Chapter 3
Haptics as an Assistive Technology

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ABSTRACT

While visual and audible cues are used within the majority of educational environments, these can leave people with visual impairments, and especially deaf-blind people, at a severe disadvantage. People with visual disabilities often have a greater reliance on their sense of touch, and while touch-based, or haptic, technologies exist, the application of these within education is limited. This chapter discusses the background to haptic technologies, examines the available haptic technologies and identifies how and where these can be used within an educational context. It concludes by identifying that multimodal devices can go some way towards offering a practical assistive technology, but that further research is required to develop an affordable refreshable haptic graphic display.

INTRODUCTION

Blind and severely visually impaired people rely heavily on their sense of touch and there is a whole industry dedicated to the production of touch-based, or haptic, devices to assist them in going about their every-day lives. These include Braille books, monitors and writers, textured pavements and rotating knobs on pelican crossings, the raised dot on the 5-key on mobile phones and cash machines, to name but a few. Whilst for sighted people touch might be considered an augmentative sense for conveying additional information to things we see or hear, for blind (and to a greater extent deaf-blind) people it can be their main means of exploring the world around them. The use of haptics within formal education is still in its relative infancy compared to other modes of assistive technology and because of this there are no strict guidelines on how to educate blind
and visually-impaired students using available haptic technologies. The focus of this chapter is on providing readers with enough information to enable them to identify relevant methods and approaches for their own individual circumstances.

BACKGROUND

Oakley, McGee, et al. (2000) state that haptics is an umbrella term covering how various types of feedback are perceived through the sense of touch. They identify these as being:

- **Proprioceptive**: Relating to sensory information about the state of the body (including kinaesthetic, cutaneous and vestibular sensations)
- **Vestibular**: Pertaining to the perception of head position, acceleration and deceleration
- **Kinaesthetic**: Meaning the feeling of motion. Relating to sensations originating in muscles, tendons and joints
- **Cutaneous**: Pertaining to the skin itself, or the skin as a sense organ. Includes sensation of pressure, temperature and pain
- **Tactile**: Pertaining to the cutaneous sense, but more specifically the sensation of pressure, rather than temperature or pain
- **Force Feedback**: Relating to the mechanical production of information sensed by the human kinaesthetic system

When the term “haptics” is referred to within this chapter it may relate to any of the feedback styles listed above. In order to understand how to select an appropriate haptic device, be it for education or use of an assistive technology, it is useful to understand why there is some disparity between the various types of feedback afforded by such devices.

Some of the earliest investigations into cutaneous stimulation and its perception by humans was conducted in the 19th century by Weber and Fechner (Lockhead, 2004) who developed formulae based on logarithms that linked stimuli to sensation in an attempt to prove that it was possible to determine the level of sensation experienced by a human in response to a known level of stimulation. This work was later expanded by Stevens in his 1957 paper On the Psychophysical Law (Stevens, 1957). Although these works may now be out of date, they are important because they were some of the earliest to put forward the argument that it is possible to determine a human response based on a known stimulus.

Bauer (1952) developed a series of experiments to determine whether texture could be used in the identification of controls within a low-light military environment. The results suggested that active feedback was far superior to passive feedback when working with textures. In this context, active refers to the user making physical movements to explore the device, whereas passive refers to the user remaining stationary while feedback is imparted by moving parts built into the device. This research was supported by Lederman, et al. (1999) who investigated the differences between active and passive touch when applied to the perception of roughness. This more recent research also investigated the difference in perception when using bare fingers, and having access to cutaneous feedback, when compared to using a hand-held probe, such as a stylus, and led the authors to comment on the “reduced effects” of “stick-like probes relative to the bare finger”.

Despite these early findings, a large amount of research, if not the majority, has since been conducted in the development of devices that employ passive feedback. Perhaps more importantly, there are a number of commercially successful devices on the market today, such as SensAble Technologies PHANToM range of haptic devices (SensAble Technologies, 2010), which are normally used with attachments that do not support cutaneous feedback.
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