XX. SENSORY AIDS RESEARCH

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A. RESEARCH OBJECTIVES

The long-range objective of the Sensory Aids Research group is to help people with sensory handicaps to communicate more effectively with their environment. Those who have been deprived of vision are our primary concern.

Since the group was formed, in the fall of 1959, work has begun in the areas of reading aids, mobility aids, sensory adaptation, and special projects. We are in close contact with Mr. John Dupress, Director of Technological Research for the American Foundation for the Blind, who acts as consultant to the group. We also keep in close touch with groups at Harvard University, Tufts University, and M.I.T. (with Lincoln Laboratory, in particular) that have directly or indirectly related interests in this field.

The group members – graduate students, for the most part – can all be classified as communication engineers. In attempting to gain the necessary background for research work in sensory aids, we have come to appreciate that there is no such class of people as "the blind." Lack of sensory capability is a matter of degree; all of us are partially or totally blind under various conditions of emotional stress, fatigue, viewing angle, light level, preconditioning, and so forth. Moreover, blind people have the same endowment in intelligence, energy, motivation, and adaptability to other senses as the rest of the population. Thus, although the title, "sensory aids research for the blind," furnishes a convenient and motivating representation of the activities of this group, it is a grossly oversimplified description of our work.

We may expect that a given artificial sensory device or system will be (a) useful to some handicapped people, (b) useless to others with the same handicap, (c) possibly useful or interesting to some unhandicapped people, and (d) useful as a tool for research on sensory adaptation, if not as a practical sensory aid. In the immediate future, most of the experimental work will fall in class (d).

Both reading machines and mobility machines can be analyzed with respect to three parts: (a) the sensor, pickup, or scanner, (b) the computer, filter, or data processor, and (c) the display, or output transducer. A tremendous range of possibilities exists for each of these three parts. Work is in progress on a double-spot scanner for letter identification in standard type fonts, and also on a curve-tracer for acquisition, but not direct letter identification, of printed or handwritten material. Mobility-aid sensors of active (acoustic sonar) and passive (optical detection of ambient environmental light) types are being studied. For both reading and mobility machines, we anticipate doing much work on tactile and kinesthetic displays. A kinesthetic display is any display that permits the subject to sense a spatial motion pattern (for example, by moving his finger or writing upon his hand, or through sequential tactile stimulation of points on his skin with a speed and spacing that produce a sensation of motion).

Current special projects include: a typewriter for simultaneous production of visible English text and punched-tape-coded Class 2 Braille; a two-channel FM miniaturized transmitter for telemetering the binaural reception at two microphones mounted near the ears of a sightless subject during mobility experiments; an electronic curve tracer for printed characters; a range-selective optical detector; and a modified Braille tape reader.

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B. DISCRIMINATORY THRESHOLDS FOR THE SENSE OF TOUCH

Knowledge of the capabilities of the human senses as communication channels and a better understanding of sensory recognition and signal-detection characteristics are needed for the development of output devices for sensory aids. In particular, in order to transmit information to a human by means of the sense of touch, one needs to know the ability of the human to discriminate changes along the various dimensions in which information can be coded. A basic waveform, which might be used in a sensory-aid device to convey discrete information, is a position pulse. Some experiments have been performed to determine the abilities of the human to discriminate between position pulses of different amplitudes.

A geared-down servomotor was used for the application of a position pulse to a subject's finger. The parameters of the position pulse were varied to determine discrimination thresholds for pulse height and pulse width, distinguishability of changes in pulse height and pulse width, and the effect of motion in different directions. The thresholds were measured by a frequency method, according to which 5 stimuli distributed over the range from the rarely noticeable difference to the almost always noticeable difference were presented repeatedly to the subject in random order. In each trial, the subject was presented with a standard stimulus and then with a comparison stimulus. The subject's response indicated whether the comparison stimulus was greater or less than the standard. The number of reports for each stimulus gives a map of the transition zone (1).

From these data, several quantities can be calculated. The mean of the errors for

Table XX-1. Experimental results.

Experiment Number	1	2	3	4	5	6	7	8	9	10
Subject	1	2	3	4	4	4	4	4	4	4
St	27.6	27.6	22.5	22.5	27.7	27.7	27.7	29	29	29
Pulse Duration	68.8	68.8	110	110	90	50	200	95	95	95
Position	1	1	1	1	1	1	1	2	3	1
PSE	26.6	28.4	22.3	22.8	26.0	26.9	27.3	28.6	27.2	28.4
CE	-1.0	0.75	-0.16	0.31	-1.65	-0.82	-0.40	-0.41	-1.84	-0.567
DL	2.27	1.79	1.99	1.80	1.46	1.62	1.64	2.36	1.23	1.34
Weber's Ratio	0.0824	0.0648	0.0887	0.080	0.0528	0.0587	0.0591	0.0814	0.0424	0.0462

Note: All times are in msec and all distances in mils.

the various stimuli is equal to the point of subjective equality (PSE). The PSE minus the standard stimulus, St, gives the constant error (CE). The probable error is equal to the difference that is noticed 50 per cent of the time – the difference limen (DL). Weber's ratio was computed by dividing the DL by the standard stimulus.

A summary of the results of the experiments is shown in Table XX-1. In experiments 1, 2, 3, and 4, the pulse-height DL was measured for four different subjects. Roughly, we found that a difference of less than 0.002 inch out of a total movement of 0.025 inch, in which the duration of the pulse was approximately 100 msec and the rise time was approximately 15 msec, could be detected. Subject 4 showed some improvement throughout the tests because he had more practice than the others.

In experiments 5, 6, and 7, the pulse-height DL was measured for three values of pulse width. The purpose of these experiments was to determine whether or not the duration of the pulse has an appreciable influence on the DL for pulse height. While the DL obtained with the 90-msec pulse was the smallest, the differences were only slight.

In experiments 8, 9, and 10, the pulse-height DL was measured for three different finger positions. A sidewise motion with the knuckle bent (position 2) gave a larger DL than either an up-and-down motion with the knuckle bent (position 3) or an up-and-down motion with the finger extended (position 1).

A single experiment was conducted to determine Weber's ratio for pulse-duration discrimination. This experiment gave a DL of 28.7 msec out of 160 msec, or Weber's ratio of 0.18. Apparently, motion can be detected more accurately than time in this range of the parameters.

Finally, a single experiment was conducted with subject 4 to determine how well a change in pulse height can be distinguished from a change in pulse duration. Five pulse durations (55, 75, 95, 115, and 135 msec) and five pulse heights (24, 27, 29, 31.3, and 35.7×10^{-3} inch) were used. The subject was given a standard pulse, and then a comparison pulse. He was asked to report whether the comparison pulse was greater or less in height, and longer or shorter in time. Only one of these four answers was permitted. From the results of this experiment it appears that the subject can accurately detect a change in the area of the pulse, but he cannot discriminate between the changes in pulse height and the changes in pulse duration.

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References

1. R. S. Woodworth and H. Schlosberg, Experimental Psychology (Henry Holt and Company, Inc., New York, 1954).