Sonically Augmented Artifacts: Design Methodology Through Participatory Workshops

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Abstract. Participatory workshops have been organized within the framework of the ANR project Legos that concerns gesture-sound interactive systems. These workshops addressed both theoretical issues and experimentation with prototypes. The first goal was to stimulate new ideas related to the control of everyday objects using sound feedback, and then, to create and experiment with new sonic augmented objects. The second aim was educational. We investigated how sonic interaction design can be introduced to people without backgrounds in sound and music. We present in this article an overview of three workshops. The first workshop focused on the analysis and the possible sonification of everyday objects. New usage scenarios were obtained and tested. The second workshop focused on sound metaphor, questioning the relationship between sound and gesture. The last one was a workshop organized during a summer school for students. During these workshops, we experimented a cycle of design process: analysis, creation and testing.

Keywords: Workshop · Design · Sound synthesis · Interaction · Rehabilitation

1 Introduction

The ANR project Legos[1] aims at studying how users learn gesture-sound interactive systems, and modify their movement and action over time with sound feedback. Three areas of application are considered: new digital musical interfaces (DMI), rehabilitation and sonic interaction design (SID).

Through these three areas, the action-sound relationship is assessed on different levels: expressiveness and sound control (DMI), movement control and movement quality when guided by an audio feedback (rehabilitation) and quality of the object manipulation by a user in an interactive context (SID). The project is based on experimental approaches and workshops in order to generate an interdisciplinary expertise in design, motor control, sound synthesis and cognitive sciences.

[1] http://legos.ircam.fr.

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We seek to develop novel methodologies for the gestural interfaces design by analyzing and comparing the experimental results of the three mentioned areas. Concerning sonic interaction design, we wanted to study experimentally how a dynamic sound interaction may improve the manipulation of everyday objects in terms of control, learning and user experience.

In this paper, we will first introduce the field of sonic interaction design. Then, the goal of the workshops and the methodology will be presented. Finally, the three different workshops will be detailed.

2 Sonic Interaction Design: A New Play-Ground for Designers and Researchers

Sonic Interaction Design is an active field that "emerged from the desire to challenge these prevalent design approaches by considering sound as an active medium that can enable novel phenomenological and social experiences with and through interactive technology." [8, p. 1]. The idea is to think about the design of sonic feedback, especially continuous interaction, to extend classical human computer interfaces HCI or digitally augmented devices. Interactive Sound Design or Sonic Interaction Design as it is named in the network of reference European COST Action SID IC0601 focuses on the relationship between a user and a system in an active and dynamic process.

Different interactive objects have been developed integrating a dynamic sonic component which allows for facilitating and guiding gestures and actions. Thus, this should allow for improving performance, promoting learning and strengthening the emotional dimension of an object *a priori* silent. These objects have been developed for experimental setups (for design and/or artistic performances) but also to study sound perception in an active process in terms of performance, learning, emotional and aesthetic dimensions.

2.1 Sonic Interactive Objects

The Shoogle [31] proposes new ways of interacting with a mobile device through sound by shaking, tiling or wobbling it. With these explicit actions, different scenarios have been proposed: when the user shakes the mobile device, long messages are associated with metallic sounding balls and short messages with glassy sounding objects.

Grosshauser et al. [9] developed a prototype to study the interaction loop between a human user and a tool in operation like a drilling machine. The authors worked on the sonification with pulsing sounds to make audible when the drilling machine is in the right position either horizontally or vertically, generally at a 90° angle to the wall while drilling and screwing[2].

O'modrhrain et al. [3,20,21] have worked on the integration between sound and touch through three different prototypes: the Pebble Box, the Crumble-Bag and the Scrubber. The PebbleBox is constructed as a wooden box, which

[2] A demo S.5.4 Chap. 5 is available at http://sonification.de/handbook/.

contains a layer of polished stones. When the users manipulate the stones, granular synthesis of natural sound recordings provide different collision sounds that change the relationship between action and sound but retaining the core physical dynamics of the original link.

Sonically augmented objects have been also used to test the hypothesis that a gesture can be intuitively and spontaneously adjusted when an associated sound recall the action (i.e. the sound appears as resulting from the action) For example, Rath et al. [25,26] have developed the Balancer corresponding to a very simple interface consisting of a wooden fence that participants could tilt. The manipulation of the interface controlled a synthesis model simulating rolling a ball along a guide. Using a model of virtual ball, users were informed of its position and velocity as a visual or audible feedback, and were able to control the virtual ball.

Another object is the Spinotron, which consists in a vertical pump [14]. The pumping action rotates a virtual gear, which is synthesized by the clicking of a physical impact model. Then, we investigated whether the sound of the gear can guide the handling of the device to perform a specific task. The task was to achieve a given rotation rate by pressing the device with and without audio feedback. The influence of the feedback was examined by assessing learning in twelve successive tasks. Results show that, while participants have said they were not helped by the sound, the performance significantly improved by the presence of sound.

All these results highlight the positive influence of the sound feedback during an interactive process with a tangible object, and show that sonic interaction design is a relevant exploration field to develop.

2.2 From Human Computer Interface to Sonic Interaction Design

Traditional Human Computer Interaction deals generally with the interaction of graphical objects on a screen via a mouse or directly in the case of touch screens.

The use of tangible objects/interfaces induces different paradigms by shifting the attention to the action operated on the physical objects.

In particular, new interactive devices enable the use of sound feedback to inform users on their gestures. Typically, objects are instrumented with sensors and micro controllers for controlling real-time sound synthesis that reacts to the manipulation of the object. The objective is then to establish a dynamic interaction between a user and the object, taking into account the sound dimension. The manipulation of the object produces sounds, which in turn influence the handling of the object.

Our claim in the context of sound design is that the necessary information is in part "available" in our environment, and in addition, exploration of our environment allows to revealing questions and problems about everyday objects: "Attention to what constitutes daily life and a dynamic exploration of the immediate environment, not only enable a better understanding of the world, but enrich the perception, construct logical meaning and sharpen critical thinking" [16].

3 Goals of the Workshops and Methodology

By organizing workshops, we wanted to create case studies in order to frame the project for the three areas of applications (Sonic interaction design, the digital musical interfaces and rehabilitation) by brainstorming and experimenting. Two workshops were addressed to the different members of the project and the last one to students from the "Human computer confluence" summer school[3].

3.1 Goal of the Workshops

The schedule and the content of these workshops correspond to an approach that summarizes the design process cycle of a new product (artifact or service) that we often find in industrial design [23].

The different steps of a new product creation can be divided into four stages: requirements/analysis, design/creation, development, and testing [15]. During the first steps, requirements and analysis are provided by experience or by more formalized approaches (usability testing, user feedback, ...). During the design/creation part, requirements are integrated to propose new ideas during sessions of brainstorming, prototyping, and analysis of existing solutions. This part has been formalized as the conceptualization of ideas (sketches) and the embodiment of the concept (prototypes) [13]. Generally the different solutions are tested in a context of use. It is an iterative process. The development part is the transfer of design requirements and specifications in the formalization of the product. The product is tested with target users to ensure that the product is in line with expectations. All these process could be linear or iterative depending on the project.

During these workshops, we focused on the three stages: analysis, creation and testing for specific usages. The idea was not to develop a final product (the development and testing phases with target users), but to develop experimental prototypes that can be share across the three different fields.

This general approach was used to organized the three following workshops:

1. Usage scenario analysis. Scenario development of the use of everyday objects incorporating a reflection on sound design.
2. Sound metaphor creation. Work on sound metaphors, questioning the relationship between sound and gesture, using the concept of basic actions and the work on the sound synthesis engines.
3. Embodied Interaction and Sound: Object Sonic Interaction. "Human computer confluence" summer school.

For the first workshop, the goal was to analyze usage scenarios integrating dynamic sound design, with the "objects" as the starting point. The second workshop was focused on sonic interaction design, with the "sound" as the starting point. The first workshop allowed us to concentrate on how the sound can contribute to the user experience of an everyday object and the second workshop

[3] http://hcsquared.eu/summer-school-2013/lectures-workshops.

to think about the sound gesture relationship within the context of interaction with objects. With the last workshop organized during the summer school HC2, we formalized a framework for participatory workshops that addresses these different topics.

Before presenting a summary of these different workshops, we introduce the participatory workshops.

3.2 What Can We Learn from Participatory Workshops

The theoretical framework of these workshops stems from our participation to the European CLOSED project[4] and the COST Action SID Sonic Interaction Design [8]. Under these projects, different workshops [6,7,29], were organized and have helped to develop a framework, in the spirit of participatory workshops [30] to generate creative, new ideas in interactive sound design context.

A methodology has been established to help the designer generate new scenarios from everyday objects by analyzing them in terms of functionality, contexts of use, associated actions, and existing sounds. Participants are encouraged to hybridize different features, associated actions and contexts of use taken from different everyday objects. The aim is to stimulate the creation of new scenarios of sonic interaction design. During these sessions, participants think together and share experiences during practical exercises.

Practical exercises are diversified, including "speed dating" [2] (generation of ideas in pairs over very short time periods regularly changing partners to promote stimulation), "body storming" [22] (playing active situations with objects to test scenarios), or "sound drama" [12] (the scenarios are staged with objects using audio post-production). This approach can be complemented by prototyping through sensors associated with micro controllers (such as Arduino[5] or Modular Musical Objects[6]).

For our workshops, we used this framework by integrating the different skills of the project members: theoretical background on sound-gesture relationship, hardware and software for motion capture, different approaches to sound synthesis (physical modeling, synthesis based on acoustical descriptors, ...). These different skills gave us the opportunity to prototype the different ideas and to confront them. The workshop organized with external participants (HC2 summer school) represented the opportunity to apply our methodology (analysis, ideation, prototyping and testing).

4 Usage Scenarios of Everyday Objects

4.1 Bring an Object with You!

The aim was to create experimental prototypes to explore how sound can change the interaction experience with everyday objects. Our work was based on the

[4] http://closed.ircam.fr.
[5] http://www.arduino.cc/.
[6] http://interlude.ircam.fr/.

analysis of everyday objects [18,23] in order to propose new user experiences integrating dynamic sound design. The workshop goal was to discuss and propose user cases of everyday objects augmented with sonic interaction that can be applied in different applications, from digital musical instruments and to rehabilitation.

This workshop was held at Ircam[7] in June 2012. The first day was dedicated to the generation of scenarios and the second day to the prototyping of these scenarios with augmented objects. Before the workshop, participants were asked to bring one or two small objects. The choice of the object was set to follow the following rules: simple manipulation with one or two hands, in contact (or not) with another object or support, associated to a specific function and purpose. The first object is supposed to give satisfaction to the user in terms of use. The second object is on the contrary supposed to represent some difficulties (difficult to hold and with a difficult task to achieve).

We introduced the first day to participants the different goals of the workshop. After this introduction, each participant presented their objects and explained their choices.

Grid for Analyzing Objects. We built an analysis grid, in order to analyze everyday products, and propose an extension of the user experience with sound design. This grid reflects part of the analysis of aesthetic components of a product in industrial design (harmonic, functional, cultural, technological and social factors) [23] but also more general approaches concerning the analysis of a product: the function of a product; the form of a product and the use of the product [18].

Participants were grouped in pairs to analyze the different objects using a grid:

– Object description: form, size, material, grip.
– Use: context, primary and secondary functions.
– Action on the object: descriptions, interaction with a support or with an object.
– Experience with the object: positive and negative.

Then, we selected a few objects to build scenarios that integrates sound feedback. The second day, we prototyped the selected scenarios with augmented objects, separating participants into two groups of five participants. At the end of the day, each group presented their works.

4.2 Analysis and Selection of the Objects

Participants brought several objects following the instructions given to prepare the workshop. Each participant explained the objects they brought. This first

[7] Participants: Sara Adhitya, Frédéric Bevilacqua, Eric Boyer, Florestan Gutierrez, Sylvain Hanneton, Olivier Houix, Jules Françoise, Nicolas Misdariis, Alexandre Panizzoli, Quentin Pyanet, Nicolas Rasamimanana, Agnès Roby-Brami, Patrick Susini, Isabelle Viaud-Delmon.

round was also intended to involve participants in a participatory framework. These objects were varied: a screwdriver, wooden and plastic citrus presses, a tea infuser, a razor, an apple corer, a rechargeable lamp, keys, a squeegee, a spinning gyroscope with its launcher, matches, a spirit level, a saw, make-up, a sponge, a clothespin, an alarm clock, a lighter, a jam jar, a coffee plunger and a measuring tape. Some objects were difficult to use or manipulate or had a baffling design. Other objects were acceptable, often used in our everyday context and elicited positive emotions during their use.

Participants were then placed in pairs in order to describe the selected objects using the analytical grid (Sect. 4.1). We asked them to highlight the negative and positive aspects of the objects both in terms of ergonomics, design, use and manipulation.

Finally, we focused on the negatives aspects highlighted by the participants. For example, the jam jar was difficult to open and manipulate, the regular movements of the spinning gyroscope were difficult to master, and the spirit level required difficult control which needed visual feedback difficult to maintain.

After this step, participants selected objects to generate scenarios focusing on usage problems. Thus, the different problems encountered were organized when using objects to sample our selection. These categories were: problems of grasping, problems of coordination or adjustment of the action, problems of design, manual or bi manual manipulation, manipulation without visual feedback, signage problems without interaction, reversed tools (for example, pressing the infuser tea to open it). The selected objects and the associated problems were:

- The jam jar and the measuring tape (Bi manual manipulation).
- The spinning gyroscope, the sponge and the squeegee (Adjustment of the action).
- The rechargeable lamp (Signage problem of the charge level).
- The spirit level (Need of visual feedback).

4.3 Imagine New Scenarios of Use

Participants worked in parallel in two groups. While one group worked on a set of objects for 30 min to provide usage scenarios, the other group proceeded in the same way on the other objects. Then the two groups exchanged objects and continued brainstorming for 30 min in the same way. The participants used simple ways to illustrate their scenarios (gestures, vocalizations, paper - pencil, ...). In a second phase, the two groups met in the same room and shared scenarios. The participants presented their ideas that were analyzed and discussed. The main ideas concerning the four objects were then summarized. A selection of scenarios are presented below.

The Jam Jar. One group proposed the sonification of the closing sound of the jam jar in order to be optimal, i.e. not too strong and not too loose.

This idea was related to the work done by Rocchesso et al. [27, 28] on the moka[8]. Another proposition was the use of two beating sounds, like the tuning of a guitar, to prevent strong closing. Other ideas were related to the idea of giving a relationship between the container and contents.

The Spirit Level. The general idea was to enable the "reading" without visual feedback in the case of the user not being in front of the spirit level. The sound could give the necessary information about the direction of the inclination. The natural metaphor of the rain stick was proposed, in reference to the sound installation "GrainStick - 2.0" by Pierre Jodlowski[9]. A possible extension was the hybridization between the spirit level and the measuring tape (rattle sound for giving information about the measured distance).

The Spinning Gyroscope. The participants struggled to run the spinning gyroscope. Its use was not particularly intuitive when starting the rotation of the spinning. Two proposals were made for its use: for relaxation and meditation like the Chinese health balls without launching and for triggering different sound worlds depending on the type of movement. The other group studied the manual mechanism to launch the spinning gyroscope. They noted two main movements: the movement of the wrist in order to move the launcher and the rotational movement of the spinning gyroscope on its axis. The movement of the launcher could be two points instrumented to retrieve information on the move. Two different sounds may be associated with the wrist and spinning gyroscope. The idea was to phase these two parameters for the gesture and action when they were optimal.

The Squeegee. Analyzing the use of the squeegee sheet glass, various control parameters are listed: the inclination of the head of the squeegee, the normal pressure on the surface, the path and the flow velocity. These parameters can also be similar to the use of a razor. Another track is to explore the sonification of the error in the control of the squeegee (the following parameters) rather than the whole gesture. For example, if we consider the pressure on the surface, too much pressure may be associated with a squeaky violin sound. The object does not present special problems of manipulation, but the goal of sonification in this case is to be aware of the movement.

Summary. During this step, participants have created scenarios for these objects by integrating a reflection on the use of sound to improve or expand their uses. Following the discussion about the different scenarios and discussions, we selected two objects (The squeegee and the spinning gyroscope) to deal with the scenarios in depth and make them interactive.

[8] http://vimeo.com/898836.

[9] http://brahms.ircam.fr/works/work/27276/.

4.4 Prototypes

Two groups were formed to work specifically on scenarios using the spinning gyroscope and the squeegee window. The goal is to prototype the scenarios by instrumenting these objects using sensors associated with sound synthesis softwares.

Fig. 1. Working group on the spinning gyroscope (1). Participants instrumented the launcher (2) and the wrist of the user (4) using sensors MO [24] to sonify the movement (3).

The Augmented Spinning Top. At first, the participants discussed how to obtain the best movement with a minimum of effort. The optimal motion was identified to be to a small dry tilting of the spinning top in order to begin the rotation mechanism. This movement gives enough energy to the spinning, allowing a first cycle and rotation. They observed that participants who were unable to produce a rotational movement, produced more erratic movements of the wrist. An imagined solution was to optimize the gesture by sonifying two parameters: the movement of the wrist (as a fixed angle), and the frequency of the spinning top due to its frequency rotation. The group was able to demonstrate a prototype of the spinning top accompanied by sensors placed on the wrist and the spinning top (see Fig. 1). When the user plays with the spinning top, he/she received a sound related to his/her gesture with the sound becoming more "rough" when the movement deviated from the optimal movement. An extension of this work could be the sonification of the phase difference between the movement of the wrist and the spinning top rotation so that the user can correct his/her gesture.

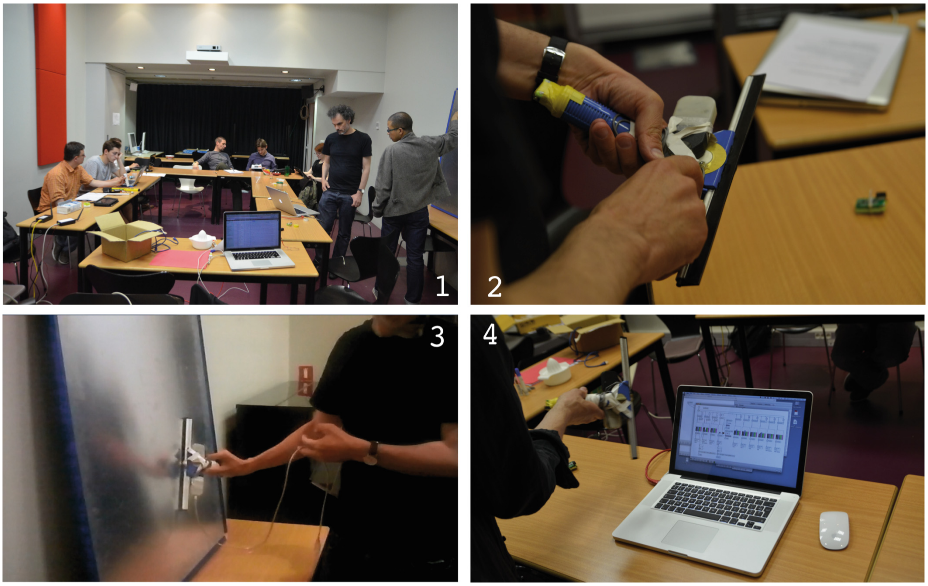

Fig. 2. Working group on the squeegee window (1). Participants instrumented the squeegee using sensors MO [24] (2), and have tested different movements (3) and different sound engines to sonify movement (4).

The Augmented Squeegee. First, participants observed different window cleaning techniques to understand the different movements. By testing themselves this technique on a surface (see Fig. 2), the sequence could be broken down into a succession of repetitive actions (a linear trajectory followed by a rapid rotation to change direction). A first observation was made: it is difficult to keep a fluid gesture during the successions of the linear path followed by the rotation and that this requires training.

To better understand the various successive actions, the idea was to sonify the different parameters such as the angle of the squeegee, the pressure exerted on the surface, and the rotation. The idea was to make fluid changes of direction and regular trajectories. The augmented squeegee with sensors should control a sound synthesis software that suggests an optimal trajectory and movement with a sound metaphor.

For example, considering the angle of the squeegee, if the user kept the race too close to the surface, a sound like "wind" or "white noise" indicates that the squeegee does not adhere enough to the surface, otherwise a grating sound is produced. Finally, between these two non-optimal situations (angles too low or too high), the right movement is sonified with the metaphor of a finger sliding on a glass.

Different types of sounds were tested: earcons or auditory icons [17] and vocalizations. The first tests suggested that vocalizations associated with the "gesture follower"[10] allowed, in the first attempt, to easily sonify the gestures being closest to the movement.

4.5 Summary

During this first workshop, we proposed a methodology to help participants to brainstorm and generate new scenarios from everyday objects.

Participants have analyzed everyday objects in terms of use, function and form. Instead of hybridizing new features and associated actions, we have focused on usage problems and selected a few objects to brainstorm on usage scenarios. Participants used different approaches to illustrate their scenarios: vocalizations, body storming and sound drama. The last part of the workshop was the work on prototyping. We selected two use cases and built augmented objects with sensors and sound synthesis to test our scenarios. During this workshop we did not particularly focus on the relation between sound and action, which is the topic of the next workshop.

5 Sound Metaphors

5.1 Introduction

The objective of this second workshop was to study sound gesture relationship. A first proposition was to work on the decomposition of the movement with basic gestures. The second one was to work on the type of relationship between gesture and sound production through sound metaphors. We also wanted to do further work on the synthesis engines (sound synthesis, physical models of behavior). This workshop was held at Ircam[11] in October 2012. A video summarized this workshop[12].

5.2 Basic Gestures and Sound-Gesture Relationship

Basic Gestures. The analysis of a complex action into elementary actions is derived from work done in the CLOSED project[13]. The aim of these studies

[10] http://imtr.ircam.fr/imtr/Gesture_Follower/.

[11] Participants: Sara Adhitya, Frédéric Bevilacqua, Eric Boyer, Jules Françoise, Sylvain Hanneton, Olivier Houix, Fivos Maniatakos, Nicolas Misdariis, Robert Piechaud, Nicolas Rasamimanana, Agnès Roby-Brami, Norbet Schnell, Patrick Susini, Isabelle Viaud-Delmon.

[12] https://www.youtube.com/watch?v=2aPsN0XC4Mo.

[13] http://actionanalysis.wikispaces.com/.

was to break down the basic tasks of daily life, especially in the kitchen and to see if they were associated to a sound resulting, or not, from the actions. We completed this analysis [10] to extend this framework by integrating the results of studies that analyze the manual gesture. For example, studies [19,32] have proposed a taxonomy of manual gesture differentiating a gesture requiring power and another requiring precision. We felt that this approach could help structure our thinking.

Sound-Gesture Relationship. We introduced different types of relationship between gesture and sound production:

- Arbitrary relationships: when a noise parameter varies as a function of arbitrarily gesture, such as when an object is moved upwards and its sonic roughness is increased;
- Metaphorical relationships: when a user pumps a device faster and faster, a virtual sound click is repeated more quickly (it uses the metaphor of a spinning top) [14].

We asked the participants to think about these two types of sound-gesture relationships applied to basic gestures using synthesis techniques (vocalizations, Foley or sound synthesis softwares).

5.3 Examples of Sound-Gesture Relationships

Each participant presented an example of a sound-gesture relationship based on elementary actions. This presentation showed that this exercise could be difficult, for example in imagining the metaphorical relation. Some participants gave examples of case studies related to an object rather than elementary gestures. Nevertheless, all participants attempted to answer it by offering reflections and proposals. Participants gave examples like the ones described below:

- Arbitrary relationship: the cinematic of a ping pong was sonified with simple oscillators depending on the direction. This example can be related to the artistic performance of Robert Rauschenberg "open scores"[14] in 1966. Another example: when there is no movement, there is silence. When the gesture is amplified, a noise becoming a granular texture sonifies the amplitude of the movement. Accidental gesture (with snap) is associated with a percussive sound. This example is inspired by "light music" of Thierry de Mey[15].
- Metaphorical relationship: when a spirit level is inclined, the movement is related to a bubble sound. A torsional movement could be associated with a liquid sound when wringing a cloth. A last example: when a drawer is opened, a sound world unfolds, giving information on its contents.

After these discussions, we defined three case studies that challenge different types of feedback (about the position or about the movement).

[14] http://www.fondation-langlois.org/html/f/page.php?NumPage=642.
[15] http://brahms.ircam.fr/works/work/22063/.

5.4 Development of the Case Studies

The participants were separated into three groups to work specifically on these three case studies. We did not use the use cases developed during the first workshop to stimulate new ideas and diversify the scenarios. We have selected the best scenarios that can be applied in the three application areas after the workshops. At the end of the day, each group gave a demonstration of its augmented object.

The Sonic Level. The idea developed with the "sonic level" was to sonify the angle relative to the horizontal axis using a virtual orchestra (an accordion, a guitar and drums). Thus, when the level is flat, the orchestra plays all the instruments (drums, guitar, accordion) and when the angle to the horizontal plane increases, conversely number of instruments decreases until the accordion was played alone (Fig. 3).

Fig. 3. The sonic level.

The eRhombe. A physical model of interaction was developed initially, producing no sound. Indeed, the objective was to first model the behavior of a virtual rhombus which is driven by the rotation of a physical sensor (gyroscope). The user rotates the sensor (MO) and must be consistent with the model when the virtual rhombus starts running and running. The next step is to sonify the virtual rhombus with an abstract or metaphorical relationship.

The Augmented Ping Pong. At the beginning, participants wanted to sonify the position and the acceleration of the racket for the gestures "forehand" and "backhand". They encountered difficulties of motion capture, e.g. to distinguish "forehand" and "backhand". The sounds used in the demonstration were based on the principles of classical sound synthesis. This work was extended after the workshop with a functional prototype and presented to ping pong players [1] (Fig. 4).

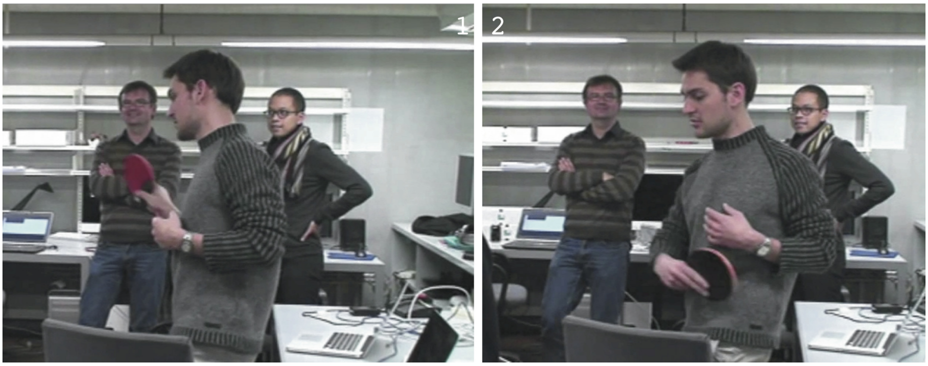

Fig. 4. The augmented Ping Pong.

5.5 Summary

The first part of the workshop was focused on sound-gesture relationships based on elementary actions. The different participants found this exercise difficult. A possible explanation is the decontextualization of this exercise. Thus, we asked participants to relate elementary actions to sounds. For participants it was hard to choose a type of sound (arbitrary or metaphorical sounds) in relation with an action without giving a context of production or a situation. This first part was a more theoretical thought on sound gesture relationships. The second part of the workshop was dedicated to the development of three different scenarios based on sonically augmented objects. The different scenarios were not necessarily related to the fist part of the workshop, but the theoretical formalization helped us to propose different types of feedback (about the position or about the movement).

6 Human Computer Confluence Summer School

We organized a workshop with students during the Human Computer Confluence HC2 Summer school from the 17th to the 19th of July 2013 at Ircam. This workshop about "Embodied Interaction and Sound" had two main topics: "Body Sonic interaction"[16] and "Object Sonic Interaction" and involved two student groups. The introduction part of the workshop was common to the two workshops. We present here the results of the "Object Sonic Interaction" part. Five students[17] participated to the workshop.

[16] Organized by the Department of Computing, Goldsmiths, University of London.

[17] Participants: Lauren Hayes - PhD student in creative music practice, Emmanouil Giannisakis - Master student in digital media engineering, Jaime Arias Almeida - PhD student in informatics, Alberto Betella - PhD student in communication, information and audiovisual media, David Hofmann - Phd student in theoretical neuroscience.

6.1 Framework

For this workshop, we refined the framework in three parts, summarized in Fig. 5, analysis of different objects brought by participants, generation of basic scenarios using constraints of basic sound and actions categories and development of two scenarios by prototyping objects with sensors and sound synthesis.

Object Analysis. First we asked participants to bring one or two items for the workshop. We gave some constraints: the object should be compact, be

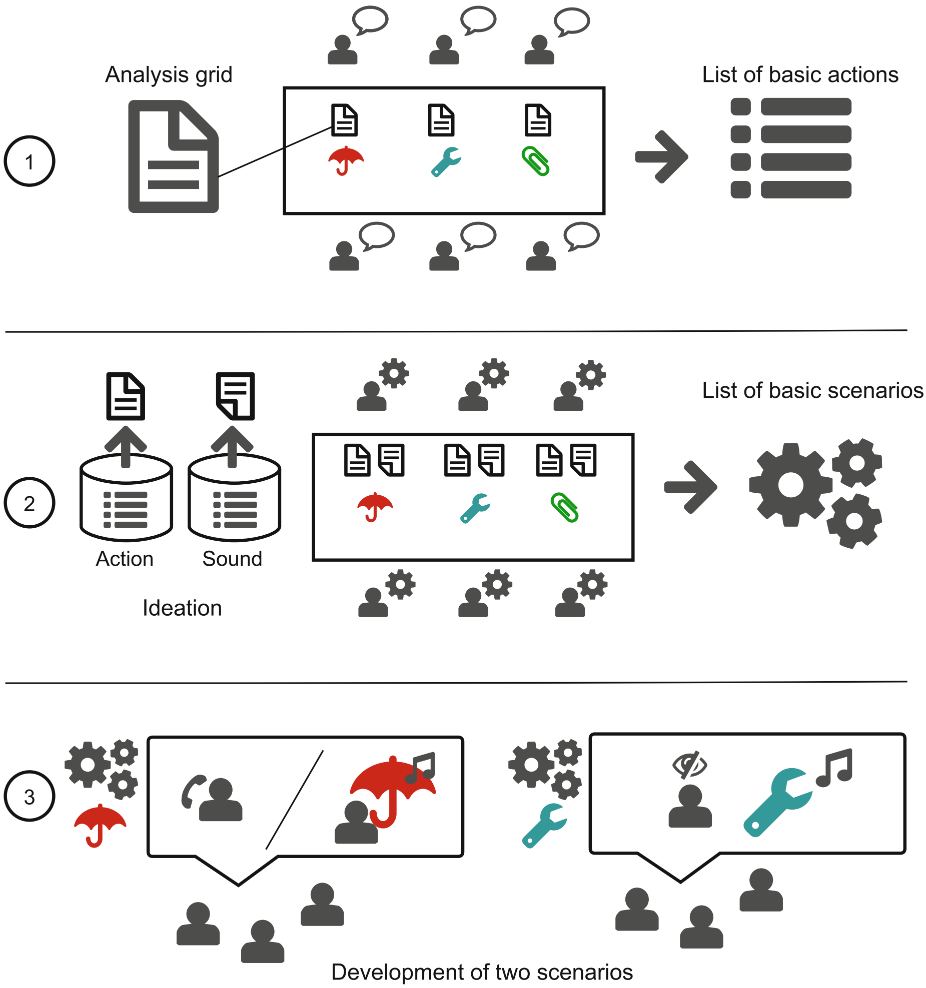

Fig. 5. Framework of the workshop: first objects were analyzed using a grid. Different basic actions were associated with each objects. We used a set of basic actions and sound categories to stimulate scenarios. We selected two scenarios and prototyped them.

manipulated by one or two hands in contact or not with another object or surface. The main function of the object should not be to produce sound (for example: musical instrument). We emphasized that the object should not be necessarily common and should stimulate their imagination. We also indicated that the different objects will be analyzed, hybridized, ..., in order to offer new user experiences with these objects through sound. They brought: a puppet, toothpicks, a dodecahedron wood block, clothespins, an infinite torus, a bracelet and a flag Poi for jugglery.

The different objects were presented by each participant and analyzed by different participant pairs, with permutations. We used the same analysis grid as it was presented before (see Sect. 4.1). We examined the different basic actions associated with these different objects and classified them as sustained, discrete or composed actions, see Fig. 6.

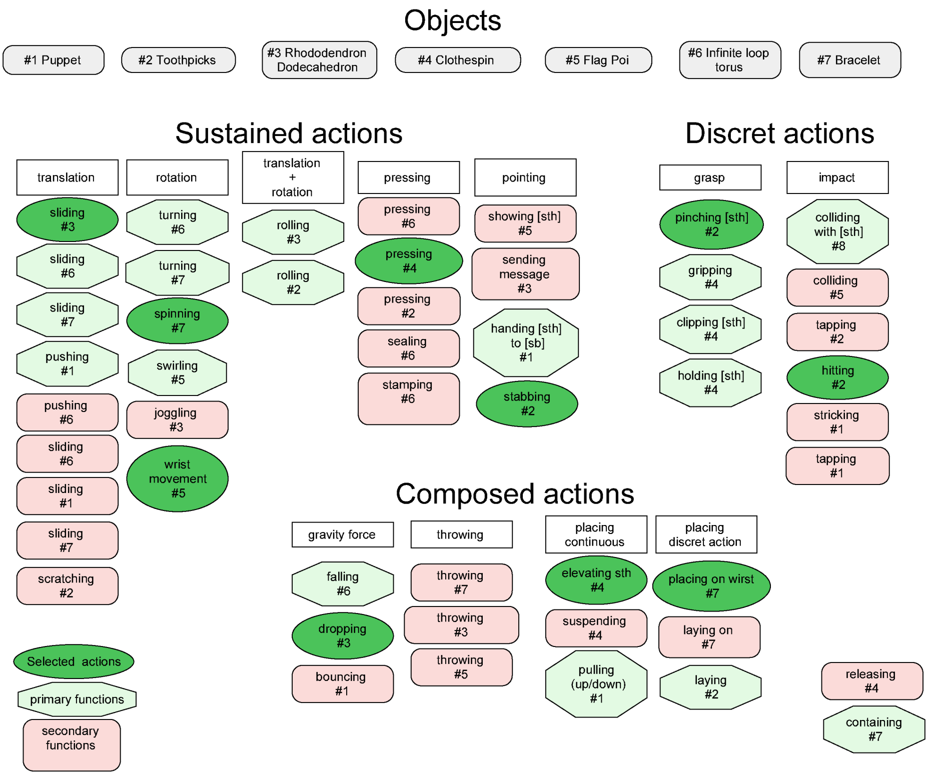

Fig. 6. The different objects (1 to 7) were analyzed with a grid. The different basic actions corresponding to primary and secondary functions are summarized and classified.

Ideation. We selected with participants ten actions among the different categories of actions (Fig. 6): sliding, pressing, hitting, spinning, stabbing, pinching, dropping, wrist movement, elevating something, placing on wrist. We proposed different categories of basic physical interactions (solid, liquid and gas interactions) that produce sound taken from the literature [11]. Ten physical interactions were also given: multiple impacts, rotation, shake, crumple, flow (gas), explosion (gas), bubble, drop/water movement, water shoot and draining. The objects were placed on the table and participants were seated on each side of the table. We randomized and selected for each object one interaction and one sound categories. We asked participants to propose sonic interaction design of new usages for each object.

After this stimulating exercise, the participants presented the 18 different scenarios. The scenarios were all different depending on the combination of sounds and actions. For example the clothespin can be used as a controller for a diving game, by spinning (the action) the clothespin you control the diver and the bubble sound indicates the oxygen lost. A scenario was proposed to learn the use of the flag Poi, the purpose was to have a smooth and periodically wrist movement (the action). When a less movement is done, there is an auditory feedback of water shooting. For the bracelet, they proposed a safety device, when pressed (the action) a hard shaking sound is heard to frighten the aggressor. Another proposition for the bracelet is a development of a mixed reality fighting game, the bracelet could be used as a controller of virtual sword. Every time a player stabs (the action) someone with the sword, the speed of a rotation sound is directly proportional to the damage inflicted. These different scenarios produced in a short time are a first step in order to hybridize these ideas for more complex propositions.

We classified the different scenarios in terms of use: gaming, social interaction, movement learning, tangible interface for performance and alarm. Participants discussed the different scenarios and selected two objects: the dodecahedron wood block and the flag Poi to generate two more complex scenarios and prototyped them with MO controller and sonified them with sound synthesis.

6.2 Slug, Snail, Toad: Sonified Dice Game

The first project was the development of a sonic game. It used the dodecahedron wood block and imagined a sonic version of the "rock-paper-scissors" game[18]. This game as an Asian origin called "Mushi-ken". The "frog" (represented by the thumb) is superseded by the "slug" (represented by the little finger), which, in turn is superseded by the "snake" (represented by the index finger), which is superseded by the "frog". They transposed a sonic version of this game, using sounds of "snake", "frog" and a sound that referred to "Slug". The wood block was instrumented with a wireless MO module [24] (Modular Musical Object) that contains a 3D accelerometer and 3 axis gyroscope). When a player rolls the dice, a sound is produced corresponding to "snake", "slug" or "frog"[19].

[18] https://en.wikipedia.org/wiki/Stone_Paper_Scissor.

[19] See the demonstration video: http://youtu.be/EULyOxyNEE4.

In order to recognize which side of the dice is played and to map the side with a specific sound, we used a software using machine learning functions based on Multimodal Hidden Markov Models (MHMMs) [4] implemented as a Max/MSP external [5].

6.3 Flash Mob

The second project was called "Flash Mob" in reference to a group of people that are regrouping suddenly in a public space to perform something atypical or artistic. They used two flags Poi instrumented with a wireless MO module at each flag end. The objective was twofold, the first one was a sonification of the movement in order to learn how to rotate the flag. The second one was the development of new musical interface for artistic performance, see Fig. 7. Two different actions were recognized with the same Max/MSP external: rotational and swinging movements. These two different movements were sonified with sound synthesis based on Buchla[20] sounds recorded previously by one student.

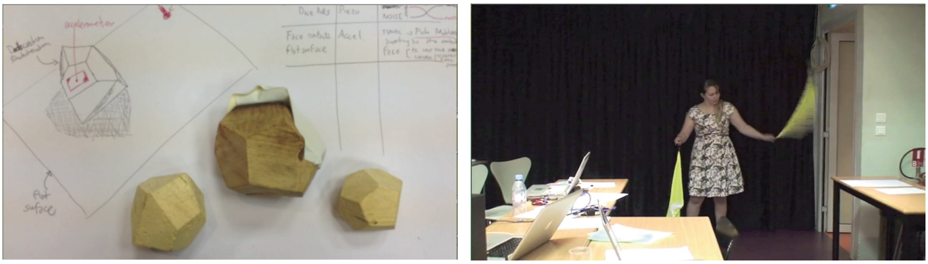

Fig. 7. The two scenarios developed during the workshop HC2. On the left the sonic version of the "slug, snail, toad" game. On the right a demonstration of the sonic flag Poi.

6.4 Summary

The different steps of the workshop and the two final prototypes were demonstrated by the students to the other students and organizers attending at the HC2 summer school. The different students who participated in the workshop were not necessarily familiar with sound, except a student, but they were very active.

A possible limit of our approach was its dependency to technologies of capture and to the Max/msp programming that limit students' autonomy to develop the prototype. But our idea was to develop participants' awareness of this new field of sonic interaction design.

From our point of view, this workshop was an application of the different concepts and issues that we introduced during the previous workshops.

[20] http://buchla.com/.

7 Summary and Perspectives

The workshop on "Usage Scenarios of Everyday Objects" was very challenging and participants appreciated this framework highly developed in the design community but less used in our respective disciplines. Participants were able to identify issues related to objects found in the remaining part of the LEGOS project and proposed answers in the form of prototyped augmented objects.

At the time, we did not test different approaches of sound synthesis to refine the sound design of the interactive objects. For example, we have not been able to fully exploit the expressive possibilities of sound synthesis by physical modeling. It was difficult to be closer to the movement. An approach of sound synthesis by physical modeling needs a finer setting in order to make audible the different gestures.

This work will be continued in order to test hypotheses concerning the role of sonic feedback in sensory-motor learning and the type of sound-gesture relationship (metaphorical or abstract).

For the workshop on "Sound metaphors", the use of sound metaphors to sonify gestures showed that beyond the issue of choosing the type of sound, it is paramount to make audible the information associated with different actions that composed the movement. The development of an interaction model as an intermediate structure between the motion capture and sound synthesis engine seems a particularly promising work.

The workshop with external participants during the HC2 summer school allowed us to test our approach and develop thought on our project. An extension of this work could be the development of educational tools for prototyping sonically augmented objects. This is a challenging objective.

These workshops have been beneficial for the LEGOS project because we developed different prototypes to test experimental situations, always questioning the three fields: sonic interaction design, rehabilitation and digital musical interfaces. Following these workshops, we have developed an object with multiple sonic affordances to explore gestural interactions and that will be used for psychological experiments.

These workshops also helped to generate more theoretical questions, especially regarding the distinction between sound metaphor and interaction metaphor.

The theoretical contribution of these workshops is on one hand an extension of a framework to propose a creative process for sonic interaction design. On the other hand we introduced a more theoretical reflection on sound gesture metaphors. It will extend the concept of auditory icons and earcons introduced in human computer interaction to the context of sound-gesture interactions involved in new tangible interface. The development of the experimental device will allow us to study these theoretical issues.

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