Chapter XL
Toward a Novel Human Interface for Conceptualizing Spatial Information in Non-Speech Audio

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ABSTRACT

We developed a concept of interfaces using nonspeech audio for building wearable devices to support visually impaired persons. The main purpose is to enable visually impaired persons to freely conceptualize spatial information by nonspeech audio without requiring conventional means, such as artificial pattern recognition and voice synthesizer systems. Subjects participated in experiments to evaluate their ability to localize pattern-associated sounds. During the experiments, the subjects navigated through various virtual 3-D acoustic environments. The experimental results showed that sound effects, such as reverberation and reflection and variable z-coordinate movement, enhance the ability to localize
**INTRODUCTION**

Novel concept of interfaces are needed to keep pace because computing devices drop in size and rise in power/bandwidth. Interfaces that rely on screens and keyboards are not always effective in mobile computing scenarios. Screens and keyboard-based interfaces are difficult to use whilst the arms and hands are involved in real-world tasks (Brewster & Walker, 2000). Brewster and Walker (2000) looked at how current interfaces to handheld computers can be improved by the use of audio, and developed purely auditory interfaces with gestural control to avoid the need for visual attention.

According to Gibson (1966), a system has organs, whereas a sense has receptors. A system can orient, explore, investigate, adjust, optimize, resonate, extract, and achieve an equilibrium. The term “sense” means “to detect something,” which is more accurate than “to have a sensation” in senses considered as perceptual systems. While the achievements of a perceptual system are susceptible to maturation and learning, special sense inputs constitute a repertory of innate sensations. Sensations can be organized, fused, supplemented, or selected, but they cannot be learned. In a perceptual system, the input-output loop can be assumed to actively obtain information that becomes more and more subtle, elaborate, and precise with practice. One can keep on learning to perceive as long as life goes on.

Gibson (1966) also conjectured that perceptual systems develop perceptual skills analogous to the way in which behavioral systems develop performative skills. Perceptual systems are amenable to learning, but the channels of sense are not subject to modification by learning.

We assume sensations triggered by sound are merely incidental, sound information is available to perceptual systems, and the qualities of the real world in relation to the needs of subjects are experienced directly.

On the basis of these assumptions about perceptions and senses, we analyzed the learning processes of subjects, considered as perceptual systems, during sound localization and spatial conceptualization experiments.

For most animal species, accurate sound localization is ecologically important since it is fundamental for survival, communication, and learning about sight-sound correspondences (Fujiki, Riederer, Jousmaki, Makela, & Hari, 2002).

The ability to localize a sound in natural space is present in nearly all animals that possess a hearing mechanism (Erulkar, 1972). However, despite the practical significance of this ability, our knowledge about the development of sound localization skills in humans is fairly limited. Sound localization ability has been exploited in our work as a background to reach a sound visualization process by subjects.

Plenge (1974) has investigated that “localization” refers to judgments of the direction and distance of a sound source. The sound image can be located inside the head by wearing the headphones. On the other hand, “lateralization” describes the apparent location of the sound source within the head. Headphones play important roles, allowing the precise control of interaural differences to eliminate sound effects related to room echoes. Therefore, lateralization may be regarded as a laboratory version of localization that provides an efficient means of studying sound direction perception.

In the conceptualization process, researchers have shown that sounds more complex than ubiquitous interrupting beeps are necessary to provide spatial information to computer users. The evaluated vOICe Learning Edition (Jones, 2004) is an actual example of interface that translates pattern-associated sounds. The subjects were also evaluated on their ability to conceptualize spatial information based on cues in “artificial” and “natural” sounds. The evaluation results revealed that “natural” sounds are essential for improving everyday listening skills and the ability to conceptualize spatial information.
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