SONIC INTERACTION DESIGN

edited by Karmen Franinović and Stefania Serafin

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10 SonicTexting

Michal Rinott

Texting has become a central activity in our digital day and age. In 2008, 75 billion text messages were sent in the United States in one month [1] alone! Texting on mobile phones, using the thumb and the phone pad, has been so influential on a generation of teenagers that researcher Sadie Plant reports that some now use their thumbs for index-finger activities such as turning on lights and pointing [2].

The importance of texting has prompted designers to seek efficient and usable solutions for text entry on mobile devices. One category of approaches, originally created for PDA devices with stylus input, has involved using continuous gestures for writing words, preventing the need to lift the stylus from the surface between letters, as is typical of the number pad interface (e.g., T-cube [3], Quikwriting, [4]). The recent ubiquity of touch screens, most notably the iPhone and table-top systems, has prompted a surge of renewed interest in continuous gesture-based input methods now using the finger (e.g., Swype [5] and ShapeWriter [6]).

Although both show good results in usability and “word-per-minute” efficiency, these gestural solutions are based on focal vision. This is so despite the fact that texting is often performed in situations in which vision is compromised: in the dark, by people with visual disabilities, and while on the move (a recent U.S. insurance survey of 1,503 drivers found that almost 40 percent of those respondents from 16 to 30 years old have said they text while driving [1]).

SonicTexting is a gesture-based text entry system that uses tactile input and auditory output. The goal in making SonicTexting was to create a texting interface in which audio, not vision, would be the central feedback modality. Making texting an auditory—and tactile—interaction is a way to decrease the visual load in mobile situations [7].

Not less importantly, SonicTexting was an attempt to create an engaging interaction that would be challenging and rewarding to master. Rather than maximizing word-per-minute texting efficiency, the emphasis in designing SonicTexting was placed on creating an engaging audiotactile experience. Inspired by the expertise achieved by teens with the number pad interface, SonicTexting was an attempt to tap into the types of audiotactile expertise people gain in playing musical instruments and using gaming controllers. Creating a desirable interaction method that does not rely on vision can include visually disabled users and can show the potential of rich auditory experience in digital artifacts.

SonicTexting was created in 2004 as a Masters Degree project in interaction design. It has been implemented to the level of a working prototype and presented as an interactive installation in various exhibitions.[1] This case study describes the process of designing this particular sonic interaction and discusses the insights gained from observing people using it within different contexts (e.g., a museum, at a conference, at a fair) to designing sonic interactions.

10.1 The SonicTexting System

SonicTexting is an audiotactile system for inputting text using continuous thumb gestures. Sound provides the sole feedback for the gestures, aiding orientation and navigation.

The gestural vocabulary of SonicTexting is based on the Quikwriting model [4]. Quikwriting is a text entry system in which the stylus is never lifted from the surface during writing. The writing area is divided into zones arranged around a central resting zone. To form a character, the user drags the stylus from the central resting zone out to one of eight outer zones, then optionally to a second outer zone, and finally back to the resting zone.

Based on this general gesture model, SonicTexting introduced two main innovations:

- A specialized input device that naturally supports this center-periphery-center motion.
- Feedback for the gesture via continuous, synchronous sound.

The following sections describe the SonicTexting system in detail.

10.1.1 Input Device: The Keybong

The SonicTexting input device, nicknamed the *Keybong,* is a one-handed device that fits in the palm of the hand (figure 10.1). The Keybong consists of a small joystick enclosed in a plexiglass shelling. The joystick movement is limited by a circular boundary. The joystick naturally supports the common gesture pattern of SonicTexting:

Figure 10.1
The Keybong.

moving from a central location, through a specific path, back to the center. The springy return of the joystick to the center requires the user to actively perform only the first part of the gesture.

The Keybong contains a small eccentric motor that provides gentle vibration feedback in the writing process. This tactile layer accompanies and augments the sound layer. The Keybong joystick is also a button: pressing it down clears the entered text. The Keybong form is designed to fit comfortably in the hand, ensure that it is held in a fixed orientation, and be small enough in size to be used inside a handbag or coat pocket.

10.1.2 The Gestural Alphabet

Writing in SonicTexting is performed by moving the Keybong joystick from the center to one of eight "axis" positions around the circle periphery (N, NE, E, SE, S, SW, W, NW) and either returning to the center, or moving around to another position around the circle (a "nested" position) before returning to the center.

The gestural alphabet is presented to the user, for initial learning, via a static visual representation of the letter locations (figure 10.2). It is read as follows: to write an *a,* the controller is moved in the *a* direction (NW), then back to the center. To write a *b,* the controller is first moved to the *a* direction, then moved along the circular periphery toward the *b* (N), then back to the center.

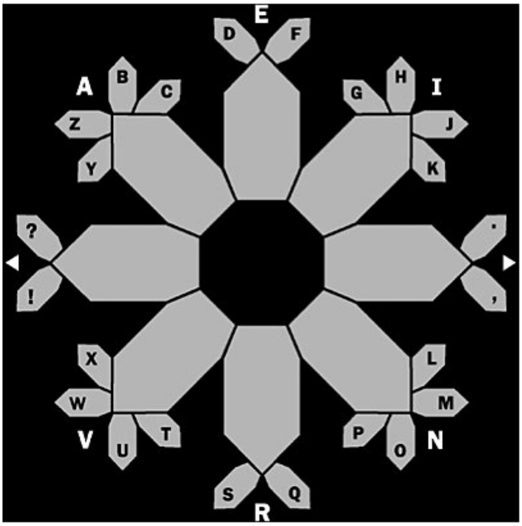

Figure 10.2
The gestural alphabet.

The nested nature of the gesture model—whereby reaching nonaxis letters requires first moving to the axis letter, then moving left or right in a zoomed-in periphery—is communicated through the fractal-inspired design of the map, created by duplicating and rotating a basic graphic element to signify the axis letters and the nested letters.

In the Quikwriting model the letter arrangement is by frequency: frequent characters require shorter gestures. In SonicTexting an alphabetical arrangement was chosen in which the letters ascend in alphabetical order clockwise. This order was selected because of a prioritization of memorability over gesture length, given the relative ease of reaching all letters using the Keybong.

10.2 Sound in SonicTexting

In SonicTexting sound provides continuous feedback during movement—an interactive sonification of the gesture path. Sound is also used after the gesture for a letter-by-letter readback of completed words.

The functions of sound in SonicTexting are:

- To guide the first, outward-bound movement to the axis letter
- To guide the next movement (if needed) around the periphery
- To provide feedback for the entry of the letter

- To provide feedback for the writing of whole words
- To aid the memorization of the gesture paths

These functions are achieved through the following sonic features:

Phonemes Looped letter phonemes, in a female voice, are played in synchrony to the user's movement. In the current implementation, the phonemes are Italian (e.g., the sounds /ah/, /bhe/, /ch/). As the controller moves outward in one of the eight axis directions, the relevant phoneme is sounded in a loop. When the controller is located between these axis directions (e.g., NNW), the phoneme sounds overlap. Navigating to a letter thus requires a process similar to that of tuning to a station on an analog radio—finding the location of the cleanest sound.

Loudness Loudness is a function of the distance between the controller and the location on the periphery of the controller range. As the controller moves from center to periphery, the volume of the looped phonemes grows louder. Thus, the user needs to find the loud sound of the desired letter.

Pitch The letter phonemes are sung in different pitches according to their position around the circle periphery. The pitch ascends clockwise, starting at the N, note by note through one octave (/ah/ sung in Do, /bhe/ in Re, /ch/ in Mi, and so on). In this way the gesture path for every letter has a unique tune, according to its path around the circle.

Tactile "acquisition" feedback A slight vibration is felt when the user reaches the area of a position and "acquires" it. On feeling this the user can let the controller return to the center. This nonsound element was selected to increase the tactile aspect of this audiotactile experience.

Learnability and expertise As users gain experience with the system, they memorize the letter locations and gesture paths. An "expert mode" was created for users who already know the gesture paths. In this mode, discrete percussion sounds are played when the controller acquires—moves into a close distance to—a position on the periphery. The sounds for these positions are pitched as in the main sound mode to preserve the gesture tunes. The velocity of the movement determines loudness of the initial part of the sound (the attack), so that faster movements create stronger sounds. Expert mode creates a very compact sound pattern, as opposed to the longer looping phoneme sounds.

Readback Following completion of a word (after a space character), the letter phonemes are read back to the user in sequence. This serves as a confirmation to the user working "eyes free" that the word has been written correctly. Moving the Keybong in any direction stops the readback and returns to live sound feedback.

10.3 Sonic Design Considerations

In the following paragraphs some insights from the design process are described:

Sonic content In this writing task, it may be more appropriate to use letter names rather than phoneme sounds (e.g., the letter name “Bee” as opposed to the phoneme /bh/). However, phoneme sounds were selected in order to create a “sonic texture” of speech sounds rather than letters. For this reason also, the readback function uses the phoneme sounds for letter-by-letter readback rather than speech-engine-generated whole words.

Voice selection Throughout the design iterations, a number of different people gave their voices to SonicTexting. One of the most notable was a very low male voice, which gave the experience of a special quality of darkness. However, the preferred voice was a female voice of a (nonprofessional) singer who spoke/sang the phonemes with a clear, resonant voice.

Spatial aspects In the initial design stages, the sonic design task was conceived of as a direct sonification of the gesture map. A number of attempts were made to sonify spatial aspects of the space. One attempt was an inhale sound when leaving the center area and an exhale when returning to it. Another was a “bump” sound when the controller moved to another “area.” In the final design these were abandoned in the search for the most minimal sonic representation. The current spatial mapping, in which the volume and pitch change through an octave, seems natural to the round space with its eight peripheral positions. The rising pitch with ascending letter order and falling pitch with descending letter order correspond to alphabet songs in different languages, which tend to contain this attribute.

Feedback and feed-forward In the basic sound mode of SonicTexting, sound provides a means of learning the gesture scheme. In this situation the sound provides feed-forward—guidance as to where to go. In the expert sound mode, sound provides feedback—an indication that the periphery point has been reached. It is assumed that in basic mode the user moves in search of the next letter, whereas in expert mode the user knows the position and needs a minimal form of confirmation. The slight vibration on “acquisition” of the position creates the possibility for silent operation.

10.4 Observations

SonicTexting has been implemented as a working prototype for an installation setting. The Keybong controller was connected to an (unseen) computer, the sound played back through a speaker above the user. A screen showed the static gesture map and a text input line where entered letters could be seen.

No formal usability testing was performed on the prototype. However, the Sonic-Texting installation was presented and experienced in a number of contexts: a design museum, a design exhibition, and an HCI conference. In total over 2,000 people tried the prototype in over 60 days of display. This section describes the main insights gained from observing visitors to the installation.

- The majority of visitors, both adults and children, reacted enthusiastically to the experience and were motivated to learn to SonicText.
- In the exhibition setting, visitors' interpretation of SonicTexting varied: some saw it as a game, others as a kind of musical instrument, and still others as a desirable mobile device feature.
- Most visitors could use SonicTexting to successfully write a word after 1–2 minutes of practice, a much shorter time than had been anticipated. Thus, the first part of the SonicTexting learning curve proved steeper than expected.
- Visitors tended to expect visual feedback to appear on the gesture map. Instructing them to "move in the direction of the letters using sound," and to "seek the pure sound," helped increase their dependence on the audio feedback and thus improved their performance.
- There were large differences among people in the degree to which they could make use of the sound output. Some "caught on" immediately and started using the sound to navigate, but for others "tuning in" to the auditory channel was more difficult to do. Children tended to be very good at this task!

10.5 Conclusions for Designing Sonic Interactions

The SonicTexting experience is in three spaces: the visual space of the gesture map, the tactile space of the Keybong movement, and the auditory space of the sound. In SonicTexting, users need to depend on their hand-ear coordination to find the letters, rather than the hand-eye coordination of the visual map. One user tried to express this by comparing the Keybong with a keyboard: "With a keyboard, the space is laid out in front of you; with the Keybong it is more abstract: the space is in the head, not in the Keybong."

In a visually dominated digital world, people are not accustomed to focusing on sound as a main feedback channel, especially for a traditionally visual activity such as text input. Methods that direct attention to the auditory channel help people change this initial tendency. Careful design of the experience—through good sound quality, lo-fi visuals, presentation of instructions via audio—dispose people to open their ears.

The interpretation of the SonicTexting prototype as a game by some exhibition visitors, as well as the tendency of visitors to return to the installation for additional practice, indicate that the interaction was enjoyable to many. Although it cannot be proven in this study, it is this author's impression that the strong correspondence between movement and sound, and the audiotactile quality of the interaction, are central causes for this enjoyment.

SonicTexting was an academic project and has not been developed into a commercial product. Despite its relative simplicity in computional implementation—recorded voice with real-time volume modifications—it created an engaging experience that people succeeded in using "on the spot." The installation generated interest in different communities—the CHI community, the industrial design community, and the SID community. This is encouraging for SID projects and for students venturing into the field interested in using prototyping to communicate SID ideas.

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Note

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Manual Labor, Facelift festival, Genk, Belgium, April 2005;

Interactivity Chamber, CHI2005 Conference, Portland, OR, April 2005;

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4 Pedagogical Approaches and Methods

Davide Rocchesso, Stefania Serafin, and Michal Rinott

Continuous interaction and multisensory feedback are key ingredients for successful interactive artifacts of the future. However, the complexity of the systems of sensors, actuators, and control logic that are necessary for exploiting such ingredients poses tremendous challenges for designers who are mostly used to visual thinking and discrete interactions. Specifically, designers not acquainted with sound lack a number of meaningful skills required to deal with sonic interaction projects:

- *Means* to present them to others
- *Language* to discuss them with others
- *Skill set* to prototype them
- *Processes* to iterate them

In this chapter we present a number of methods adopted and adapted to enable thinking about sonic interactions, generating ideas and prototyping them at different levels of fidelity and specificity. These methods are focused on the special challenges and possibilities of interactive sound.

4.1 Basic Design Methods

The birth of design as a discipline is usually attributed to the Bauhaus school, founded in Weimar in 1919 and later moved to Dessau and Berlin, where it was closed in 1933. Although the life span of the Bauhaus was relatively short, its impact on design practices and theories was huge. Since the foundation of the school under the direction of Walter Gropius, it was clear that a discipline had to be grown out of education, and the importance of introductory courses (grundkurs) was immediately evident. What was less clear, at the beginning, was what to teach and how to teach. It took many years and the effort of several educators to develop a basic design method that would produce mature designers. The early classes of Johannes Itten were a sort of sensory training for students. Then, László Moholy-Nagy introduced some technological elements to widen the range of possible phenomena and configurations that could be experienced by students. It was only with the classes of Josef Albers that a drive for objectivity entered design education. The sensory awareness of the designer was cultivated through exercises, trial and error, and confrontation with peers. It was Albers himself who pushed this method further over 27 years of teaching in the United States. Specifically, Albers's decade at Yale University (1950–1960) refined the basic design method of education as research, and its peak was reached in studying the interactions of colors [1]. The exercises assigned by Albers and the solutions given by his students demonstrate a synthesis of many decades of efforts, in both artistic and scientific contexts, to understand color perception. This synthesis of art, science, and technology was even more explicit in the New Bauhaus, founded in 1937 by Moholy-Nagy in Chicago, and it inspired the creation of the Hochschule für Gestaltung in Ulm (1953). Especially under the direction of Tomás Maldonado, the basic design classes developed a method based on problem solving, where objectives and constraints are clearly expressed in the exercises. At the same time, the introductory classes were specialized according to specific curricula (visual communication, product design, and others), and several variants of basic design started to emerge.

In the early twenty-first century some theorists and educators have been reinterpreting basic design [2–4] and proposing it as a key pedagogical approach even in design contexts that are much larger than those faced by the design schools of the twentieth century. In contemporary contexts the designer has to face interaction as an important, if not pivotal, element of configuration. The sensory, cognitive, and social phenomena that a designer should consider are complex and multifaceted. The complexity of the interaction design space can be tackled by thinking in terms of basic interaction phenomena constructively. The fundamental gestalts are the basic, immediate, and inherently meaningful actions of a person, such as pushing, pulling, and shaking [5], that are exploited in interaction. Such gestalts may result from abstraction of actual interactions [6] or be derived from the movement primitives considered in motor sciences [7]. A difficulty is that these gestalts are not properties of objects but are rather emerging properties of user-object interaction unfolding in time. A method of inquiry may proceed by analyzing actions, extracting interaction gestalts, and designing exercises around a specific interaction gestalt [8].

In the context of musical instrument design, Essl and O'Modhrain [9] proposed the grouping of actions according to some shared physical behavior that can be abstracted from the specific physical object. Their PebbleBox described in chapter 6 is a prototypical design of such approach.

Workbenches such as the PebbleBox served the purpose of developing basic design practices in contexts where interaction is primarily mediated by sound. This helped to define basic sonic interaction design as the practice of research through education that is being developed in those schools and laboratories that have prominent interest in the sonic manifestations of objects.

A central problem in basic interaction design is the choice of appropriate raw materials. This is no longer as simple as it was for Albers to experiment with configurations of colored surfaces. And it is not only a problem of choosing an effective toolkit of sensors, actuators, and microcontroller boards. There is often the choice between designing the materials themselves or using readymades and augmenting them with technologies. Although the first choice allows a finer degree of experimental accuracy and a sort of semantic neutrality, the second is often faster, cheaper, and highly expressive. An oscillatory balance between function and expression is found to be important in interaction design practices because it allows an understanding of the expressive features of objects in use while at the same time it elicits new uses, or misuses, of objects [6]. In basic sonic interaction design, sound synthesis models and algorithms are to be considered among the raw materials to work with. They play the same role that colored paper sheets played in Albers's exercises.

Another crucial issue is how to evaluate basic designs and how reliable such evaluations are. The methods of psychophysics and experimental psychology, although valuable and applicable when reliability and repeatability of results are mandatory, are not usually included in basic design practices. An experiment, while being a difficult and time-consuming endeavor, can only help nail down a precise scientific question. That a question of this kind arises as a crucial element in a design process is the exception rather than the rule. Conversely, direct experimentation, shared appreciation, and discussion are invariably present in design practices. This is what makes basic design very close to experimental phenomenology, where the process of knowledge acquisition is distilled in a few selected self-speaking demonstrations [10]. Indeed, introspection and intersubjectivity are the key tools of experimental phenomenology or descriptive experimental psychology dating back to the method of understanding by demonstration advocated by Franz Brentano in the nineteenth century [11]. Basic design and experimental phenomenology, in this respect, both use the practice of shared observation as the only possible way of assessing the properties of objects. The fact that this sharing may include naive subjects may increase the robustness of results. Bozzi [12] proposed the interobservational method, where an experiment is performed by jointly exposing a small group of subjects to the stimuli. Because the members of the group have to agree on a report, problems of outliers and degree of expertise are largely reduced. At the same time, joint observation and discussion contribute to make the description of facts more stable and rich. In the design practice, it is clearly more convenient to let the team of designers play the role of subjects and perform such interobservation. Even though experimental phenomenologists recommend the direct participation of the experimenter without a privileged position with respect to the subjects, a potential bias is recognized in reducing the group of subjects to the students of a class or to just the team of designers. Such bias was clearly present, for example, in the color-shape tests performed by Kandinsky with his students in the Bauhaus [13]. However, a justification for this convenient choice may obviously be found in the difference in objectives between experimental psychology and design.

In interaction design, especially where sound and haptics are important, the dissemination of interactive experiences is problematic. Video examples can sometimes replace first-hand experiences, but discussions around prototypes or interactive sketches are invariantly present in basic interaction design practices. Sometimes, videos can become prototypes themselves, especially to overcome the difficulty of augmenting a prototype object with interactive sound (see section 4.3.2).

4.2 Sensitizing to Sonic Interactions

Whether teaching interaction design within other design disciplines (graphic, industrial, multimedia) or teaching in an interaction design program, these design students do not typically have background knowledge and competence in sound design. A challenge encountered in teaching sonic interaction design to visually oriented students has been to motivate them and enhance their interest in exploring the possibilities offered by sonic feedback.

We first describe different exercises that we propose to the students in order to understand the importance of sound in real and mediated environments. Such exercises range from sound walks to description of sounds in physical objects to sound-only stories. We then describe exercises that are targeted to the development of sonic feedback for artifacts.

4.2.1 Performing Sound Walks

One of the first exercises we propose to students who are not used to working with sound or thinking about sound is to perform a sound walk around a specific location [14]. Sound walks were originally proposed by Murray Schafer as an empirical methodology to identify and describe a soundscape of a specific location [15].

When performing a sound walk, people are asked to navigate in a delimited area with open ears, remembering all the sounds heard. We ask students to perform such exercises in pairs, where one person is blindfolded and the other one acts as the guide.

This exercise has proven to be an ear opener and a good starting point to enhance students' motivation in performing more elaborate assignments. The exercise is always followed by a discussion in the classroom to share the different experiences. These introductory experiences with sounds resemble the practices of sensory training developed by Johannes Itten in the Bauhaus.

4.2.2 Listening and Describing Audio Dramas

Another exercise aimed at enhancing the appreciation of sound is the exposure to audio dramas. An audio drama is a collection of timed non–speech-based sound effects combined in a soundtrack. While listening to the soundtrack, students are asked to associate meaning and create a story. The outcome of this exercise is that students realize that audio-only content, even when not containing speech, can be used to evoke a narrative structure.

One particularly interesting audio drama is *The Revenge*, a radio play without words written and performed by Andrew Sachs in 1978. *The Revenge* was commissioned by the BBC with the precise goal of investigating whether nonverbal sounds can render a meaningful entertainment [16].

4.2.3 Writing a Short Audio Drama

After having listened to existing auditory content, coming either from the real world or from a recorded soundtrack, students are taught to create their own content. This is achieved by asking them to design a short audio drama, involving the collection of content, either from existing sound libraries or generated by the students themselves.

First, students are introduced to the concept of Foley (the process of live recording of sound effects) and Foley artists and are encouraged to creatively record different sonic material. They are then introduced to basic sound-editing tools and allowed to creatively explore how to combine, merge, and transform the available material in order to create a story of about 3 minutes. Once the assignment has been completed, it is followed by a class discussion. Here, some of the students present their productions, and the audience is asked to describe what they hear. The different interpretations of the perceived story are discussed.

This approach can be stretched further by asking actors to perform by following the proposed sound track [17]. The analysis of the performance makes students aware of how sounds affect gestures and how, conversely, gestures may affect the mental representations elicited by sound.

4.2.4 Exploring Audiotactile Interaction

The exercises described up to this point do not include any interactivity. Their main goal is to motivate students to start working with sounds and to get them familiar with manipulating and editing sonic content.

In the following series of exercises, we focus on audiotactile interaction: the tight connection between sound and touch. The first exercise is inspired by an experiment conducted by Lederman and Klatzky [18]. The goal of the experiment was to investigate the ability of subjects to recognize different objects while blindfolded, only using their sense of touch. While performing this experiment, they noted the stereotypical nature with which objects were explored when people seek information about particular object properties. For example, when subjects are asked to recognize the texture of an object, they move their hands laterally; when they seek to know which of two objects is rougher, they typically rub their fingers along the objects' surfaces. Lederman and Klatzky called such an action an exploratory procedure, by which they meant a stereotyped pattern of action associated with an object property. The authors suggest that this way of interacting with real objects should also be adopted when one is designing interfaces based on touch [18].

Our exercise starts by dividing students into pairs. One student is asked to close her eyes while the other student is asked to pick a surrounding object and give it to the blindfolded student. The blindfolded student is asked to recognize both the given object and some of its properties such as weight, material, texture, shape, and size. The person who provided the object is then asked to note which kinds of gestures the other person is performing while interacting with the object. In the second part of the exercise, while the student is still blindfolded, she is asked to identify the different sounds associated with the object. First, the sound-producing gestures are reported, that is, the sounds the student produced while interacting with the object to identify its different properties. Then, all other possible sounds obtained when interacting with the object are identified. As the last part of the exercise, the students are asked to brainstorm on how the given object can be enhanced with other sound-producing gestures, for example, by shaking it or hitting the object. Students are asked to reproduce the sonic interactions between gestures and sounds by using either physical objects or their own voices.

After being "sensitized" to sound through exercises such as those described in the previous sections and through the presentation and discussion of inspirational examples from the field, students can often envision interesting and evocative concepts for sonic interactions. The next section deals with ways to sketch and prototype these ideas easily.

4.3 Sketching and Prototyping Sonic Interactions

Creating interactive prototypes is, in general, a complex task. In the relatively young field of interaction design, a number of methodologies have been developed that attempt to circumvent the complexity of fully functional prototypes yet still answer the need of testing out ideas during the design process. These ideas of “just enough” prototyping, “smoke and mirrors” techniques, and “experience” prototypes are central to the maturation of interaction design as a design discipline (as opposed to an engineering one). They enable students’ focus to move from the technology to the experience it entails in the stages of the process where this focus is needed. Houde and Hill [19] have proposed that prototypes for interactions can address three dimensions: role, look and feel, and implementation, where *role* refers to questions about the function that an artifact serves for the user, *look and feel* denote questions about the concrete sensory experience of using an artifact, and *implementation* refers to questions about the techniques and components through which an artifact performs its function. In these terms, these methods forgo the implementation dimension to focus mainly on the look and feel dimension and to different extents also on the role dimension. Such methods include presenting users with screens made of paper (e.g., Post-its)—a method aptly named paper prototyping—and creating fake prototypes that work by having someone behind the scenes pull the levers and flip the switches, called the “Wizard of Oz” technique.

This section describes two main methods aimed at providing students and practitioners with a means to sketch and prototype sonic interactions and thus to present and discuss sonic interaction concepts before the actual implementation of a working prototype. First, the sketches and prototypes enable the creators to get a feeling of the experience they entail. Second, they provide a means for others to experience them. This enables the creators to perform meaningful observation and receive feedback at early stages of the design process.

The methods described are relevant and useful both as a step in a design process leading to a working prototype (e.g., in a hands-on–type course) and as a final product of a design assignment (e.g., in a more conceptual design course). As an obvious extension, they are relevant for practitioners of design dealing with interactive objects and environments.

The two methods presented enable the description of sonic interactions regardless of their complexity (from simple sonic events to tightly coupled, continuous sonic interactions). This is done by separating the design from the implementation, thus enabling designers to think about sonic behaviors and communicate them to others before (and regardless of) implementation. The two methods are related but to some extent complementary. They can be used in sequence within a project, or only one can be chosen according to the fit of its attributes to the project nature. Both methods are valuable before physical prototyping with interactive sounds.

4.3.1 Vocal Sketching

Vocal sketching involves the use of the voice, along with the body, to demonstrate the relationship between action and sonic feedback. Vocal sketching, in essence, is as simple and straightforward as it sounds: the designer uses his or her voice to produce the sound that would be generated in the sonic interaction. The vocal performance is usually accompanied by some physical action. This "performance" activity is so simple and natural that many vocal sketches are created within conversations without the vocalization being regarded as a sketch. In using it within an educational context, we propose to make this activity more conscious and defined and thus make it more valuable within the design process.

The following attributes of vocal sketching make it a useful tool for the early stages of designing sonic interactions:

Intuitive A testament to the intuitive nature of this method can be found by watching children play with toys. The engine sounds of toy cars, made by the vocal tract, change these—for those involved in the activity—from inanimate plastic objects to powerful vehicles (all the more so for toy guns transformed into deadly weapons). Another rich behavioral reference is the preverbal play between parents and infants: vocal sounds are often used in accompaniment to different forms of movement and action (e.g., a beep when touching the nose).

Available Vocal sketching requires nothing but the willingness to make sounds. Although people differ in their control over their vocal apparatus, everyone can create expressive sounds with his or her voice [20]. Issues of social comfort arise and can be lessened by facilitation methods described later in this section.

Communicative Vocal sketching can be performed alone but is more likely to be used in a group of two or more people. It is a way to describe the sounds that the designer may hear "in her head." However, forcing the sounds out of the head and into a real vocalization obliges the designer to make a specific description and enables a discussion around it.

Group-friendly Vocal sketching is a method that really shines when used by a group as a shared tool to plan and describe a sonic interaction. The group members can use their multiple voices to overcome the limitations of the voice and create multitrack performances. In a workshop setting focused on vocal sketching [21], participants used their multiple voices to describe a temporal interaction in which the sonic feedback changed from disharmony to harmony over time. It is probable that the shared production of a vocal sketch by a whole group increases the commitment of the designers to this solution.

Enactive Vocal sketching is related to body storming, a method of "physically situated brainstorming" [22] in which the designer acts out the design ideas with his or her body or tries to gain insight from a bodily experience that is related to the end user's experience [23]. Especially when vocal sketches are made for tightly coupled interactions, vocal sketching happens in parallel to the body actions that create these sounds.

Vocal sketching poses some challenges; these and some possible remedies are described below:

Social comfort Not everyone is comfortable with making nonverbal sounds to demonstrate ideas. The willingness to do this depends on personality and contextual factors; extroverts will probably be more likely to enjoy this, and people seem to prefer to vocally sketch in smaller groups and with people they feel comfortable with. The main method of alleviating this discomfort has been some form of warm-up activity prior to vocal sketching. This activity should require people to make sounds within a framework that they are not responsible for, such as a silly game with very defined rules. The person hosting this activity needs to give a personal example to set the stage for others. In a workshop setting [21], most participants acknowledged that they felt some discomfort in making sounds. All stated that this discomfort decreased as the workshop progressed. It should be noted that such discomfort is also found when sketching by drawing is considered. Some people consider themselves poor sketchers and refrain from making freehand sketches. However, designers are usually trained at drawing and, in most cases, enjoy showing off their drawing abilities.

Ephemerality Vocal sketches are easily created and easily disperse. However, if a vocal sketch is to become a guiding element in the design process, it needs to be captured, by video for example. Using a technology as simple as a video camera can to some extent take away the simplicity and spontaneity of vocal sketching. Capturing a vocal sketch, however, can be used as a starting point for computational sound models; ways to extract data from vocal sketches are currently being investigated in the community of sonic interaction design [24].

Voice limitations The vocal tract is limited; we cannot make any sound we want. A few obvious limitations are the temporal limitation caused by our breath span, the "single-track" nature of our voice, and the subset of sounds we can produce. Vocalizing in a group can alleviate most of these limitations. Learning to use the voice more professionally can help expand the range of sounds that we can make, as human beat-box practitioners demonstrate extremely well.

No "reality check" Vocal sketching enables high degrees of creativity in thinking about sonic behaviors. The obvious challenges here are the unknown feasibility of the design solutions and the fact that the difficulty of implementation is not a factor in the design process.

4.3.2 Sonic Overlay of Video

We use the term *sonic overlay* to refer to a form of video prototyping in which an interaction is filmed and the sonic elements are added over the footage at a later stage, creating a video of a fake sonic interaction.

Video prototyping has a rich history in the field of interaction design. In 1980, Robert Spence used cardboard models and filmed interaction to illustrate bifocal display as a novel information visualization technique [25]. In 1994, Bruce Tognazzini and his team at Sunsoft created a video prototype to demonstrate their ideas for the new interface design, and the resulting overall user experience, offered by the next generation Starfire computer. This video became an influential vision to the computer of the future. Today many companies such as Microsoft use videos to describe their interaction ideas and visions. Wendy Mackay, Ratzer, and Janecek [26] have proposed that video can be added to a design brainstorming session. In this "video brainstorming" method, participants of the brainstorming session select a few ideas and demonstrate them in front of the camera, creating "video sketches"—outcomes of the session that are easier to understand and remember than text notes.

Video prototyping is also becoming a common practice for design students. Some interaction design education programs have included a special course in video prototyping in their curriculum,[1] exploring the different levels of fidelity that can be used to communicate a concept through video. The ease of editing and sharing video has made video prototypes feasible and useful not only for selling ideas to management but for sharing ideas at many stages of the design process—from very sketchy, low-fi videos shot with a simple camera and no editing to more planned and designed videos with various camera angles, edited effects, and the like.

In their 1990 CHI tutorial on "Storyboards and Sketch Prototypes for Rapid Interface Visualization" [27], Curtis and Vertelney described the idea of using "special effects" to prototype interaction ideas—in their case, printing out screen visuals and using camera effects such as zoom, pan, and the like to simulate interactive screen elements. Somewhat similarly, in our sonic overlay video prototypes, students shoot video and overlay the sounds and effects over it at a later time.

The following attributes of sonic overlay make it a useful tool for the early stages of designing sonic interactions:

Sound-centered Students are instructed to shoot simple videos and focus their efforts on the sonic part of the video. The method is aimed at allowing the student to get an impression of different sound options over a fixed interaction: different sound options can be easily compared, thus sensitizing students to the impact of sound and giving them a tool to test ideas with. Filming an interaction makes the continuous aspects of interaction prominent and can push students to develop sonic interactions that are tightly coupled to actions.

Diverse Sonic overlaying gives the designer the best possible conditions for creating the desired sound. At the editing table, the variety of sonic materials available to the designer can be found or created, be they voice, everyday objects, music, downloaded sound samples, and the like. The sounds can be overlaid with temporal precision because even simple video editing programs provide audio tracks on the timeline. Also useful are the options to easily record over video using the built-in microphone as well as the ability to create multiple sound tracks and thus to easily layer a number of different sounds.

Good communication tool With Web video-sharing platforms such as YouTube, students can bounce ideas back and forth between themselves and tutors with ease; they can even annotate the videos directly. The language of video is highly communicative and easy to understand, and thus, video prototypes can be shown to different stakeholders, and opinions received, during the design process.

Sonic Overlay has some disadvantages, described below:

Nonenactive The greatest disadvantage of this method is the passive experience it entails. Both the creator and viewer do not directly experience the interaction but rather view it secondhand.

Non–real-time Sonic overlay cannot be performed spontaneously as part of a brainstorm or group design session but rather requires the designer to go "to the drawing board." As video editing tools become simple, it may be possible to find methods to use them in more integrated fashions within the design session.

No "reality check" Like vocal sketching, sonic overlay enables high degrees of creativity in thinking about sound. The designers are not limited by their technical skill set;

they are limited mainly by their imagination. This promotes interesting and original solutions. The obvious challenge here are the unknown feasibility of the design solutions and the fact that the difficulty of implementation is not a factor in the design process.

4.3.3 Example: Sound and Pepper—A Project about Adding Information through Sound

This section describes a project developed using the sketching and prototyping methodologies described above as well as a working prototype.

The Context

The Sound and Pepper project was created within a class called "Interaction Design Hands On," at Holon Institute of Technology in Israel. The class (4 hours weekly for one semester) combines students from various disciplines, predominantly design and engineering. The project spanned over 2 weeks and was the work of two students: an industrial designer and a graphic designer.

The Brief

The design brief was to use sound in order to add information to an everyday object. Students were instructed to produce a sonic overlay in the first week and a working demo in the second week.

The Concept

During the initial brainstorming, the students reviewed daily activities of an imaginary person, moving from the bedroom to the bathroom and on, going over mundane actions and the information that might enhance them. This process brought them to the kitchen and to the activity of cooking. Using the boiling kettle as an example, they sought to add information to the spice containers. They identified two opportunities: giving each spice a sound, such that the right container can be identified without looking at it, and giving an indication of the amount of spice poured into a dish, to enhance the feedback and prevent overspicing.

The Process

A video prototype was produced to explore and communicate the concept. One of the students was filmed in her kitchen, stirring a dish and shaking different spice containers before selecting one and pouring spice into the dish (figure 4.1). This video was overlaid with a new soundtrack in which each shaking and each pouring action was

Figure 4.1
A video prototype of the Sound and Pepper project.

accompanied by a sound. Although the sounds were not precisely placed and were not yet chosen with coherence (one spice gave a liquid sound, another a musical sound, another an everyday grating sound), the video was very successful in communicating the concept and convincing the designers, their teachers, and co-students of its value.

A discussion of the sounds of different spices was the next step, with the students analyzing the character and characteristics of each spice. Two main methods were used. The first was an association game in which each student gave keywords related to the spice (e.g., for cinnamon: belly dancers, orientalism, bells; for salt: crystals, glass). These associations were often visual, sometimes conceptual, and sometimes auditory. The second method was vocal sketching, predominantly to portray the relationship between the shaking action and the sounds. For example, for pepper, the sound associated with the grinding action in a pepper grinder was performed vocally. The keywords generated from this process were used to find sound files on the web. A collection of sounds was made for each spice, and the best was selected and trimmed.

The Final Deliverable

A working prototype was produced in a 1-week process. Five spice containers (salt, pepper, cinnamon, chili, and paprika; figure 4.2) were embedded with mercury switches for detecting pouring motions, and light sensors for detecting a hand passed over the container. These were connected via an input-output board to the PC. When a hand was detected over the spice, the sound of the spice was played once. When the container was shaken, the same sound was generated with every shake, making the sounds play over each other. This most simple solution, in implementation terms, proved effective. The spice sound texture became more dense with every shake of the

Figure 4.2
A prototype of the Sound and Pepper project.

container. An epiphenomenon was that when the shaking was stopped, the sound slowly faded, as though in parallel to the small cloud of spice dispersing in the air. Although this prototype was limited in many ways (by cables coming out of the containers, by the feedback related not to the actual amount of spice but to the shaking behavior), it worked, with real spices in the containers enhancing the experience.

Evaluation

A large number of people tried the prototype in an educational setting: an "open house" in the lab and an exhibition of the final course. This enabled a meaningful amount of feedback on the concept and the protoype, which was largely enthusiastic. The prototype was also filmed in a kitchen setting, and this video was posted to YouTube (http://www.youtube.com/watch?v=zF_3ZlpxiZk). The project also attracted media attention and appeared on TV and radio. However, the prototype was not evaluated in the real setting of a kitchen due to lack of time. In this sense, the project can be seen more as a "sensitizer" and primer toward SID than as an attempt to build a real product. The use of sonic overlaying on video proved an extremely effective way to work in this project in that it got the designers focused and committed to the concept early enough to enable the creation of a working prototype.

4.4 Problem-Based Learning and Sonic Interaction Design

The problem-based learning (PBL) approach is a pedagogical method adopted at Aalborg University to introduce students to projects in sonic interaction design that last a full semester.

Historically, PBL started in the early 1970s at the medical school of McMaster University in Canada and was slowly adopted by different faculties worldwide [28]. PBL can also be traced back to the problem-solving approach described in section 4.1.

In PBL students are active learners and collaboratively solve problems while reflecting on their experiences. The instructor in this approach is considered mostly as a facilitator who helps students solving the problem. PBL becomes interesting when a variety of disciplines need to be incorporated to address a problem, which is clearly the case in sonic interaction design.

Problems are chosen by the students themselves and structured in such a way to be able to integrate and apply knowledge from different disciplines. This also allows students to realize connections among disciplines and promote carryover of knowledge from one discipline to another. In this way, PBL is a method that facilitates transdisciplinarity, defined as the ability to start from a problem and, using problem solving, bring the knowledge of those disciplines that contribute to the solution.

Most of the problems addressed by students are transdisciplinary by nature in that they start from a given question and use several disciplines to address it and solve it. PBL projects require a high level of social, communication, and cooperative skills among students. These skills are in high demand in professional work. Given the high amount of workload a project requires, usually the final results are very satisfactory, and learning can be effectively measured. PBL has proven to be particularly suitable for education dealing with design of interactive systems [29] and multidisciplinary settings [30].

As also observed by Schultz and Christensen [29], PBL is a valid methodology for approaching interaction design projects, especially for the possibility to explore, analyze, and define the problem space, the importance of teamwork and team development, and, eventually, to find a solution to the given problem. The problem space, domain, and context have to be analyzed, and problem definition and requirements need to be defined. Team members have different roles, which must be clear to all. In teamwork both interpersonal and intrapersonal skills [31] are important.

A related pedagogy of sonic interaction design, albeit based on workshops taking a few days of collective practice, has been developed by Hug [32]. In particular, he uses filmic materials to extract narrative metatopics or abstractions of narrative fragments. Each metatopic is assigned to a group, which develops a project around it. Narrative and performative elements are shown to emerge and combine both at the analysis and at the prototyping/demonstration stage.

4.4.1 Example: The Soundgrabber—Combining Sonic Interaction Design and PBL

The Context

The Soundgrabber installation (see figure 4.3) was created during the fourth semester of the medialogy education at Aalborg University in Copenhagen. The Soundgrabber represented the final project of the semester, in which courses in audio design, physical interface design, measurement of user experiences, and sensors technology were offered.

The Brief

The Soundgrabber installation investigated the following problem: Is it possible to make sound tangible by means of an intangible user interface?

The Concept

The aspiration of this project was to challenge the physical impossibility of designing an intangible installation that creates the illusion that people are tangibly interacting with sounds.

The Process

A group of six students worked on this project. Students were all enrolled in the medialogy program, but their main interests ranged from programming, graphical interface design, interaction design, animation, and audiovisual effects.

The design of the Soundgrabber went through several iterations before reaching the shape shown in figure 4.3. The first prototype was made of carton boxes, and was built with the mere purpose of testing the possibility of grabbing sounds and moving them around in space. All prototypes were created using the Max/MSP software platform for the auditory feedback. One of the last prototypes had also visual feedback in order to help the user to locate the position of the sounds. However, the visual feedback distracted the user from focusing on the audio and pseudohaptic experience, so it was not used in the last prototype.

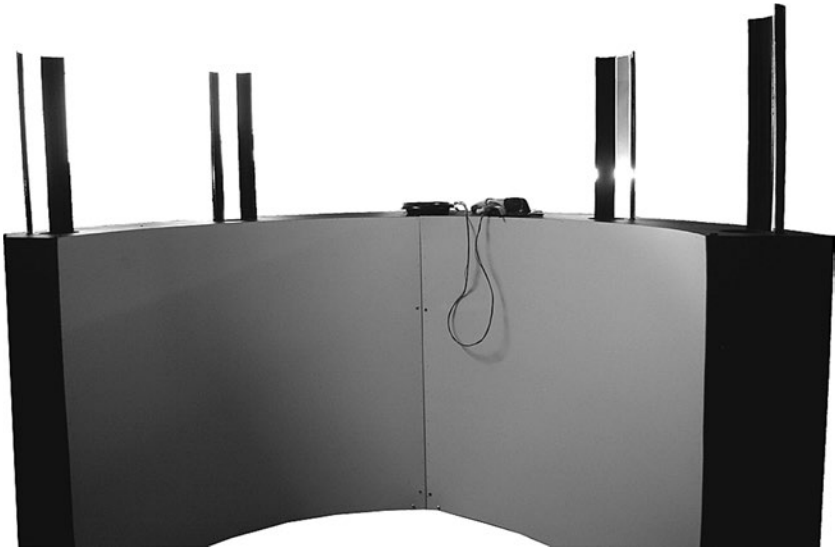

Figure 4.3
The Soundgrabber in use at Sound Days in Copenhagen, 2008.

The Final Deliverable

The Soundgrabber is a physical interface designed as a semicircle. At the top of the semicircle, four columns are placed. At the bottom of each column a speaker is installed. Each column is embedded with light sensors that allow it to detect the position of the hand of the user moving vertically parallel to the column. Moreover, a bucket is placed in the center of the semicircle. The user interacts with the Soundgrabber using a glove embedded with a bend sensor. By bending the hand inside the bucket, the user is able to grab a sound, listen to it (thanks to the speaker embedded inside the glove) and release it in one of the columns.

Evaluation

In order to evaluate if the installation answered the problem formulated, the Soundgrabber was evaluated by allowing users to play with it and then answer a questionnaire inspired by the sensory substitution presence questionnaire [33]. In such a questionnaire, statements such as “I felt that I was able to grab a sound” or “I felt that I was able to relocate the individual sounds” were made, and subjects were asked to answer in a scale from 1 to 5 if they agreed or not with the statement. Results showed that the sensory substitution between audition and touch worked because there was a statistically significant number of subjects who felt they were able to move sounds around and grab them.

4.5 Physical Prototyping with Interactive Sound

How do product designers approach the design process? They start by sketching with paper and pencil. They produce many sketches and compare them. They use sketches as generators of thoughts. Then they build mockups that can give a physical impression of the product and even allow a limited form of experience in use. Mockups must be developed quickly, and they must be cheap and easy to abandon. Then there are prototypes that allow a full experience and a more complete evaluation. Prototypes could be evolved into products.

Nowadays, products can include visual, haptic, or auditory displays. Via an auditory display we can actually mold the acoustic behavior of objects to be passive (responding to actions), active (stimulating actions), or continuously coupled with actions.

In a pedagogy of sonic interaction design, the connection between gesture and sound is further investigated by testing basic sonic interactions in physical realizations. This goal is achieved either by extending everyday objects with sensors or by creating novel sonic objects. Students are provided with a palette of basic sensors together with a microcontroller to acquire the sensors' data. As basic sensors, students have the possibility to use buttons, pressure sensors, tilt sensors, and accelerometers. They are also introduced to tools that make it possible to perform basic sound synthesis and processing in real time. An exercise of this kind takes usually 3 or 4 days, divided into an introduction to the technology used, both for the sensors and the sound part, development and implementation of ideas, and presentations of final results. By the end of the 3- or 4-day workshop, students usually acquire a basic understanding of how to design novel objects embedded with sensors.

4.5.1 Sound Models

As emerging from the exercises described in section 4.2, the sounds of everyday objects are immediately associated with events or processes. We may distinguish between basic acoustic events and temporal organizations of continuous or discrete signals. If such organizations have some temporal regularity, we call them textures. If a designer wants to augment an object with a sonic indicator of action (or sonic affordance), events, processes, and textures are the classes of sound that should be considered. Methods and tools inherited from the field of sound and music computing [34] are readily available for the designer. However, further research is needed in interaction-centered sound modeling for the goal of designing better sounding objects and environments [35, 36].

The palette of sound synthesis methods is quite large [37], although they are not equally suitable for prototyping interactive artifacts. Abstract synthesis methods, such as frequency modulation, were introduced as an economical means to produce rich musical spectra but are not very suitable for contemporary product sound design. They would produce, in most cases, abstract sounds that are difficult to relate to events, processes, forces, and dynamics. Some general principles of frequency modulation and nonlinear distortion are, however, still useful, especially at the stage of dynamic processing of sound. For example, making a sound spectrally thicker by modulation is an easily conceived thing to do.

Additive synthesis is certainly rich and easy to think of, but it goes against the goal of economic representations of sound, as each sinusoidal component must be specified in its temporal behavior. Still, sinusoidal modeling is most easily coupled with sound analysis, so that resynthesis with modifications becomes one of the most effective ways to approach auditory displays. A designer could start from recordings, even of vocal sketches or other forms of imitation, derive a noise plus sines plus transients model [38], and process this material in its components. The challenge with this kind of processing is to have transformations that are meaningful to the designer. For example, if I record a water drop in a sink, I would like to make the drop bigger, or the liquid denser, and these transformations can be nontrivial if expressed through a sinusoidal model.

The subtractive synthesis model, including linear predictive coding, is useful for timbral transformation and sound hybridization. It makes it possible to preserve the temporal articulation of sound processes as it is captured by a recording, for example of a vocal imitation.

Sometimes the designer is faced with the problem of devising a sound process that does not sound repetitive and has relatively constant long-term characteristics. Many natural phenomena such as fire or water flow have such textural character, and they can afford sustained listening without inducing fatigue. Special techniques are required to synthesize convincing sound textures without using overly long recordings. Again, linear predictive coding is one of the enabling techniques for texture generation, together with wavelet decomposition and tiling and stitching of samples [39].

Thinking of sound as a side effect of physical interactions allows the organization of basic events, processes, and textures into hierarchies that also have a strong perceptual basis [40]. Sound synthesis by physical modeling is the natural framework to exploit such organization, from elementary events such as impacts or drops to complex processes such as rolling.

4.5.2 Software Tools

The repertoire of software tools that can be used to make sounds with numbers is very large [41]. Most of them, however, have been designed for musical use. So we have software applications for recording, composition, and performance.

In sonic interaction design, the focus is mainly on what has been called procedural audio [42]. This is the possibility of generating sound algorithmically, using some sound synthesis method, and of relating such generation to the events and processes as they are captured by a set of sensors. Among the software available for procedural audio, which are the programs that are so rapidly accessible as to become sketching tools in the hand of the designer? There is no definite answer to this question, as it heavily depends on the designer's background. Some languages and environments, such as SuperCollider, are enablers of performing practices such as "live coding," which can be considered as dynamic production of code sketches that have immediate audible effect. Actually, if the designer becomes proficient with an audio-oriented programming language, the production of sonic sketches can become faster than what is achievable with any other means. Nevertheless, most interaction designers show their legacy with visual design in preferring visual languages and environments such as Puredata or Max/MSP. The latter is the only software for audiovisual interaction that is mentioned in Buxton's book on sketching user experiences [43]. Several sensor boxes are available on the market that come with software modules that are ready to be used in Puredata or Max/MSP patches, and this gives the designer an effective toolbox to produce interactive prototypes relatively quickly.

Although the aforementioned tools embed general-purpose languages and give the freedom to produce virtually any sound, in many cases it makes sense to use specialized tools. For example, sound for interaction sometimes requires the composition of scenes or sonic tapestries. For this specific purpose, Misra and colleagues developed software for texture generation and transformation [44].

Between the specific and the general are those systems that make it possible to represent a wide range of phenomena within a consistent frame. An example is the Sound Design Toolkit [45], a set of software modules for Max/MSP that rely on the accurate physical modeling of basic physical phenomena (impact, friction, bubble) to construct a hierarchy of events, processes, and textures that are easily described in terms of interaction with everyday objects.

4.5.3 Example: The Sonified Moka—An Exercise in Basic Sonic Interaction Design

A basic design exercise on the theme of screw connections, quite compelling in terms of interaction, was developed at IUAV in Venice [46]. It shows how physical prototyping can be combined with sound modeling while maintaining a focus on the direct experience of interaction.

The Context

As part of design education at the graduate level at IUAV, the exercise is part of a series of workshops aimed at extending the basic design methods to interactive contexts, as explained in section 4.1.

The Brief

The exercise was formalized into three components:

Theme Continuous feedback for mechanical connections.

Objective Design the feedback for a screw connection, such as found in the moka, in such a way that the right degree of tightness in coupling can be easily reached.

Constraints The feedback should be continuous, nonsymbolic, immediately apparent (or preattentional), and yet divisible into three clear stages.

The Concept

The purpose of the exercise was to explore the effectiveness of sound in guiding and conditioning continuous manipulations of objects.

The Process

A solution to this exercise was found by adapting a physics-based sound model of friction, which gives rise to a wide palette of timbres. Depending on the vertical force exerted by an object sliding on a surface, the sound can range from a gentle noise to a harmonic squeak to a harsh and irregular grind. The transition can be made gradual, yet the three different qualities of coupling (loose, tight, too tight) can be clearly perceived. The effectiveness of this gesture sonification largely depends on sound design choices, such as parameter mapping, range of parameter values, and temporal articulation of sonic events.

The Final Deliverable

The chosen sound model was applied to a moka augmented by a force sensor that was giving a continuous measure of the tightness in coupling.[2]

Evaluation

Evaluation is an intrinsic part of the basic design process. The various design solutions were readily compared through direct object manipulation, and group discussion made it possible to develop a consensus on reported phenomena and to highlight possible problems [46]. For example, the degree of expressiveness afforded by the sonic object was such that interactions turned playful, performative, and even extreme, thus challenging the robustness of the prototype.

4.6 Conclusions

We have presented a collection of methods and tools ranging from general to specific, wide to narrow, easy to laborious, and so on. These methods can obviously be used together, and in fact in our teaching practice this is usually the case.

For example, the strengths and challenges of the vocal sketching and sonic overlay show that they are to some extent complementary: vocal sketching is quick, low-fi, and transient; sonic overlay is slower to make and higher in finesse. A good option is to combine them. In our teaching, students use vocal sketching in a group brainstorming session to reach initial ideas for their sonic projects. They then present their initial design ideas in class using their voices. This performance is captured by one of the group members on camera. After this activity, students are asked to use the vocal sketch and captured video as a base for a more elaborate sonic design to be presented in the next lesson. The students overlay the video with new sound options, creating more elaborate sound designs to be presented and discussed in class. In this process, the experience and sensibility acquired during training sessions such as those described in section 4.2 are highly valuable. A natural next step is to use the video prototype as a reference and guide for the implementation of a working prototype.

One of the big challenges in creating a framework for the pedagogy of sonic interaction design is the breadth of contexts in which this topic is taught and applied. General design programs may want to introduce sound design in a short workshop; graphic design programs may strive to equip students with tools for introducing responsive sound to visual interfaces; product design programs may search for ways to make students aware of the potential of sonic feedback in digital products; and interaction design programs may require a more complete set of skills for the sonic domain. From the "other side" of the educational map, sound design programs may search for ways to help students move from the design of fixed sounds to the design of responsive sound; composition and computer music programs may want to introduce students to this potential field of application for their skills; computer science programs with a focus on human-computer interaction may want to create awareness to this design topic, and the list goes on. Each of these disciplines has a different set of terms, different needs, different skills, a different angle. It is our hope that this attempt to group together an initial collection of teaching methods can contribute to a sharing of knowledge between educators and to the further development of awareness of sonic interaction design.

Notes

1. Video Prototyping, Copenhagen Institute of Interaction Design, http://ciid.dk/education/portfolio/idp11/courses/video-prototyping/overview/.

2. Basic sonic interaction design Web site, http://soundobject.org/BasicSID/.

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