DOI: 10.61782/fa.2023.1006

CONNECTING SOUND DESIGN FUTURE WITH HISTORICAL CREATIVE PRACTICES: DEVELOPING DIGITAL TOOLS BY MODELLING HISTORICAL SOUND EFFECTS

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ABSTRACT

This paper describes the development of three digital sound prototypes based on three sounding objects selected from those in use at the Swedish Radio Sound Studio. Knowledge about historical and current creative practice was gathered through an in-depth interview with the Swedish Radio sound engineer and sound maker Michael Johansson and the observation of his Foley practice. A design workshop was carried out with music composers and interaction designers to ideate how these historical sound design concepts could be developed in the digital domain. On the basis of the workshop results, we built three prototypes that were exhibited at Tekniska Museet in Stockholm where we gathered feedback from 126 people. Finally, we discuss what we have learnt from utilising an approach rooted in historical creative practice, emphasizing benefits for contemporary digital sound design.

Keywords: *sonic interaction design, historical sound effects, creative practice*

1. INTRODUCTION

Existing sound production methods are challenged by the emergence of digital objects and new forms of digital storytelling (e.g. VR) which are often silent. As a consequence, new Sonic Interaction Design (SID) methods, rooted in existing sound making practices and expert knowledge, are required. Foley practice [1] is key to this endeavour, as it is based on experiential knowledge about the sonic possibilities of everyday objects, and on the gestures and movements needed to utilise them. Two aspects of Foley practice are particularly amenable to SID. First, Foley is often based on acoustic modelling, rather than the attempt to reproduce natural processes. For example, a mechanical wind machine produces noise through friction (rubbing material on wooden slates) and utilises the circular motion of a handle. Secondly, historically we can see that similar gestures have been used with different sound machines producing different sounds. In this paper we report on the design methods we developed to practically connect historical practice with the design of new digital sound objects. We describe research conducted in the context of the Radio Sound Studio project, which utilises methods from ethnography, sound computing and design, to provide a tangible approach to connecting new sound design developments with historical literature and practice. This way, the project aims at developing solutions of interest for artistic sound practices as well as more utilitarian sonic interaction designs for new objects. As specific outcomes, we describe three prototypes that were developed and exhibited at the Tekniska Museet in Stockholm. In the discussion, we reflect on our approach and trace how design decisions developed through the proposed process.

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2. BACKGROUND

Foley practice provides a way to investigate sound production and perception from ecological [2] and enactive [3] stand points. The unique skill of Foley artists, honed through practice and rehearsal, is to be able to perceive the many sonic affordances of everyday objects, i.e. the possibilities these might offer for action and sound , and reproduce these sounds as effects in various media. The feedback loop created in performance, where the artist continuously listens and fine tunes gestures in order to produce the desired sounds, creates the embodied, often tacit [4], knowledge which is at the heart of Foley practices [5]. Harnessing this knowledge, by investigating current and historical methods of sound performance with acoustic materials [6], is key to be able to develop similarly intuitive and meaningful new sonic interaction with digital tools and techniques. We can say that the concerns of Foley artists and current sonic interaction designers are similar: their practices both rely on how well the resulting sound approximates the required sound, and how performable the purposely built device is (be it an acoustic machine, a combination of everyday objects or a digital model). As a consequence, we need to find methods to study the process of meaning creation with sound by connecting traditional Foley practice and emerging digital models, as well as developing ways to refine the creation and evaluation of sonic interactions [7]. One approach to address the latter is to combine physical modelling and procedural audio [8] to recreate sounds produced by everyday objects, materials and behaviours (the breaking of a wood stick, or a ball rolling, for example).

The development of digital 'sounding objects' and digital musical instruments (DMIs) have some common concerns, particularly in relation to the balance between offering a low threshold for learning and, simultaneously, producing complex and meaningful sonic articulations [9]. In the practice of Foley, and in the history of sound machines, we can find some solutions to these concerns [10]. Examining a specific object [11], utilising ethnographic techniques such as in-studio observations and interviews, may be particularly useful. This may help to uncover the complexities of the accumulation of tacit knowledge as part of both the design and play processes combined ([12–14]). Furthermore, workshop-based methods have been employed to study sound-gesture relationships [15, 16], and to prototype sound interactions from everyday objects [17–19].

Figure 1. Swedish clogs, squeaky box, wooden spoon in wet cloth scraping

3. FROM FOLEY TO DIGITAL SOUND

In this project, we collaborated with Michael Johansson sound engineer and sound maker at Swedish Radio. To understand his Foley practice, we conducted an in-depth semi-structured interview about his background and practice, and observed his Foley performance (see [20]). Through this process, three sonic interactions, and corresponding sound objects, were selected to become the focus of further study. The first was used in a radio play called "Turid - A Viking saga". Turid, a young girl, needs to make a sacrifice to the gods by spreading butter on the "Holy rock". To do this, Michael used a wooden spoon wrapped on wet cloth scraping on a rock (Figure 1). Two aspects were interesting for us. First, the fact that sounding objects are completely mundane. Secondly, that they portray something quite different from their normal use. The creativity of this sonic substitution is interesting, and we wondered whether it could be expanded upon. The second sound objects were used in the same play and were old Swedish clogs (Figure 1). They were used to portray footsteps, but also as a way to indicate the bodily presence of a character in a story without visuals. The third sound effect was a mechanical wooden sound machine purposely made for producing creaks and squeaks sounds: a "squeaky box"(Figure 1). It consists mainly of a wooden resonance box and two handles made of wood and metal at the opposite ends of the box. This is not an everyday object and it is used to produce creaks and squeaks made by imaginary doors, floors or boxes. The object presents the performer with some explicit affordances (through the handles), however, since it is not linked to everyday actions, it might provides a performer with additional possibilities for creation. A more thorough description of this phase of the project, the selection of the sounding objects and the development of initial digital models can be found in [20]. After selecting these three sonic interactions, we used them as starting points for an ideation design workshop with music and interaction design students.

4. IDEATION WORKSHOP

There are no established ways to ideate new sonic interaction designs on the basis of existing Foley practice, however design research has identified two main phases in any design process [21]: an initial exploratory, divergent phase followed by a more focused, convergent phase. Accordingly, we designed two tasks for our ideation workshop: (1) ideating, in groups of 3-4, sonic experiences with the sounds provided; (2) sketching, in pairs, interfaces for sonic interactions with the given sounds. Research [22, 23] has shown that listening to sounds acousmatically (listening to sound without seeing its cause) opens up a very free and creative space in which any association between a sound and its imagined meaning is possible. This is a divergent task that can provide participants with a large space of potential sonic experiences ready to be considered in the convergent task that follows. The second task, involves sketching an interface. This, even when done with a highly speculative attitude, requires a more concrete and convergent mode of thinking as human and material limitations come into collisions with creativity. A thought such as "If I do this with my left hand, I cannot also press this button" will limit the way we sketch an interface, for example.

The results of these two tasks were a number of sonic interaction ideas, and 8 interface sketches, three of which were further developed.

4.1 Structure

The workshop took place at the Royal College of Music and lasted 4 hours. It involved 10 university students from KTH (Royal Institute of Technology) and KMH (Royal College of Music) (6 male and 4 female; of which 2 were music composers and 8 were interaction designers). After a short introduction, participants listened to various recordings of the selected Foley sounds (for brevity, we will refer to them as "footsteps", "spoon", "squeak"), as well as initial digital renditions of similar sounds based on procedural models by Farnell [8]. During the first task, participants, divided in 3 groups, were invited to ideate new sonic experience that could use these sounds. They could sketch with pen and paper and/or use any sound application they were familiar with. The task lasted 1,5 hours including presentations. During the second task, participants, divided in 4 pairs (two people could not stay after the first task), were tasked to sketch interfaces for the given sounds and told to ignore practical and feasibility concerns to avoid limiting their imagination. The task lasted 1,5 hours including presentations. Pair P1 ideated for the spoon and squeak models; P2 for footsteps and spoon models; P3 for the footsteps and squeak models; and P4 for the spoon and squeak models. A 30 minutes discussion concluded the workshop.

4.2 Task 1: results

4.2.1 Group A

This group created a musical "beat" made by mixing and processing the given sounds. Initially, they thought about creating a beat with footstep sounds and simulate walking and running by increasing the tempo. Then they decided to import all the sounds in a sequencer and listen to them randomly mixed together. Sounds were looped and effects were added to create a rhythm. They imagined that the beat would be played accompanied by a visualisation of the wave that could be slowed down, freezed, or zoomed in. The group was asked why, to start, they played all the sounds together. They said: "*It is tedious to hear all the sounds one after the other*". One researcher suggested that introducing an element of chance at the start of a process might be a good way to avoid an order bias. The group also agreed that while they initially played all the sounds together to listen to them quickly, this idea became the basis of the musical beat.

4.2.2 Group B

Group B sketched their ideas on paper. They focused on the footsteps sounds and imagined a story. The group perceived the footstep sounds as suggestive of very different scenarios: a prison courtyard, or a kid starting to walk for the first time, for example. They realised that from footsteps one can hear many different things: "*This could be someone walking on snow, but also someone eating fruit, for example*". The group ideated a survival horror game based on a story mixing Greek and Nordic mythologies. They imagined a character waking up in a snowy forest in a cabin in the woods, surrounded by monsters like cyclops. They listened to the sounds one by one and noted down their ideas. Overall, the group found interesting that

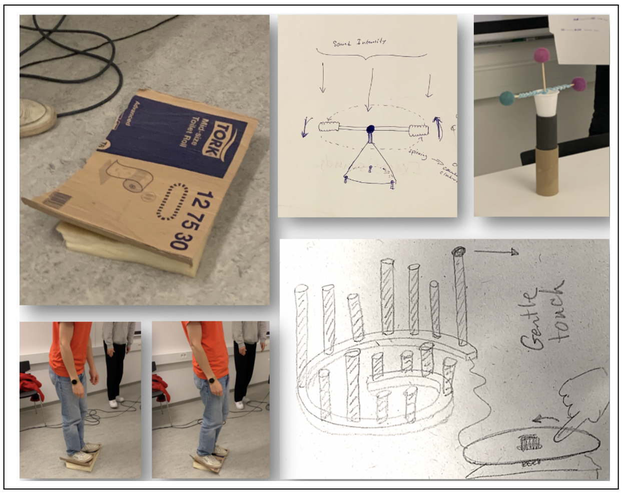

Figure 2. Segway, Seesaw and Spiral sketches

once they had a scenario in mind, they could find many interpretations for the sounds provided that would fit the story. They found the footsteps and the spoon sounds to be easy to interpret in a variety of ways, while the squeaks and creaks were more difficult. The spoon sounds, when pitch-shifted, could for example be birds pecking on a tree, or animals in the forest. Additionally, they imagined processing the sounds to make the scary sounds of the monsters.

4.2.3 Group C

This group talked about creating a sound installation for an art gallery. Visitors would be allowed to walk around a dark, immersive room and sounds would come from different directions. The spatialisation would be automated and forever changing. They used a granular synthesiser to process footsteps and squeaking sounds. A trackpad was used to change the grains' characteristics. Finally, they experimented with a creaking sound using a number of plugins including pitch shifting, distortion, ring modulation, and more. The goal was to render the sound "abstract". They stated "*We were all interested in how to get the sound out of context and creating something completely different*".

4.3 Task 2 results

4.3.1 Pair P1

P1 started by sketching an object for the squeak model that would invite a motion "naturally" associated with these sounds, e.g. a lever. This developed into a *seesaw* that could rotate and move up and down, providing many parameters for mapping (see Figure 2). For example, pressing down the central point of the seesaw would increase the intensity of the sound (this was compared to a jackhammer movement). The seesaw rocking movement could change the pitch, and rotating the top part of the object could stretch the sound. The object could stand on a table, however they also considered the possibility of a real-size seesaw that multiple people could operate producing low frequency sounds. For the spoon model, they imagined a game similar to *air hokey*. Different areas of the flat surface would correspond to different pitches and tempos so that, by moving the disks around, one could create sweeping sounds or tapping sounds. This could be done with multiple people combining different sounds. This ideas was inspired by the use of the trackpad by Group C in task 1.

4.3.2 Pair P2

P2 thought about controlling the speed or tempo of footsteps to synchronise them to film, taking up an idea initially mentioned by Group A in task 1. Initially they thought of a tredmill-like interface that would detect the speed of the performer footsteps and allow choosing different surfaces. After discovering a rectangular piece of foam among the materials provided , they stated: "*(Standing on it and leaning forward and backwards) was quite a nice feeling so... it would be nice to get the audio (doing that) as well*." This interface used a rectangle piece of foam and a hard flat material on top (see Figure 2). Leaning forward would make the footsteps go faster, and leaning backwards would make them slow down. They compared this to a *segway*. Tapping one foot would change the surface. They also thought that one could lean left and right, but no mapping was proposed for that. Two prototypes were created for the spoon sound. The first looked like a handheld *xylophone* made with a piece of cardboard and segments of plastic straws as bars. The second was made by two sponges covered by rough paper or, a different version, by small plastic bags full of air. Sliding over the xylophone interface with a stick would control the amplitude envelope of the sound and provide the sense that the "sound has gone a distance". The resulting sound would be dynamic due to the rough, bumpy surface. With the second interface, the player would rub the two objects together. The sound could last for as long as desired (if based on a rotary motion) or be rhythmical (if rubbing in opposite directions in rapid bursts). As this would be a digital interface, surface models would be selected through buttons in the objects. Embedded sensors would gather data about speed of rubbing, pressure, etc. and used to control the sound.

4.3.3 Pair P3

P3 focused on thinking about an interface that could provide many possibilities for data to sound mapping. The first idea was a sphere or a cube (similar to the Rubik's cube) divided in a number of sections that could move against each other, and with surface sensors so that by touching the sphere the performer could change a number of parameters. The interface could have an inside "texture" that would create resistance when moving the parts against each other. They said: "*it would get slower or faster inside, and that would be related to frequency (of the resulting sound)*". Twisting the interface would become increasingly difficult, so friction would increase and be reflected in the sound. This interface was developed thinking about the squeaking/creaking sounds although not exclusively. A spiral interface with a number of vertical sticks was sketched for the footsteps (see Figure 2). Touching the sticks, would produce footstep sounds. Additionally, the sticks could be moved up and down and control other sound parameters. As moving the sticks and touching them at the same time would be difficult, they expanded the idea by attaching a disk to the spiral. The disk would receive some input data (the timing of the touches but also other data), which would be used to move the sticks up and down. This would create a visualisation of the sounds, but also provide an additional opportunity for mapping.

4.3.4 Pair P4

P4 created interfaces that could affect many sounds at once. They converged on a soft and interactive controller: a foam cube. Each side would play a different sound, and effect chains would be assigned to the corners of the cube. By pressing one face close to the corner, an effect chain would be applied to that side's sound: the harder the pressure the "wetter" the effect. By pressing exactly on the top of the corner, all three sounds connected to this corner would be mixed. A second interface for mixing different samples, different tracks, and for building a musical composition was sketched. A number of soft, small and coloured balls constitute the interface. Each ball would represent a different audio sample. For example, the two purple balls could be two different spoon samples, and the three blue balls could be three different squeaky sounds. Picking up a ball would start a loop - alternating, polyrhythmic patterns might be built by picking up the balls in various sequences. Pressing the ball, rolling the ball between the hands, or even throwing the ball in the air would apply different effects to the sounds. Many interactions would be possible, some quite controlled - e.g. bouncing the balls rhythmically on a table - and some unpredictable - e.g. smashing the balls together.

4.4 Discussion: reflecting on the relation between Task 1 with Task 2

One participant (member of P1) was struck by easier it had been for him to think freely and creatively during the 1st task in comparison to the 2nd, where he started to think quite pragmatically about how the digital sounding object would work. He stated: "*We tried to abstract it (the spoon scraping) and think more about attack and sustain, but we thought about the motion.*". A member of P1 stated that they did not feel limited in task 2. However thinking about "intuitive" mappings was challenging. He stated: "*Pitch is interesting because we thought of it as being height, but we also talked about the jackhammer thing, that maps quite nicely to squeaking (and modifying pitch) via pushing or doing something more forceful.*". Regarding the order of the tasks, one pair thought that there seemed to be no connection between their work in task 1 and task 2. A member of P2 stated that the 1st task influenced his thinking in the 2nd task (sounds were looped in task 1 to make them continuous, and this approach continued in task 2). The members of P4 thought that a number of ideas from task 1 carried forward to task 2. They stated: "*With the first project, we talked a lot about processing the sounds and using effects to make them unrecognisable from the original sample.*" and "*I think also this idea of polyphony. Playing sounds at the same time, it was from the first part of the discussion. So we just went that way and have objects that can play multiple sounds.*"

5. THREE SOUND DIGITAL PROTOTYPES

We developed the "Creaksaw" (inspired by the seesaw/jackhammer interface described by P1), the "Fotaluta" (inspired by the balancing interface described by P2), and the "Skrapcykel" (inspired by the spiral interface described by P3) (see Figure 3). All prototypes used Arduino micro-controllers linked to laptops running Pure Data, allowing for procedural sound models to be controlled in real-time using standard electronic sensors.

Figure 3. The three prototypes

5.1 The Creaksaw

This prototype [1] has a main handle made from wood, that rocks, like a seesaw, on its centre mount. The centre mount rotates in the horizontal plane. The centre column is made from two tubes, one fitting inside another. This allows the centre column to extend and contract vertically. An accelerometer is attached to the wooden beam at the top of the Creaksaw, which allows for its angle to be measured as it moves. The centre mount is fixed to a potentiometer which turns when the wooden beam is spun in the horizontal plane. The final sensor is a linear force sensitive resistor, attached to the side of the inner (upper) cylindrical tube that makes up the centre column. The synthesis model used for the squeaks and creaks was developed by combining the friction model from [24], which is based on the physics of the sound generating process, and the door creak synthesis model by [8]. The accelerometer attached to the wooden beam controls the lateral force of the model form [24]. This drives the creak sound from this model. The accelerometer is also connected to the *Creak* variable in the model from [8]. The output from the two models are blended together at the output. The weighting of each model at the output is dependent on the potentiometer - full turned to one extreme will be the friction model and at the other it will be the door creak model. We called this parameter “Tightness”. The final sensor, the linear force sensitive resistor, is linked to the modal frequencies of the objects being moved. This increases or decreases the pitch of the sound as the top of the Creaksaw moves up and down.

5.2 The Fotaluta

A foam base is covered in blue cloth and covered by a hard surface on top, allowing a user to stand on the platform and manipulate its angle by adjusting their body weight [2]. Two photo resistors are placed at the centre of the feet outlines on the hard surface, which inform the software if someone steps on the platform. Four pressure sensors on the underside of the solid platform measure whether the user is leaning forward or backwards, left or right. The model is a variation on the footsteps model by [8]. Two properties of the model are controlled by the Fotaluta: the pace of the footsteps (by leaning back and forward) and the amount of roll of the foot on the ground (by leaning left or right).

5.3 The Skrapcykel

A bicycle wheel is place on a frame so it can spin in the horizontal plane. A digital rotary encoder is positioned on the platform, pressing against the bicycle wheel, turning as the wheel turns [3]. A potentiometer is placed beside the rotary encoder, but not in contact with the wheel. The remaining sensors are two force sensitive pads, placed on a block, under the bicycle wheel, that can be triggered when coloured pegs attached to the spokes of the wheel enter in contact during spinning. The scraping model is based on [24] generates a series of stochastic impact sounds. The output from the digital rotary encoder is processed to obtain a rotational velocity, which in turn is mapped to the velocity parameter of the scraping model. The potentiometer's output is mapped to the size of the grains involved in the scraping. This ranges from a fine to rough grains. Additional sound effects can be triggered by brightly coloured pegs, attached to the bicycle spokes, striking two force sensitive pads. These additions provided a way to mix and compose sound as inspired by the ideation workshop.

6. TEKNISKA MUSEET EXHIBIT

The digital objects were exhibited at Tekniska Museet in Stockholm for 4 days in December 2021. The objects were on top of tables forming a semicircle in front of a screen where a series of short videos were looped. In addition to trying out the objects, the audience could attempt to synchronise the sounds to the videos. A researcher from the team was always available to answer questions and to ensure that nothing would be damaged. At the end of their experience, visitors were asked to provide feedback in a very simple way. They could vote their favorite

[1] Creaksaw `https://tinyurl.com/474bjmmm`

[2] Fotaluta `https://tinyurl.com/4rsxnpt7`

[3] Skrapcykel `https://tinyurl.com/km9a3yf4`

sound object, and they could answer two questions about the object: (1) what aspect did you like the most? (2) what aspect would you design differently?

6.1 Results

We received 126 votes in total. The Creaksaw received 59 votes, followed by the Fotaluta with 45, and the Skrapcykel with 22. Visitors liked the variety of sounds the Creaksaw could make (sometimes scary and sometimes funny), and how "realistic" they could be. They also found the interaction to be "natural", simple, and intuitive, while providing a high level of control and many ways to adjust the sound. Feedback indicated that the object could be sturdier, and provide more resistance to movement. In regards to the Fotaluta, visitors liked the experience of having to lean (forward, backward, left and right) in order to create sound. One person commented: "*It was fun trying to keep the rhythm of the steps, while trying to keep the balance*". Others mentioned that it was fun jumping on the foam (although jumping was not mapped to a sonic result), playing with it and using it to control the sound. Other comments referred to liking the possibility of choosing different surfaces. Some people found leaning left and right not useful, and one person suggested that there could be a "parapet" (an horizontal bar) to help the user support themselves when leaning. Visitors liked the sonic versatility of the Skrapcyckel, and the "feel" of the wheel. One person described the interface as "crazy" in a fun way. One person commented on the coloured pegs attached to the spokes that could trigger extra sounds while the wheel was turning. They found this aspect particularly fun and they sketched on paper a new version of the interface with particular focus on this aspect. They wrote: "*I would assign different sounds to different pegs, and then the user can make their own "music box."*

7. DISCUSSION

Through this novel design process, we have developed digital sound design prototypes that produce continuous sounds in response to simple, continuous gestures that involve part of the body, or the whole body. A number of design decisions can be traced through the phases of this process. For example, focusing on *changing the tempo of sounds* was a concept developed by Group A during the first task of the workshop. P2 used this idea in the "segway" interface, which then was implemented in the Fotaluta prototype. Furthermore, the three final prototypes combine a number of different the ideas stemming from the workshop. The Creaksaw combines the *seesaw* idea of P1 with the increase in friction due to twisting of P3's *Rubik's cube interface*. When considering the initial "squeaky box" sound-action association, we can see that this process has allowed us to develop a different, but still intuitive and simple to perform, sound-action association for the squeaky/creaky sounds. The Fotaluta is inspired by the *segway* interface of P2. It combine balance and leaning (an action which involves the whole body) to control the speed/tempo of a sound, something the exhibit's visitors seemed to highly enjoy. This is a major departure from the action we make to create footsteps. To a certain extent, a much simpler action is involved, lowering the learning threshold for this sounding object. Interestingly, it connects with Michael Johansson's idea of sound representing a bodily presence, as the output sound depends on a body's weight and balance rather than its movements. Finally, the Skrapcyckel was a combination of the "spiral" interface for footsteps sounds of P3, and the continuous handheld rubbing interfaces developed for the spoon sounds by P2. The idea of using a bike wheel came from the spiral interface sketch (see Figure 2). The sticks inspired attaching pegs to the spokes to trigger sounds rhythmically. The main sound model mapped to this interface was a scraping model (mimicking the spoon sound), which could (like P2's handheld rubbing interfaces) go on for ever (if we rotate the wheel for ever) or be performed in a discontinuous manner (if we move the wheel back and forward rapidly). Quite differently from the previous prototypes, this sounding object allows to create a background sound (the scarping) as well as occasional foreground sounds (those connected to the pegs), allowing to produce a structured music composition (an idea that can be traced back to Group A in Task 1). While one visitor was highly enthusiastic about this concept, and called it a "Music Box", the voting put this prototype last, perhaps due to a perceived higher level of complexity comparing to the other prototypes.

8. CONCLUSION

In this paper we have described the methods developed in the Radio Sound Studio project for connecting historical sound design practices to the ideation of digital sound design objects. The methods were successful in rapidly generating a variety of ideas for sonic experiences, interactions and interfaces from three mundane sounds and objects. The feedback we gathered from the exhibit's visitors at Tekniska Museet was positive and enthusiastic, allowing us to identify what worked intuitively as well as aspects that need refinement. Future work will focus on refining the design process and methods we developed, and further exploring the new sound-actions-interactions associations that emerged from this study.

9. ACKNOWLEDGMENTS

The Radio Sound Studio project is funded by the KTH NAVET Centre.

10. REFERENCES

[1] V. T. Ament, *The Foley grail: The art of performing sound for film, games, and animation*. Routledge, 2014.

[2] J. J. Gibson, *The ecological approach to visual perception: classic edition*. Psychology Press, 1979.

[3] F. J. Varela, E. Thompson, and E. Rosch, *The embodied mind: Cognitive science and human experience*. MIT press, 1992.

[4] M. Polanyi, *The tacit dimension*. University of Chicago Press, 1967.

[5] S. Pauletto, "Embodied knowledge in foley artistry," *The Routledge Companion to Screen Music and Sound*, p. 338, 2017.

[6] P. Dourish, *Where the action is: the foundations of embodied interaction*. MIT press, 2004.

[7] P. Susini, O. Houix, and N. Misdariis, "Sound design: an applied, experimental framework to study the perception of everyday sounds," *The New Soundtrack*, vol. 4, no. 2, pp. 103–121, 2014.

[8] A. Farnell, *Designing sound*. Mit Press, 2010.

[9] S. Fels, "Designing for intimacy: Creating new interfaces for musical expression," *Proceedings of the IEEE*, vol. 92, no. 4, pp. 672–685, 2004.

[10] A. R. Jensenius, "Action-sound: Developing methods and tools to study music-related body movement," 2007.

[11] N. Cross, "Designerly ways of knowing," *Design studies*, vol. 3, no. 4, pp. 221–227, 1982.

[12] S. Serafin and A. De Götzen, "An enactive approach to the preservation of musical instruments reconstructing russolo's intonarumori," *Journal of New Music Research*, vol. 38, no. 3, pp. 231–239, 2009.

[13] F. Keenan and S. Pauletto, "Evaluating a continuous sonic interaction: comparing a performable acoustic and digital everyday sound," in *SMC Conference*, 2019.

[14] F. Keenan and S. Pauletto, "'listening back': Exploring the sonic interactions at the heart of historical sound effects performance," *The New Soundtrack*, vol. 7, no. 1, pp. 15–30, 2017.

[15] E. Tomás, T. Gorbach, H. Tellioglu, and M. Kaltenbrunner, "Material embodiments of electroacoustic music: an experimental workshop study," in *NIME Conference*, 2019.

[16] D. Holzer, H. Frisk, and A. Holzapfel, "Sounds of futures passed: Media archaeology and design fiction as nime methodologies," in *NIME Conference*, 2021.

[17] J. Armitage, A. McPherson, *et al.*, "Crafting digital musical instruments: An exploratory workshop study," in *NIME Conference*, 2018.

[18] A. Xambo Sedo, S. Saue, A. R. Jensenius, R. Støckert, and Ø. Brandtsegg, "Nime prototyping in teams: A participatory approach to teaching physical computing," in *NIME Conference*, 2019.

[19] R. Bresin, S. Pauletto, J. Laaksolahti, and E. Gandini, "Looking for the soundscape of the future: preliminary results applying the design fiction method," in *SMC Conference*, 2020.

[20] S. Pauletto, R. Selfridge, A. Holzapfel, and H. Frisk, "From foley professional practice to sonic interaction design: initial research conducted within the radio sound studio project.," in *Nordic SMC Conference*, 2021.

[21] N. Cross, *Design thinking: Understanding how designers think and work*. Berg, 2011.

[22] S. Pauletto, "Film and theatre-based approaches for sonic interaction design," *Digital Creativity*, vol. 25, no. 1, pp. 15–26, 2014.

[23] S. Pauletto, D. Hug, S. Barras, and M. Luckhurst, "Integrating theatrical strategies into sonic interaction design," in *Audio Mostly Conference*, 2009.

[24] S. Baldan, S. Delle Monache, and D. Rocchesso, "The sound design toolkit," *SoftwareX*, vol. 6, pp. 255–260, 2017.