different with the data tines connecting the upper rim and lower base. The tines have introduced a high frequency "hissing noise" to the ringing of the bell that may be due to acoustic interferences.

The Hypertension Singing Bowl can be tapped, or rubbed or scraped with different rates and forces to produce different sounds, and can even be used in a musical performance. The sound is immediate and responsive, and is independent of the size and complexity of the dataset. It is also an unusual example of a sonification of digital data that does not depend on computation, signal processing, speakers, or electrical power to work.

The development of the singing bowl raises the question of whether a listener can understand information about the dataset from the sound. The data visualisation theorist Jaques Bertin distinguished information from data by defining information as the relationships between data points in a dataset, rather than the data values themselves [8]. From this perspective the capability to listen to an entire dataset in a single sound has the potential to enable a highly informative global understanding about the relationships within an entire dataset all at once.

Acoustic Sonification is a systematic and repeatable process. However, different designs will have different acoustics and produce different sounds from the same dataset. A design that sonifies particular information relations in one dataset does not necessarily generalise to other datasets. Design research involves critical reflection and evaluation of points in the design space as part of the design process. Listening tests are one way to explore dimensions of variation in the design space around the singing bowl in order to search out designs that maximise the perception of information about the dataset, taking into account human auditory perception, psychoacoustics and cognition.

5. AN ANNOTATED PORTFOLIO OF ACOUSTIC SONIFICATIONS

The Hypertension Singing Bowl is part of an ongoing series of experiments in Acoustic Sonification. The first experiment was a pair of bells shaped from a dataset of Head Related Transfer Functions [6]. The next experiments extended the concept to other sonic metaphors by mapping the HRTF dataset to a rattle [5]. Current work is exploring systematic variations on a 3D printed tuning fork as a foundation for a theory of additive acoustics analogous to the theory of additive synthesis from sine tones.

This collection of artifacts provides a basis for a trial of Gaver's proposal that annotated portfolios can be a way to formulate theory from research through design. The annotated portfolio on the next page is modeled on an example provided by Gaver of an annotated portfolio of stereo equipment, kitchenware and grooming appliances designed by Dieter Rams [9]. Please note that this is a first trial of this approach and is work in progress.

6. REFERENCES

Annotated Portfolio of Acoustic Sonifications

The Hypertension singing bowl is shaped from a year of blood pressure readings. Each reading alters the thickness of one of the bars in the middle of the bowl, which effects the acoustics so that different data sets produce different resonant frequencies. The bowl is played by rubbing the perimeter with a stick to produce a sonic reverberation that can last for minutes. The meditative sounds of singing bowls have been part of Buddhist meditation for centuries, and alternative healing in the West. High blood pressure, or hypertension, is called the “silent killer” because of the lack of symptoms combined with the fact that it is a significant factor in many life-threatening diseases. The sound of the singing bowl draws attention to blood pressure readings by making them audible, providing a sonic meditation on personal well being, and a reminder to live a healthy lifestyle.

The interaction is understandable, familiar or self-explanatory. There is room for performance and virtuosity.

The sound is a summary of a complete dataset. Different data sets produce different sounds.

A tuning fork produces a stable and repeatable reference tone for tuning an instrument or an orchestra, but there are many other applications in science, engineering and medicine as well. Slow motion video shows how the shape of the tuning fork amplifies the fundamental frequency and damps other frequencies produced by more complex bending and rotating movements. The relationship between the length, thickness and material of the tines, and the frequency of the fork is well understood. But what happens when you add extra tines, or vary the geometry in other unconventional ways? The understanding of variations in tuning forks may provide a baseline for designing predictable acoustic sonifications.

The Binaural Bells are bell shaped objects 3D printed in stainless steel that ring when struck. The shape of these bells has been modulated by data from Head Related Transfer Functions that capture the way the outer ear filters sounds from different directions to enable directional hearing. The thickness and angle of the bell affects the pitch and timbre. The thickness of the Left bell is modulated by the HRTF for the left ear, and the right bell is from the right ear. The pitch of the left bell is different from the right bell, because of differences in the data from each ear. The 1.5 second ringing sound of the bell is an acoustic summary of the complete HRTF which consists of thousands of data points. The similarity and difference between the HRTFs from different people can be heard by similarity and difference in the pitch and timbre of their individual bells, and may provide a way to aurally analyse and classify databases of HRTF recordings.

Sound engages curiosity that may lead to new perspectives and understandings of the data.

The form, feel, interactivity and sounds are pleasing to the senses, emotions and mind.

The Binaural Rattle is modelled on decorative silver baby rattles of the Victorian Era. As the name suggests, the rattle is shaped from the same datasets as the Binaural Bells. The rattle integrates both left and right HRTFs as the upper and lower halves, summarising the entire binaural HRTF in one short sound. The interaction of shaking rather than striking, produces short percussive sounds rather than pitched ringing. Further experiments are needed to test whether differences between the HRTFs from different people can be heard in different rattles.