PRODUCT SOUND DESIGN: PAST, PRESENT, AND FUTURE

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1 INTRODUCTION

Product Sound Design (PSD) is applied acoustics, psychoacoustics, and audio signal processing. It is an emerging, interdisciplinary field [1], with roots in acoustic measurements and product sound quality [2, 3].The core idea in PSD is to balance the functional, aesthetic, and informative properties of sounds produced by our everyday tools, devices, and systems. PSD is informed also by the practices of industrial and interaction design. It treats the relation between the people and products (or specifically, their sounds) as dynamic, interpretive, and multi-layered phenomenon, and aims to integrate sound design within the early stages of product design and development.

Recent advances in mobile and networked technologies require more emphasis on how to get the user involvement right. Interaction design, i.e., the core competence to facilitate the interaction between people and IT products by computational means, has specialized industrial design long time ago [4]. Sonic Interaction Design, where the sound mediates the interaction either as a display of processes or as an input medium, specializes product sound design in a similar way [5]. With the availability of processing power, sensors, and actuators, synthetic sounds are gradually replacing mechanical sounds in many objects. This makes product sound design even more compelling, because the continuous interaction and multi-sensory feedback are providing challenges for engineers and designers. With a good combination of acoustical interactions, ecological psychoacoustics, and digital sound synthesis tools, good educational practices of today have a potential to shape our sonic future.

The present contribution aims for a review on how product sound design came about, how it is practiced today, and how it needs to be extended to become a future profession. It first provides a background in Sec. 2, then an overview on the past of the PSD in Sec. 3. Sec. 4 presents a framework to track the changes in product characteristics, people, and the multi-layered appraisal relationship between people or products, following the background set by Blauert and Jekosch [6, 3]. For the future, following famous dicta "*the best way to predict the future is to invent it*" (A. Lincoln) and "*the future is already here — it's just not evenly distributed*" (W. Gibson), we will specifically look at the practices of the COST Action IC0601 Sonic Interaction Design[1] and its guidelines on how the PSD of interactive products could be carried out in the future[2]. Finally, the conclusive remarks are provided.

[1] http://www.cost-sid.org
[2] http://trac.sme-ccppd.org/SID/wiki/SIDTrainingSchoolProductSoundDesign201008

2 BACKGROUND

PSD has a strong relation to Product Sound Quality, which is defined in [6] as: "*a descriptor of the **adequacy** of the sound **attached** to a product. It results from **judgements** upon the **totality of auditory characteristics** of the said sound - the judgements being performed with **reference** to the set of those **desired features** of the product which are **apparent** to the users in their **actual cognitive, actional and emotional situation***".

Some concepts in this definition, indicated by bold-face by the present author, require further discussion. The term "adequacy" requires a set of mental "references", and it is worth investigating how the references and "desired features" are formed in people's minds. The term "product" can refer both to the classes of products, or to specific samples. The sounds can be "attached" to products in several ways; a useful distinction is between consequential or intentional sounds [7]. Consequential sounds are a result of a product's functioning and its moving mechanical parts. PSD practitioners have some freedom in shaping the right sound. Intentional sounds are chosen (often by a designer) to be a part of the product functionality or a user interface. Often, direct action and active manipulation are needed to trigger product sounds so that they become "apparent" to people in actual contexts and "situations". The engineering and design of both consequential and intentional product sounds need a tool-set that can provide *target sounds* in actual contexts.

Digital sound synthesis, especially discrete-time physical models [8] of everyday interactions (impact, friction, etc.), acoustical systems and musical instruments provides continuous sounds that can be shaped, engineered, and designed like any other product attribute. The interplay between musical acoustics and physics-based sound synthesis can inform also PSD. In fact, pleasurable artifacts are often likened to musical instruments in interaction design [9]. Currently, physics-based digital sound synthesis platforms, such as the Sound Design Toolkit (SDT) [10], are being specialized for managing the acoustical and user interactions. They can act as sonic sketching tools, with continuous sound feedback to of physical actions, as they occur in everyday life.

3 PRODUCT SOUND DESIGN IN THE PAST

In PSD, we are after practical guidance [11]. We would like to understand, e.g., why a Brand A kitchen blender sounds better than B for most of the people, even it is louder. Is it because its acoustic profile masks speech less, respecting thus the ear and the voice? Or does it match better the stereotypical references of people concerning the sound of kitchen appliances, and therefore to sound symbolism? How many pulses should be applied to the piezo-electric lighter, and in which pace, so that people would feel confident that the burner will light, but still not annoyed by the repetition and rhythm of the auditory events? More, how to get the sound design right in the contemporary ICT-products which do not have moving parts, but capable of producing any sound synthetically?

These kind of questions mark several paradigm shifts for the operation of acousticians, who, for decades were working on reducing the acoustic emissions of products on the

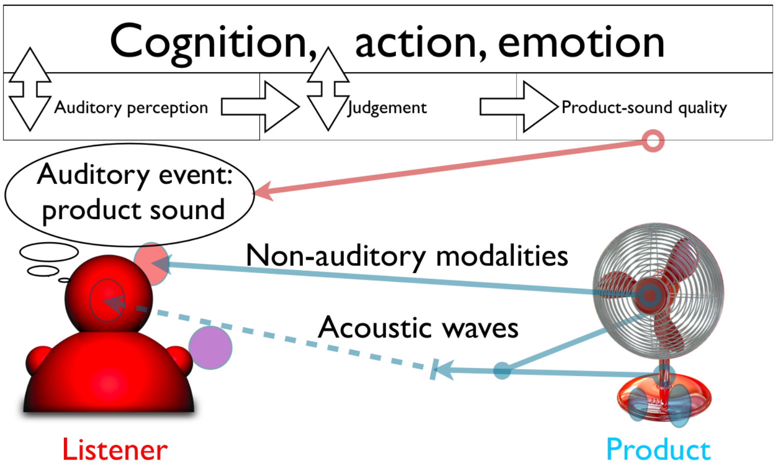

Figure 1: *The product sound quality assessment process, after [6].*

dB(A) scale [6]. When this aim was achieved around the Eighties, for instance in airplanes or passenger cars, the acousticians realized that product sound emissions have further characteristics to consider, e.g., the temporal and spectral properties. Around that time, the term *sound quality* was coined, and acoustic emissions and the auditory events induced by them were regarded as *multi-dimensional* [6]. Several physical and psychoacoustical attributes were identified to contribute to the *quality of sound*.

In the Nineties, a link between the general product quality and product sounds were established, and a new definition has been proposed [12] as "adequacy of a sound in the context of a specific technical goal or task". Moreover, the importance of social sciences (esp. cognitive psychology) has been realized, and the resistance in engineering to find a common ground with social sciences on product sound quality has been indicated [12].

These developments parallel what happened in a different discipline: human-computer interaction (HCI). Specifically, the goal- and task-oriented approaches, and more involvement of cognitive sciences were the defining characteristics of what is now called "the second-wave of HCI" [13]. However, these approaches were challenged by the demands of social, mobile, location-aware, personalized IT products and services that involves human cognition, action, and emotions more directly. Hence, the third-wave of HCI was born. PSD is in a similar transition today, as outlined in [3].

4 PRODUCT SOUND DESIGN TODAY

Blauert and Jekosch have described the product-sound-quality assessment process in [6], as redrawn on Fig. 1. Compared to classical psychoacoustics, the acoustics waves have a concrete source, i.e., the product. While auditory perception is a matter of psychoacoustics, the concept of judgement[3] requires (cognitive) psychology. Judgement is also based on non-auditory modalities, such as vision and touch. Both perception and judgement affect or affected by the response-modifying factors, i.e., cognition, action, and emotion. In the process, different layers of information reduction and abstraction

[3] The term "appraisal" is preferred here over "judgement".

are involved, which are elaborated in [3].

Blauert and Jekosch identify the design possibilities in intentional sounds, but note that engagement in such selection and design activities could bring the product-sound engineers from the center of their engineering profession towards the artistic expression. Artists, they claim, do not ground their choices on functional adequacy and/or compatibility, but are after an effect. In addition, they indicate that the inversion of the quality cycle on Fig. 1 by design is rather hard because of information reduction and associated non-linear and time-variant processes.

Our SID community tries out, nevertheless. With a good combination of acoustical interactions, ecological psychoacoustics, and digital sound synthesis tools, we believe that the product (sound) appraisals can be constructed by development and design. The key element here is a synergy between different disciplines, as practiced in Interdisciplinary Product Design and Development (PDD).

The situation bears resemblance to the birth of industrial design after the Bauhaus movement [14]. At that times, industrial product developers were not equipped with the necessary technical skills for the challenges of the rapid commoditization. As a remedy, first the artists, by systematic exploration and reflection, aestheticized the industrial production, and subsequently, industrial design was born as a distinct profession and academic discipline at the intersection of technology and design. A century later, commoditization is challenging the IT sector in a similar way; this is why we are witnessing a growing interest in the PSD around the world. Only with a good and grounded combination of acoustical interactions, psychoacoustics, psychology, and PDD, good educational practices of today will have a potential to shape our future (sonic) environment.

5 FUTURE PRODUCT SOUND DESIGN

There is no doubt that the traditional approaches on product (sound) design and evaluation will fall short on future interactive products that help people to express their skills, emotion, and affection. Some factors indicating the changes are outlined on Table 1, where PDD stands for Product Design and Development, EE for Electrical Engineering, CS for Computer Science, ID for Industrial Design, and IxD for Interaction Design.

It is useful to distinguish between the traditional evaluation and a broader approach evaluating how a user identifies with the product and how the product stimulates the user. In this view, the product is designed to engage sensory, perceptual, motor, cognitive, and emotional human capabilities for product appraisals. There is currently a lack of practice of describing which capabilities are addressed in design, how various aspects are constraining the utilization of these capabilities, and how the mappings between the human capabilities and product modalities are aligned. Product sounds are just one part of the whole; what counts is the holistic, coherent, and multi-sensory product experience.

Similar observations were reported in [15] regarding multimodal interfaces, and a structured approach has been proposed as a solution. The basic idea of this approach, illustrated in Fig. 2 and adopted to product sounds, is that future products will be designed to coordinate the human action and perception for a particular effect, subject to human capabilities and skills. If the product modalities are fully aligned with human capabilities,

Table 1: *Mapping the PSD progression to layers of sound quality, after [3].*

Layer	Attributes	Past	Present	Future
Product	Product cycles	Slow	Fast	Faster
	Sound production	By-product of mechanical design	Electro-acoustics, DSP	Physical Computing
	Role of sound in PDD	Sound is of no concern	Deliberately built	Continuous interaction, multisensory feedback
	Expertise needed	Acoustics psychoacoustics	Psychology, cognition, EE, CS, HCI, ID, IxD, ...	Interdisciplinary PDD
	Sound design freedom	Limited	Full	Balanced
Sound Quality	Abstraction Layers	Acoustic, auditative	Aural-scene	Aural communication
	Issues	Acoustic emissions, auditory events	Gestalts, 3D auditory scenes	Emotions, meaning
	Measurement methods	Acoustics, psychoacoustics	Discretistic, syncretistic	Contextual evaluation
People	Reference formation	Mere exposition	Audio-visual, social media	Natural interaction
	Attention demand	Low	High	Lower (desired)
	Auditory fitness	High	Low	Higher (desired)

then the product resonates with the user.

An example of a product with a simple auditory function is an electronic door bell. It affects people on multiple levels, ranging from the sensation of hearing the bell, through perception of its urgency (it is ringing rapidly), cognitive and semantic inference (that must be my daughter who will change her clothes and rush out), emotions and appraisals (every time she does that, I am dropping my pen with a startle. I hate this door bell), to purchasing decisions (I should change this door bell).

A comparison of Figs 1 and 2 highlights the importance of accessibility as an evaluation method; evaluation constraints can be considered as accessibility filters that blur the reception of the designer's intentions by the users. They can be structurally decomposed in user and external constraints. The user constraints are user feature, user state (emotional and cognitive contexts), and user preference, whereas the external constraints are structured as device constraint, environmental constraint, and social context. The observations, remarks, and the evaluation outcomes then can be tabulated, similar to Fig. 2.

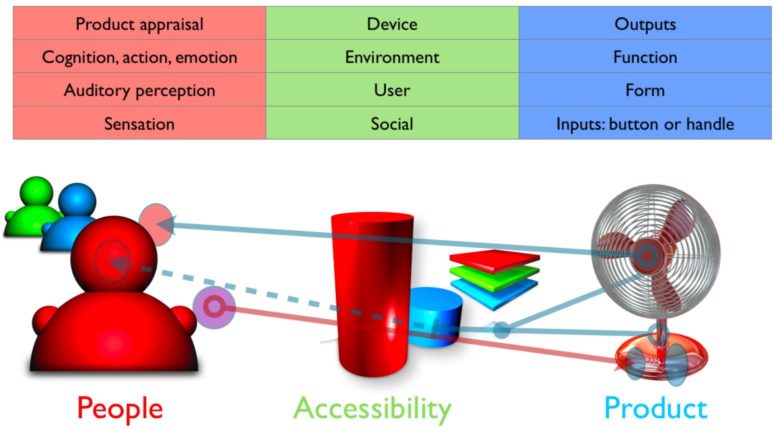

Figure 2: *The product sound design and evaluation model, after [6] and [15]. The people, products, and accessibility issues are expressed as layers in this framework, to check how well the product (sound) design intentions are appraised by people.*

5.1 SID Guidance in the Product Sound Design Summer School

This model has been tried out in the curriculum of a summer school in August 2010. The objective was to educate the future members of product design teams for a specific competence on interactive sound and the evaluation methods needed therein. This objective attracted around sixty applicants from all over the world, and 21 participants were accepted to the summer school. In four days, they went through the PSD phases suggested in [14] and depicted on Fig.3. The context was actual products and services of two start-up companies. In the following, an outline of the PSD phases is provided.

Phase 0 consists of sensory tuning exercises that relate to people and accessibility parts of the model. Specifically, due to visual dominance and masking in cross-modal integration, people do not usually capture the fine details of the sounds around them, nor have they a vocabulary to describe what they sense, perceive, or recognize. Soundwalks, for instance, is a good activity to elicit this [14]. Phase 1 is the analysis of successful sound design in products, computer games, or narrative media that already passed through the accessibility block, with an emphasis on the investigation of desired effects and human capabilities. Phase 2 is essentially sonic sketching and prototyping, generating concepts for achieving the desired effects and investigating the I/O modalities without technological investment or commitment. This phase also triggers the evaluation model, as the prototypes provide indications for constraints and accessibility issues. Vocal sketching and digital Foley are good examples of methods that can be used at this phase [14].

Phase 3 is building on the effects and I/O mapping investigated in Phase 2, replacing the mock-up I/O devices with sensors and actuators, and the sound generation is handled by a software synthesizer. These all can be carried out, for example, with SDT [10]. At this phase, the sound design is embodied and contextualized, and can inform evaluation. Next, in Phase 4, real-time physical computing and digital sound synthesis blocks are optimized and finalized, and ported on an embedded device or host operating system. Finally, Phase 5 contains a formal evaluation task, and brings the development back in Phase 1, if the desired effects, functional adequacy and/or functionality are not achieved or accessibility issues are hinting improvements.

6 CONCLUSIONS

This contribution reviewed on how product sound design came about, how it is practiced today, and how it needs to be extended to become a future profession. Rather than a chronological account, it tried to capture the essence of big paradigm shifts affecting the PSD practitioners, and express the required competencies within a model. Finally, the experience of putting this model in practice within a training activity is provided.

While there is a strong motivation and interest, both academic and commercial, there is

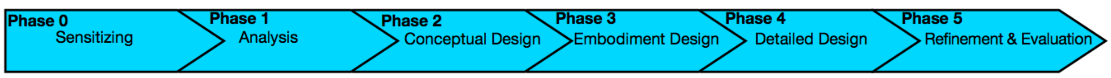

Figure 3: *PSD phases, as outlined in [14] and used in COST-SID PSD Summer School.*

currently not a grounded PSD curriculum or industrial practice. Such a grounded stance is the exact goal of the PSD, starting ground-up with education.

6.1 Acknowledgments

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