

# Plastic Brain Mechanisms in Sensory Substitution<sup>1</sup>

P. Bach-y-Rita<sup>2</sup>

## Introduction

In recent years considerable success has been achieved in the development and utilization of apparatus designed to provide the blind with a substitute visual input. Several groups of investigators have used the skin to relay the output of a camera to the central nervous system, one of the best known results being the Bliss-Linvill Optacon, to enable the blind to read printed matter (7). Our own endeavors at the Smith-Kettlewell Institute of Visual Sciences have been directed toward development of a tactile vision substitution system (TVSS) to present pictorial information to the blind (3, 4, 5, 12, 30). Briefly, with the TVSS, optical images picked up through a television camera are presented as a two-dimensional pattern of pulses to a mosaic of stimulators arranged on the skin of the trunk. Information of the patterned stimuli is then transmitted via the ascending somatosensory system to cortical areas for analysis and interpretation. Several factors indicate that the pictorial information can be interpreted as "visual". For example, after sufficient training with the TVSS apparatus, including learning the motor control needed to direct the camera toward the visual field, our blind subjects report experiencing the picture as located in space in front of them rather than on their skin. They rapidly acquire the ability to make perceptual judgments and discriminations, using monocular cues of depth, perspective, parallax, subjective spatial localization, and relative size of objects as an aid to relative distance. Although the resolution is limited and the TVSS is still in the early stages of development, practical application for education of the blind, and vocational applications (such as providing access to oscilloscopic information and to microcircuitry, by means of a microscope adaptor for a blind electronic engineer) are being actively evaluated (4).

Our studies have revealed that information normally received through one sensory system, the visual, can be received through another, the somatosensory. This demonstrable fact is dependent on plastic neural mechanisms, the existence of which formed the

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<sup>2</sup> Smith-Kettlewell Institute of Visual Sciences Pacific Medical Center, San Francisco, California 94115.



Fig. 1. A blind subject is shown walking down a corridor using the portable system shown in Fig. 6. The batteries are held in pouches on a vest; the power supply is mounted on the right side of his vest, while the stimulus circuitry is on the left side of the vest. He is holding a control board on which are located video level, pulse-width, and pulse-amplitude controls. The stimulus matrix is under his shirt, held against his abdomen. (Reprinted from *Brain Mechanisms in Sensory Substitution*, P. BACH-Y-RITA, 1972, with permission from Academic Press.)

basis for our original conception of the development of a TVSS (2, 3). It would appear that the responsible plastic mechanisms are predominately central rather than peripheral, inasmuch as perception of pictorial inputs is readily transferred by our trained blind subjects when the stimulus matrix is moved to a new area of skin, or when the type of stimulus is changed from mechanical vibrations to electrical pulses. Moreover, a tilting of the camera does not disturb the recognition of an object even though the pattern on the skin is distorted.