Critique of Pure Psychoacoustics

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Since product-sound quality has become a major engineering issue, psychoacoustics is widely applied to industrial R&D processes. In this context it can be observed that engineers, when applying psychoacoustics, sometimes have a restricted understanding of its foundations and, thus, the potency of psychoacoustic methods. A common misbelieve is, e.g., that psychoacoustic quantities can reliably be assessed with instrumental methods. This paper attempts to help differentiate the concept of psychoacoustics in two ways. In a first step it is argued that context free, so-called unbiased versions of psychoacoustic quantities, identifiable and assessable in laboratory experiments and then generalizeable, do actually not exist. In a second step, it is argued that the traditional view as to which what is perceived appears as the causal results of physical stimulation existing independently from the observer, is not conclusive in epistemological terms. Instead, a more comprehensive description of perception is offered in which what is traditionally called "stimuli" is unveiled as observer-dependent as well as what is traditionally called "sensations".

1. Introduction

We start with a rough schematic of a person who is listening and consequently describes verbally what s/he is hearing (Fig.1). The situation includes an acoustic event (sound waves) impinging upon the ear, the transformation process in the auditory system and subsequent activity in the auditory cortex. In the course of this cortical activity, an auditory event appears in the perceptual world of the listener. Persons may react in different way. They may react motoricly, e.g., run away, react emotionally, e.g., with constriction of vessels (anxiety), and/or they may consider the auditory event conceptually, i.e. start thinking about it. In the latter case there are adequate pathways to the language section of the cortex where a description of the auditory event in terms of wording becomes apparent. From this activity motoric excitation of the voice may be prompted, leading to an acoustic event which an observer may interpret as a series of morphemes such as "There is a tone".

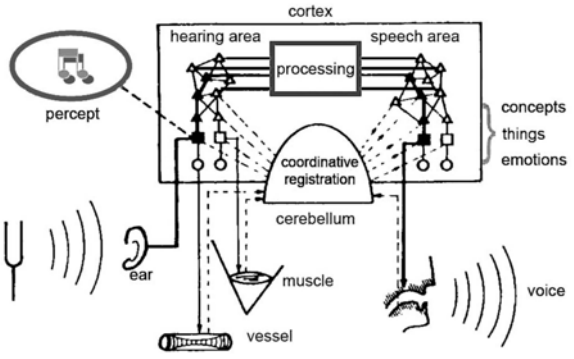

Fig.1: Schematic of a listening person

2. The Approach of Pure Psychoacoustics

In classical (pure) psychoacoustics the conceptual processing in the brain is largely abstracted from and perception is interpreted in terms of our knowledge about the auditory periphery. The listeners are, consequently, reduced to a three-port system with one in- and two outputs (Fig. 2), where the first output is only accessible to the listeners themselves (introspection).

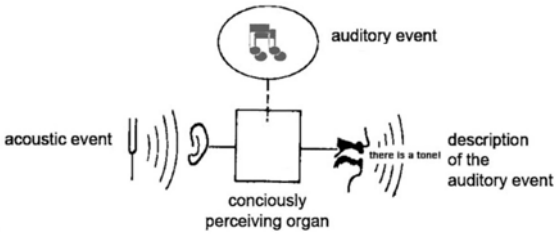

Fig. 2: Schematic, abstracted from Fig. 1

The essence of psychoacoustics is the claim to *measure* auditory events, i.e. to describe them quantitatively and thus, to investigate into perceptual quantities. To this end, the listeners are assigned two functions, perception and quantitative description of what they perceive (Fig.3).

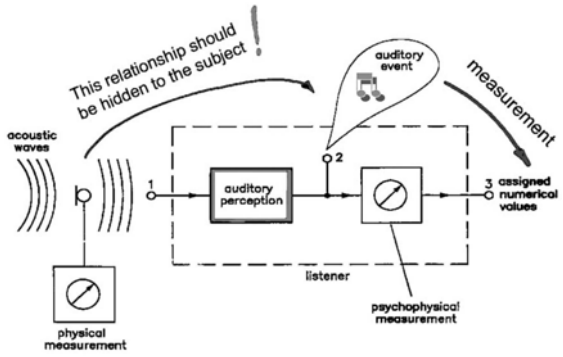

Fig.3: On the essence of "pure" psychoacoustics

Yet, since only the auditory periphery is considered, the listening experiments are performed under laboratory conditions with acoustic test signals that are supposed to provide no cue to any meaning at all. Consequently, the listeners do not get any information about the sound sources and are advised to selectively concentrate on a specific perceptual attribute of their auditory events, disregarding any thoughts or feelings − compare [8, 3]. From the data obtained in this way, model algorithms have been developed which are in use to instrumentally predict the values of elementary psychoacoustic quantities. Some of these have already been standardized and implemented on measuring equipment.

Of course, it is tempting to the manufacturers of such equipment to claim that they actually instrumentally *measure* psychoacoustics quantities (Fig. 3). Yet, what they only do is to provide an estimate of them, neglecting any contextual knowledge and cognitive

activity of the listeners. The equipment cited in Fig. 3 does actually not measure loudness, but provides a *loudness index* at best − with a very narrow range of generalizeability. This does, of course, not imply that such a loudness index is not useful, e.g. for comparison of different sound sources in the same context.

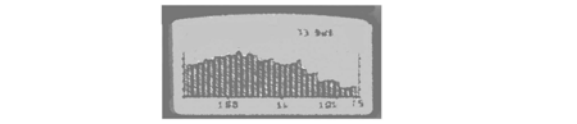

Fig. 5: Advertisement for a "loudness" meter

3. Considering the Context

It is well known that the loudness of an auditory event cannot solely be derived from the acoustic input to the listeners' ears. For example, the same acoustic signals at the eardrums lead to auditory events of different loudness when presented either via loudspeakers or earphones. Cross-sensory information, such as visual or tactile one, leads to loudness moderation. Further, the current activity of the listeners and their knowledge about and understanding of the situation are of profound influence. Thus, it does not come by surprise that loudness judgments vary enormously across listeners (subjectivity). In an attempt to model these facts, the notion of *response-moderating factors* has been introduced [4] − see Fig. 4. Note that these factors are meant as descriptors and not as causal reasons for the variances in loudness judgments.

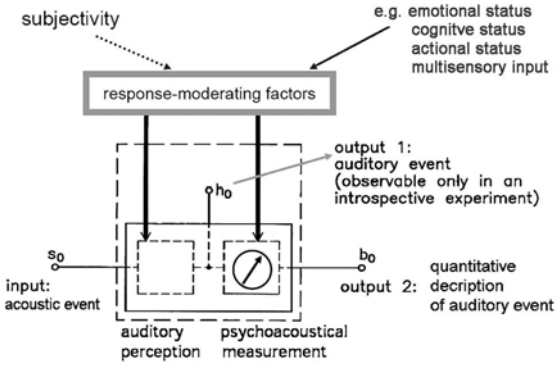

Fig.4: Modelling context dependency of aural perception

In consequence, the solutions offered by pure psychoacoustics have to be improved to arrive at more powerful prediction tools. To this end, a concerted attempt may be needed, including, e.g., psychoacoustics, cognitive science & technology and new fields that investigate specifically into the assignment of "meaning" to auditory events − such as semio-acoustics [5].

4. The Nature of the Stimulus

Most engineers consider stimuli as physical processes which prompt the organisms to "produce" what is perceived. Often they hypothesize a physical, "objective" world in this context which is thought to be the causal reason behind perception. In contrast, what is perceived is conceptualized as items that (only) exist in the listeners' perceptual worlds. Consequently, it would only be the latter ones that require psychological interpretation.

Yet, the theory of cognition has accepted for quite a while [6, 8] that the physical world, i.e. the world of "stimuli", is of perceptual nature as well. Physical objects are in fact mental constructs, derived from sensory observation – though by the rules of physics.

A proof for this notion is provided by the following experiment of thought [1]. Consider an equipment constructed from mirrors in such a way that it allows persons to look inside their own eyeballs. As is well known, eyeballs function as CAMERA OBSCURA, i.e. their lenses project photographic pictures onto the retinae. These pictures, in physical terms specific electromagnetic wave patterns, are conceived as the physiologically adequate "stimuli" of the visual system. The visual system processes these patterns and feeds the results into the visual cortex. Upon arrival of the signals from the periphery, the visual cortex assumes a specific state of activity at the peak of which the visual events appears in the persons' perceptual world. Yet, what they then see is retina pictures, i.e. what was originally considered to be the stimuli − causing themselves ?? − an invalid circular argument.

It goes without saying that equivalent experiments can be performed in auditory perception, but the visual example is more figurative and easier to grasp. Yet, also sound waves and vibration are indeed perceived.

In consequence, we have to take into account that physical stimuli are, without doubt, items of perception as well and need treatment as such when interpreting the results of perceptual experiments – whereby, to be sure, the rules of physics may be applied to arrive at maximum interindividual generalizeability, i.e. to obtain *objectivity* in a statistical sense.

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