EVALUATION OF THE SONIC MOBILITY AID[a]

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I. INTRODUCTION

Recent years have witnessed an upsurge of interest in electronically sophisticated "mobility devices" by researchers and workers with the visually handicapped. This interest is in part due to the multiplication of devices of all kinds from various research settings throughout the world. It has little to do with the actual market availability of most of these devices and even less to do with the demonstrated utility of these devices from the point of view of travel mobility. With very few exceptions (Deatherage, 1965) there have been no published reports of experimental evaluations of these "aids" and little in the numerous "field testing" reports would indicate careful assessment procedures.

One reason for this situation is that research on mobility devices presents certain problems regarding learning and training criteria within the range of potential usefulness of the instrument. As Dupress has suggested, the blind traveler requires many different types of information for safe mobility (Dupress, 1965). A "safe" mobility device must generate information regarding the presence of a safe terrain in terms of area and surface strength; and it must also indicate step-up and step-down conditions in terrain level changes. If one adds to these requirements the additional demand that the mobility device generate this information on an early-warning basis, it is easily seen that mobility device assessment involves the sorting out of a complex interaction between coded information and human decoding skills. Obviously this assessment can be interpreted more easily (although less precisely) in a global "field-testing" situation. The risk involved in this type of assessment is that one loses contact with the hypothetical components of the learning process. However, it should be

[a]Based on work performed under VA Contract V1005P–376A.
[b]A division of Boston's Catholic Guild for All the Blind.

noted that the learning component assumption underlying experimental laboratory assessment may reflect an untenable position with regard to training parameters. In other words the optimal conditions for training mobility skills may not prove to be the optimal conditions for assessment procedures. Our attempts to unravel the learning process through an atomistic assessment may lead to inferior recommendations.

This dilemma becomes particularly acute in connection with evaluation research on mobility devices having no specific training philosophy or validated methodology. Assessment in this context is inextricably linked with the development of training methods, and it is here that the assumptions and biases of the investigator become most visible and important. Given the existing state of the art of mobility devices, it is probably no accident that assessment efforts are typically structured on the "field-testing" model. Our existing electronic knowledge, while still relatively primitive, is well ahead of our understanding of efficient training parameters and other aspects of the man-machine system.

Within this context of training and assessment this report describes an experimental evaluation of a mobility device that is presently marketed[c] and has shown promise in limited field testing situations (Leonard & Carpenter, 1964; Gissoni, 1966).

The Kay Ultrasonic Aid

Experimental work on the feasibility of a frequency modulation ultrasonic mobility aid was first described by Dr. Leslie Kay in 1961. Based at least in part on the analogy of a bat orientation system (Kay, 1961, 1962), the Kay device soon received wide scientific recognition and a degree of popular attention through the International Congress on Technology and Blindness, New York, 1962. In its present form the Kay device consists of three components: a torch, a power supply, and a receiver. The receiver is like that commonly used in transistor radios, a little plastic hook keeping it in place near the opening of the ear. The power supply of the device is an external 9-volt radio-type battery connected to the main torch by cable. The torch or transmitter-transducer unit is shaped like a small flashlight, approximately 7 in. long and weighing approximately 9 oz. This unit contains eighteen transistors, correlated components, and the ultrasonic transducers protected by an external wire-mesh. In operation the aid sends out a beam of ultrasonic energy. Upon striking an object a portion of this energy is reflected back to the unit, being picked up by the detection transducer.[d] Upon entering the torch this energy is modulated into the

[c]Ultra Electronics, Ltd., Western Ave., London W3, England.

[d]A mean transmission frequency of 60 kc./sec. is used, producing a mean beam width of 15 deg. The rate of change of frequency of transmission is arranged to produce an audible echo note of 3 kc./sec. when the echoing object is at 20 ft. or

audible range of the listener and heard as signals having a definite loudness, pitch, texture, and tonal pattern. The interpretation of these signals by the listener constitutes a "language" of sound and necessitates learning. The training and evaluation program reported here is based on this aspect of encoding the audible information.

More detailed electronic specifications of the device are described by Kay (1963).

II. OBJECTIVES OF THE RESEARCH

Previous research on the Kay device suggested certain guidelines for training and evaluation. In general it has been proposed that the basic utility of the device considered simply as an obstacle detector lies in its ability to answer the question: "Is my travel path clear?" (Gissoni, 1966). Assuming that this question represents the most basic mobility skill, our training program attempted to build greater skill sophistication to the point of considering the possible utility of the Kay device also as an environmental sensor and navigational aid. Consequently, one objective of this research was:

> *What kind of mobility information can be conveyed reliably and validly by the Kay devices and under what conditions can this be done?*

Another dimension of interest in the Kay device lies in the relationship of personality factors, motivational dynamics, and personal abilities to training readiness and skill acquisition. In this connection we asked ourselves the following question:

> *What background factors can best predict success in training with the Kay device?*

If, for example, a certain constellation of personality factors is closely related to performance in training, this information could be quite useful in the design of subsequent training programs or field trials with this device. Considered in a more general way, the relationship of personality factors and training parameters is of interest to mobility training in the widest sense.

Perhaps the most important issue concerning the Kay device is the problem of training itself. Here we are concerned with the components

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7 ft. (according to the range selected by a push button control). For a single reflecting surface such as a smooth cylindrical post or a smooth wall, the echo is almost a pure note. The pitch of the note is proportional to the distance and is interrupted periodically during the interval when the transmission frequency rapidly reverts to the beginning of the frequency sweep. Although an interruption in the echo occurs naturally in the system, transient clicks are also heard if they are not gated out. This has been arranged with the result that the aid is almost silent when pointing into free space. Therefore, any note or sound heard indicates an object (Kay, 1965).

of the learning process and the trainer's ability to communicate these skills effectively. What kind of training regimens are most appropriate in this instance? Is there a similarity between the acquisition of mobility skills with a cane or dog and those of the Kay device? Should Kay device training be done in conjunction with existing mobility aids such as the cane or dog or should it be done separately?

Questions of this kind become crucial in light of the increasing tendency toward acceptance of electronic mobility devices such as the Kay device. The individual or institutional purchaser of a device must be given some consistent guidelines for training purposes, and we felt under an obligation to provide the outlines of training techniques having some demonstrated value. In this connection our question was:

What type of training methods are best suited to rapid learning of mobility skills with the Kay device?

Finally, we attempted to determine certain factors in the man-device system which did not lend themselves easily to quantification and statistical presentation. Questions involving the degree of enjoyment in the use of the ultrasonic system; the relative risk experienced when the Kay device is inevitably compared with the habitual travel aid; the amount of concern with personal appearance when in public with the device; these questions were answered through extensive interviews with our trainees and trainers.

For a potential "user" population, what personal factors are important in optimum daily involvement with the Kay device?

Many difficulties of operations-type research such as the Kay device evaluation can be alleviated by a careful specification of research objectives. As far as this research is concerned, these four questions constitute our research objectives. In the remainder of this report we will explore these objectives in terms of both skill-training-evaluation procedures and background information variables. Our findings as they specifically relate to these objectives will be presented and discussed in the last section.

III. DESCRIPTION OF TRAINING AND EVALUATION METHODS

We initially determined that our evaluation procedures would be extensions of the training regimen. The first step was, therefore, the determination of the skill parameters associated with the ultrasonic system. We were guided in this by some field testing data reported by Gissoni in a privately circulated tape recording (Gissoni, 1965), and also by the advice of Dr. Leslie Kay (Kay, 1965). After a period of familiarization with the Kay device in a variety of settings and tasks, we determined that the evaluation would include the following skills:

(a) Determination of object in travel path.
(b) Accurate estimate of distance from stationary object.
(c) Accurate estimate of distance from moving object.
(d) Accurate estimate of distance from stationary object while moving.
(e) Location of single object in a simple field.
(f) Location of multiple objects in complex field.
(g) Location of multiple objects in a fixed pattern.
(h) Location of multiple objects in a fixed pattern in an outdoor area.
(i) Navigational ability in a semi-familiar field (includes step-ups, step-downs, object identification, doorway passage, etc.).
(j) Navigation of a standardized obstacle course.

In addition to these specific skills we attempted to evaluate the effectiveness of the man/machine system under a variety of environmental conditions, including rain and snow, and a variety of psychological conditions including self-controlled home use.

Types of Information Conveyed

In order to understand the meaning of these skills it is necessary to describe the kind of information conveyed by the device. It has been noted that when the aid is pointed into free space there is little or no informational feedback to the user. The existence of any note or sound then indicates an object in the path of the ultra-sound beam. Therefore, the most basic skill associated with this system is the simple determination of an object within the range of the instrument.[e] However, a series of graduated skills must be built on this simple base and these skills are related to the following kinds of information:

(A) *Pitch*

The further the aid is from an object it is sensing, the higher the pitch of the signal in the receiver. Similarly, the closer the object the lower the pitch. A change of distance of the sensed object will immediately be reflected in a change of pitch. In this respect the aid is sensitive to distance changes of approximately 1 in.

(B) *Texture*

The sound of the note produced upon reflection will vary with the nature of the reflecting surface. A hard and smooth surface such as a plate glass or an even wall will produce a distinctly different texture in the sound from a rough or uneven surface such as a decorative paneling

[e]See note on The Kay Ultrasonic Aid in Section I for a description of the range control.

or fence. Although the pitch remains constant, the clarity of the sound will change. Using this information it is possible to discriminate certain classes of objects by their surface characteristics.

(C) *Tonal Pattern*

Certain types of objects produce characteristic tonal patterns in the received signal. This is due to surface features such as the degree of smoothness and other features such as the regularity of the "design." For example, using the aid it is possible to discriminate a bush or shrub from a wall, the received signal varying subtly with the variations in the leaf patterns. Slight rises and falls of pitch may serve as additional information in this case.

These three types of information constitute the basic "language" of the Kay ultrasonic aid. Through the use of various techniques, such as horizontal and vertical scanning, the user can, with this information, determine both the height and width of objects as well as locate himself in relation to a set of external reference points. For example, it is possible to discriminate a tree from a stoplight by the use of horizontal and vertical scanning; the information in this case would indicate a different surface texture (smooth pole versus a rough tree trunk) and the presence of a "bush" type sound achieved through vertical scanning of the branches of the tree.

Similarly, it is possible to discriminate a flight of stairs through the use of vertical scanning. Standing at the bottom of a staircase, a vertical scanning movement will produce a series of notes each one slightly higher in pitch than the preceding one. It is possible to "play" a pseudo-musical scale in this way (Gissoni, 1966) and often it is possible to count the stairs by determining the exact number of pitch changes. This same principle is useful in determining step-ups and step-downs such as curbs, although this is a subtle and difficult discrimination.

Evaluation Methods

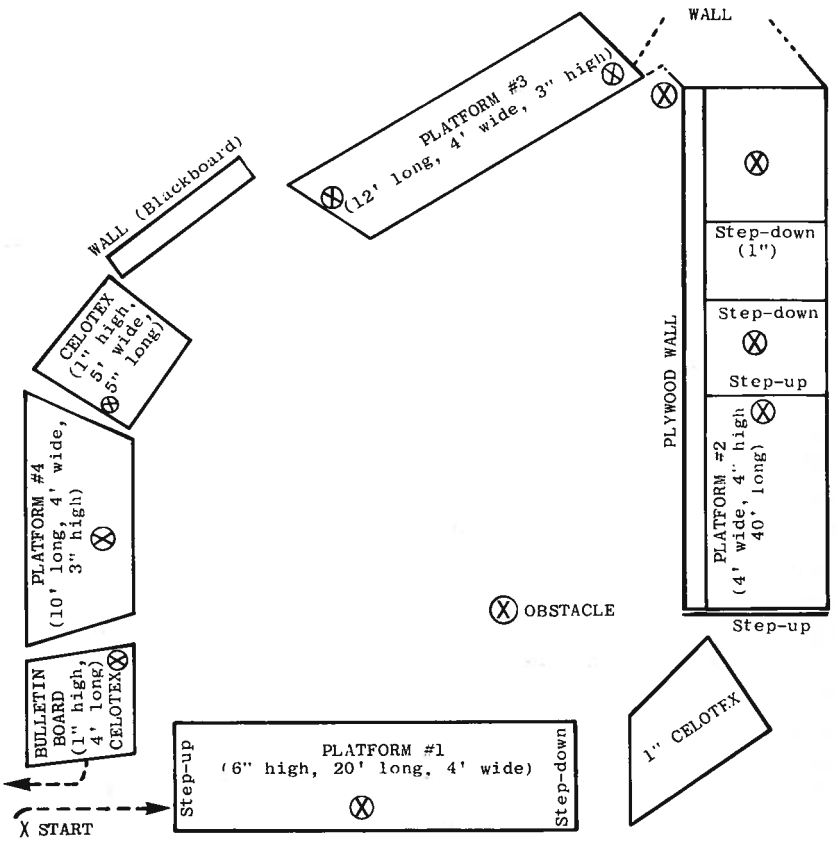
Evaluation of all skills was in each case tied closely to the training methods. In almost all cases the specific evaluation consisted of an error and/or time analysis of the subject's performance in a training technique. The only exception to this was the evaluation based on the use of an obstacle course prior to training and at the end of the training program. However, in all cases the trainees were instructed when evaluation was taking place.

Obstacle Course Training and Evaluation[t]

Prior to training with the Kay device, all subjects were tested on an obstacle course in order to evaluate their existing mobility skills. With one

[t]We wish to thank J. Mickunas, Jr., for his assistance in helping us reconstruct the obstacle course used in his research on cane mobility (Mikunas, J. Jr. & T. B. Sheridan, 1962).

exception, a guide-dog user, all of the subjects used a cane on this course. An effort was made to make the course representative of the important aspects of the environment which the blind traveler must face. In this regard we included bounded and open spaces, step-ups and step-downs, different types of obstacles in the travel path, and the selective availability of auditory cues. Figure 1 illustrates this course.



OBSTACLE COURSE FOR CANE AND KAY DEVICE EVALUATIONS

FIGURE 1. — Circular course of four major wooden platforms with Celotex surfaces between platforms, and ten obstacles as indicated.

The trainees were also evaluated at the end of the training program but this time using the Kay device in negotiating the course. Performance on both occasions was defined in terms of traverse time and "harm events" such as bumping into an object, tripping on an object, sticking the cane in a crevice, and stepping off the course.

The course was set up in a large empty room in the training site. This room was used exclusively for the obstacle course evaluation. The course was approximately 150 ft. long and divided into eight sections (see Fig. 1).

Upon entering the room the trainee was given a brief description of the course through the following instructions:

> "This is the beginning of the obstacle course. There is a step-up to start and a platform. To your right there is a wooden wall. Walk until you reach the end of the platform. Then, turn a gradual left and continue. You will find a long walkway with a step-up and down in the middle. Cross over this and continue. As you walk through this course your turns will always be to the left. The course is roughly circular and you will end it quite near the beginning. Be on the alert for obstacles along your way and various step-ups and downs. Walk until I ask you to stop. O.K.? Any questions?"

Each trainee walked the course twice. The subject's traverse time and "harm events" were recorded by the trainer who followed him over the course. This same procedure was repeated at the end of the training program with the exception that the subject used the Kay device instead of the cane or dog.

Ranging Training and Evaluation

A primary emphasis of the training program was on the acquisition of ranging skills. Approximately 20 hours of training were devoted to these skills. Four separate types of ranging skills were trained and evaluated in the following sequence:

1. *Stationary Ranging #1.* Our subjects were instructed to stand while the trainer moved within a line of perception of the device in either a backwards or forwards direction. A ten-foot range was employed and the floor marked with 5 intervals of 2 ft. each. Subjects were first familiarized with different intervals of the total range presented in random sequences and then asked to estimate the distance from the trainer based on the pitch information. The subject then stated the interval he thought the trainer was on (numbered one through five). Approximately 5 hours of training time were devoted to this skill.

Evaluation of the stationary ranging followed the same pattern: familiarization with intervals of the range followed by subject estimates of his distance from the trainer in terms of the interval mark. Twenty-five estimates were made by each trainee of intervals of 2 to 8 ft. from the trainer. These intervals were presented in random sequences over all subjects.

2. *Stationary Ranging #2.* In this ranging exercise our subjects continued to remain stationary. The trainer moved in and out of the line of perception from side to side, each time appearing at different interval points in the 10-ft. range. Subjects were trained to estimate their distance in this manner without the benefit of an anchoring of judgment based on a continuous moving scale as in stationary ranging #1. The same interval loca-

tions were employed for training and evaluation. Approximately 5 hours of training were spent on this skill and the evaluation followed the same format as in #1.

3. *Moving Ranging #1.* Another aspect of ranging involves the ability to estimate distance from a fixed target while moving. In this case the same intervals were used with a wooden wall as the target. Subjects were familiarized with the interval and taken to various interval points by the trainer. After placing themselves at an interval, they were asked to estimate the distance to the wall in terms of the interval points. Approximately 5 hours of training were spent on this task.

Evaluation of this ranging component was based on 15 trials or estimates of various intervals presented in a randomized order across all subjects. The intervals ranged from 2 ft. to 10 ft. and a subject could score a possible "right" 15 times. A subject scored "right" if his estimate was within 3 in. of the correct interval.

4. *Moving Ranging #2.* The final ranging skill attempted to train the subject to maintain a constant distance between himself and another moving person. This skill was considered a test of the ability to use distance cues from a moving target while moving at the same time, a somewhat more difficult task than passively estimating the distance of a moving object. A skill of this kind could easily relate to the use of the Kay device in a ticket counter line or a supermarket line. The training for this skill attempted to instruct the subject to maintain a common distance between himself and the trainer on a series of different trials using different constants. On individual trials the trainer would move either forward or backward after establishing a fixed distance between the subject and himself. The trainee would then attempt to increase or close the gap to the established distance, depending upon the movement of the trainer. This phase of training ran approximately 5 training hours.

Evaluation of this skill was structured so that the subject had to maintain a constant distance at three ranges: 4 ft., 6 ft., and 8 ft. The trainer would move forward or backward and the subject would try to maintain the constant distance on the respective trial. Three trials at the three different distances were run and scored for a possible 9 points (the trainer moving 9 times) reflecting a total of 27 points over all trials. Any estimate over 6 in. from the established distance for the trial was considered an error. The sequences of the distances were randomized over the total sample.

Scanning and Locating Training and Evaluation

Following the training and evaluation of the ranging skills, we turned to skills which emphasized object location. In this regard we developed three measures of this skill, staged in terms of relative difficulty:

1. *Simple Location.* In this exercise our subjects stood at the center of a series of 5 concentric circles each 2 ft. apart. The trainer would enter the short range of the aid at different points, first within a 180 deg. arc and then within a 360 deg. arc. The subject would turn and scan with his aid slowly and attempt to locate the trainer. After locating the trainer he would estimate his distance and walk over to him. Approximately 5 hours of training were spent on this skill.

Evaluation consisted of specifying five separate points throughout the 360 deg. on different circles, and asking the subject to locate the trainer at these points. These points were at various distances from the center (see Fig. 2). A subject could score a total of 10 points (two over each trial; one for location, and the other for correct estimate and reaching the trainer). There were five trials.

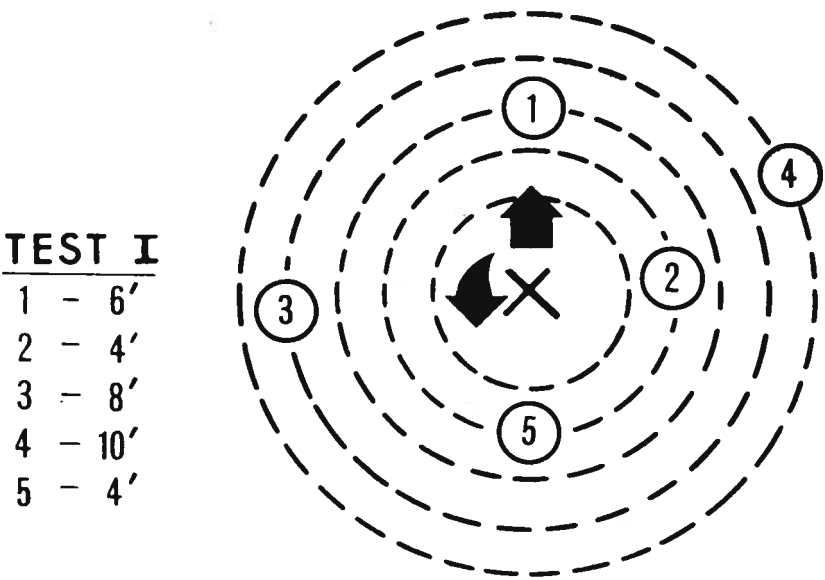


FIGURE 2. — Simple location.

2. *Multiple Object Location.* The same concentric circles were used in this training and evaluation. However, in this case different objects were placed at varying distances from the center and over the 360 deg. The subject was asked to scan over the total circle and locate and identify these objects (the objects could be identified by horizontal and vertical scanning after a brief period of familiarization).

Evaluation consisted of locating and identifying four objects (a small 3-ft. metal can, a 3-ft. piece of upright cardboard, a 1½-ft. wooden basket, and a 4-ft. metal can). The subject would slowly scan in a clockwise

direction and attempt to locate and identify these objects. Four trials were run. A subject could score a total of 8 points, two points per trial for correct location and identification. The order of the objects was changed over trials although the distance from the center remained the same, (see Fig. 3). Performance on this skill was also timed.

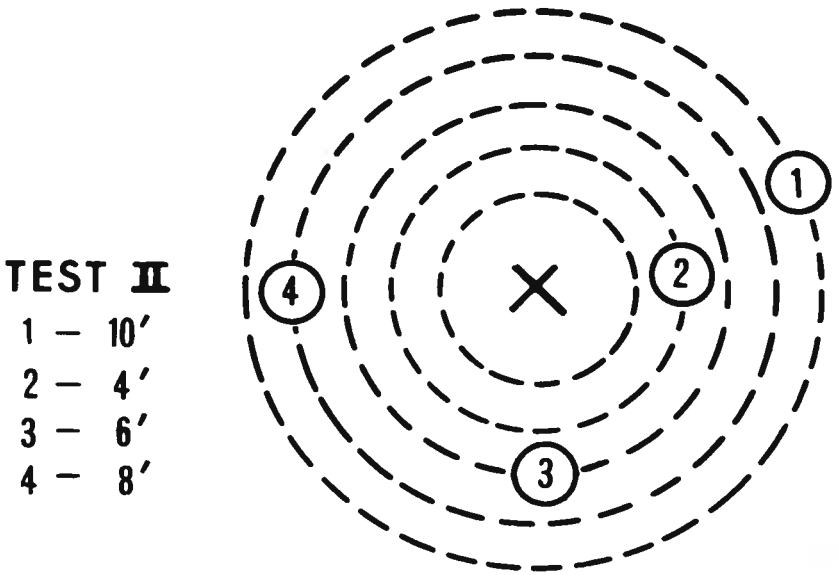


FIGURE 3. — Multiple object location.

3. *Moving, Scanning, and Locating.* This skill involved the ability to locate objects while moving through an area. Different objects were placed in varying sequences and the subject was instructed on how to scan in order to create an "auditory map" of his immediate environment. The subject was told how many objects were in his environment and what they were. He was instructed to find them in sequence before returning to the object he detected first. This skill involved both horizontal and vertical scanning in order to correctly identify and locate the objects.

Evaluation consisted of the same placement of the same objects as used in *Multiple Object Location.* Standing in the center of the circle (see Fig. 4) the subject was instructed to walk a rough circle (counterclockwise) and attempt to locate and identify each object in turn before returning to his initial object. The subject was told that there were four objects and was briefly familiarized with each of them before evaluation. A subject could score a possible 8 points over 4 trials minus any points for returning to any object which was not his original one. The order of the objects was randomized over all trials and for all subjects.

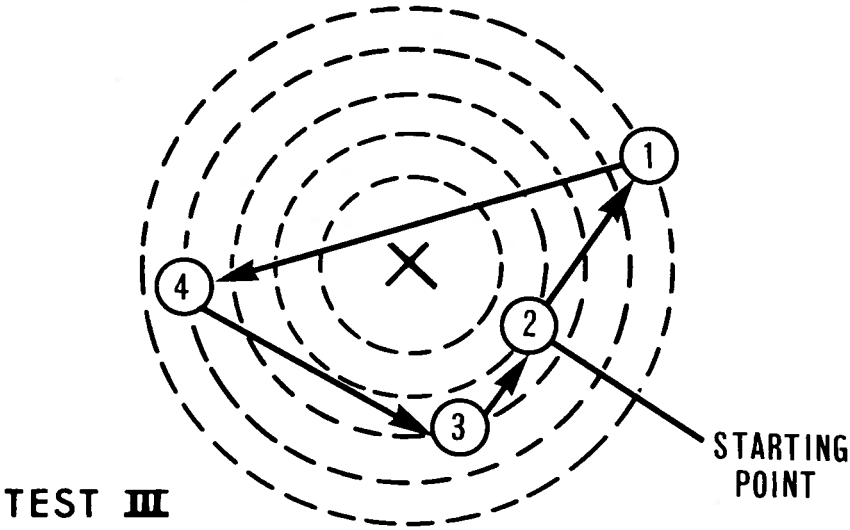


FIGURE 4. — Multiple object location.

Outdoor Training and Evaluation

Building on the development of indoor ranging and scanning techniques, the training program next emphasized outdoor performance. In this regard we continued our emphasis on ranging and scanning techniques (including long ranging) using natural objects and obstacles such as trees and bushes. We also developed certain navigational skills such as recognizing pathways, grass borders, curbs, doorways, steps, and driveways. Approximately 40 hours of training time were spent in this phase of the program. Evaluation of this phase involved two components:

1. *Tree Location.* This skill was quite similar to the indoor *moving, scanning, and locating.* Trees were used as targets and subjects were asked to find each tree in turn before returning to the starting tree. The course was approximately 50 yards in length (see Fig. 5) with the trees separated by approximately 10 yards. Each subject was given two trials on this course and his performance timed. A point could be earned for each correct tree identification. A point was subtracted if the subject returned to a tree previously identified. It should be noted that this was also a long-range use of the aid.

2. *Outdoor Mobility Course.* This course was designed to assess the generalized skills considered necessary in order to use the Kay device as a navigational aid. The course selected was a moderately difficult travel area (see Fig. 6). Subjects were familiarized with the course by walking through it once with the trainer before evaluation. All "harm events" were counted

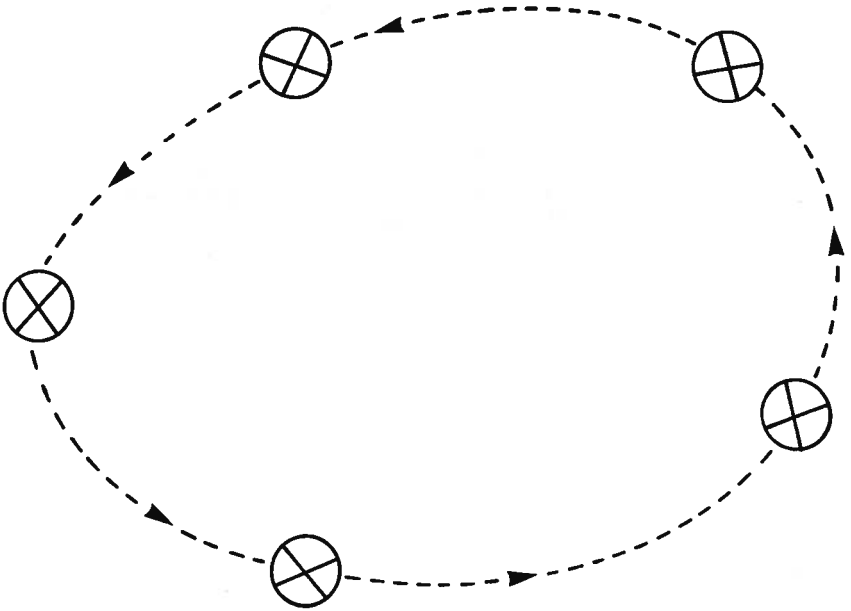


FIGURE 5. — Evaluation of five trees.

equally, such as bumping a curb, failing to follow a wall, missing a step-up or step-down, losing a grass-gravel border, and failing to find a doorway. Performance was timed and a point was given for each "harm event" committed (scored in a negative direction).

In addition to the formal training given at ACRIBAR, four subjects used the aid in their home or work environment for varying periods of time. This time was logged by the subjects and notes were kept by them on their personal use. All time logged outside of formal training was included in the quantitative estimate of total training time (see results section).

Additional Notes on Training and Evaluation

A number of technical developments were introduced at various points in the training program. These included:

A. The substitution of mercury cells for the carbon-zinc batteries in order to maximize battery output and control diminishing instrument pulse-rate and volume. The mercury cells delivered longer battery life and proved to be a more reliable power source.

B. The testing of a radio-link procedure designed to allow the trainer to hear the feedback from the subject's aid. This link proved to be valuable in outdoor work, giving the trainer better understanding of

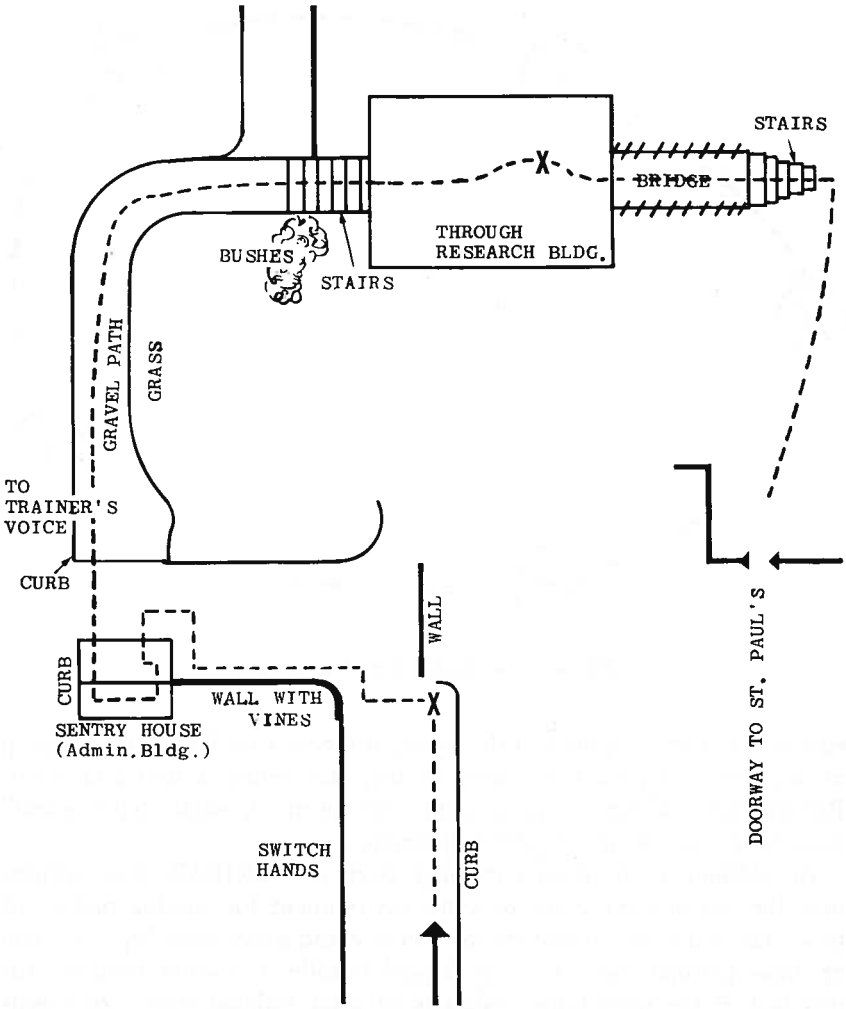


FIGURE 6. — Outdoor mobility course.

subject error and helping to shape the direction of supportive instructions.

A two-way citizens' band transceiver was used in this linkage, the transmitter connected by leads to the Kay device receiver. This transmitter picked up the same signal received by the subject, transmitting it within a range of 50 yards to the trainer's receiver.

IV. BACKGROUND VARIABLES

Description of Subjects

A total of 19 subjects participated in the training program over a 20-week period. However, the final sample on which complete data exist is 14. Five subjects were excluded from the final sample because of early termination (illness, job relocation or, in one case, death).

Initial screening was based on a sample recruited by mail from a list of approximately 150 selected blind males living in the Boston area. Subjects were screened first in order to produce a sample representative of an anticipated U.S. blinded veteran population for the years 1965-1975. A sample of 42 was then invited to ACRIBAR for preliminary interviews. Twenty-seven potential trainees were then selected from this sample. Selection at this stage was guided by the interviewer's estimate of the subject's ability and willingness to participate in a lengthy training program. Following this, intensive interviews and testing were conducted by a clinical psychologist on this sample of prospective trainees. Two subjects were dropped from this sample for reasons of incipient psychosis.

Four subjects were then randomly selected from this sample of 25 for a preliminary 1-month training period during which the project trainers received intensive teaching experience. During this time training methods were tested and developed to the form utilized in the formal training program.

Following this 1-month pretraining period, these four subjects were dropped from the final sample. Shortly before formal training began, 2 subjects dropped from the final pretraining sample reducing it to 19.

Age and IQ

The age range for the sample of 14 subjects completing training was 21 and 57 years. The mean age was 33.9 years and the median for the total distribution was 31.5.

The IQ range for the final sample was 100 to 144, based on projections of verbal sub-scale scores on *Comprehension* and *Similarities* from the WAIS. The mean IQ was 124.5 and the median was 125.5.

Vision and Hearing

All subjects were examined by a physician in order to determine the degree of remaining vision. With the exception of four subjects (who were subsequently blindfolded for all training and evaluation, Table 1) all subjects were judged totally blind.

Pure tone hearing tests were also conducted for all subjects using a standardized audiometric technique. On the basis of this test all subjects were judged to have normal hearing in at least one ear.[g] In addition to the

[g]This normal ear was subsequently employed for all Kay device training.

TABLE 1

Subject number	Degree of remaining vision	
	Right eye	Left eye
01	Light projection and very gross objects against light background (L > R). No color vision.	Anophthalmos with prosthesis.
02	Central acuity 1/160. Gross objects in all quadrants. No color vision.	Same as right eye.
07	Light projection only in all quadrants.	Same as right eye.
14	Central acuity almost 2/160. Light projection only in all quadrants. All colors good.	Light projection only in all quadrants.

audiometric testing, all trainees were given the Seashore Audio Perception Test. Scores on the timbre scale, the pitch discrimination, and the tonal memory section were derived, as well as a composite score for all three subscales. The composite score for the Seashore ranged from 7 to 41 out of a possible range of 3 to 42. The mean composite score was 22.9 and the median of the total distribution was 27.5. Table 2 gives the range, mean, and median for the Seashore subscales.

TABLE 2. — *Range, Mean, and Median for Seashore Subtests*

	Range	Mean	Median
Timbre	31–50 (0–50 possible)	41.8	41.0
Pitch	32–48 (0–50 possible)	43.3	44.5
Tonal memory	5–30 (0–30 possible)	22.5	27.5

Existing Mobility Skills

With the exception of two subjects (one using a guide dog and the other no mobility device) all subjects were cane users. Based on interview data, an estimate was made on the extent of previous mobility training (formal dog or cane training), and this figure was expressed in terms of weeks of training. The range for the final sample was 0–24 weeks with a mean of 10.8 weeks and a median of 11.0 weeks.

Age of Blindness

This represents the age at which the subject became legally blind. A score of zero represents congenital blindness The range for the final sample was 0–44 years with a mean of 16.3 years and a median of 13.0 years. Although these figures are lower than what would be expected from a representative blinded veteran population, they represent the best sample obtainable for the present study.

Previous Education

This represents the previous formal education of the subject expressed by the number of completed grades. A higher score indicates more education. The range for the final sample was 9 to 16 with a mean of 12.6 and a median of 12.0.

Hours in Kay Device Training

The number of hours spent in training were tabulated. These figures include hours spent in home practice as described in the *Description of Training and Evaluation Methods.* The hours for the final sample ranged from 26 to 99 with a mean of 61.1 and a median of 60.5.

Trainee Favorability[h] *Toward Device*

This represents rank estimates by the trainers regarding the subject's attitude toward Kay device training. Subjects were rated in the middle of the training program. All subjects were rated independently by the two trainers, their ratings having an interrater reliability of .85 (Kendall rank-order correlation). Higher scores represent greater estimated favorability.

Personality Ratings

It was decided to include ratings of subject characteristics by the project staff in the experimental and quantitative analyses. Three characteristics (motivation, anxiety, and concentration) thought to be potentially related to eventual task performance comprised these "personality ratings":

1. *Motivation.* This estimate was based on the psychologist's rating after the subjects had been accepted into final training. The main criteria were the subject's enthusiasm for the project and the motives behind that enthusiasm. For example, subjects mainly interested in financial remuneration were given a lower ranking even though their apparent enthusiasm level was similar. In all, 20 subjects were ranked; however, for the purposes of the statistical analysis, only 14 subjects were used. Fourteen was used as the highest rank (or highest motivation), one the lowest.

2. *Anxiety.* In previous psychological literature, anxiety has consistently been cited as one of the primary blocks to effective learning. In the

[h]Favorability is used as a synonym for favorableness.

present study, it was decided that any anxiety rating should be closely related to the learning experience of the subjects. Thus, the two trainers were asked to rate subjects' general level of anxiety in the training situation, anxiety being clinically defined as signs of nervousness, upset, uncertainty, etc. Subjects were ranked from 1 to 14. The higher ranks represented higher anxiety. Interrater reliability was .58 (Kendall).

3. *Concentration.* It was decided to ask the trainers to rate a more cognitive characteristic which seemed appropriately linked to Kay device learning ability—viz., concentration, or the ability to attend effectively to the training situation and to the training stimuli. Higher ranks on concentration represented higher concentration and vice versa. Interrater reliability was .82 (Kendall).

Personality Test Scales

Objective paper and pencil testing, though severely limited by the fact of the subjects' blindness, was nevertheless included as a possible source of prediction of success in training and performance[1]. Three tests were selected for their relative brevity, previous validity, and conceptual relationship to the possible learning skills required in the project:

1. *The Marlowe-Crowne Social Desirability Scale.* This test is composed of 33 true-false items. It was originally developed as a non-pathological test of social desirability (to replace the Edwards Scale). While it was very successful in the empirical literature, the construct changed such that it was considered a scale for "need for social approval." As research has continued (cf. Marlowe and Crowne, 1964), the construct of "defensiveness" has seemed increasingly appropriate. The scale has related to measures of repression against hostility, defensive behavior on projective tests, and defensiveness in interview behavior. Of more interest to the present study, it has been increasingly associated with cognitive and perceptual styles (cf. Cohen, 1966, for review of literature). Cohen (1966) found that high Marlowe-Crowne (M–C SDS) scorers had a greater intolerance of ambiguity and preferred more structured perceptual stimuli. He also found that M–C "defensiveness" was inversely related to openness to new and unusual experiences. The M–C SDS is scored as high defensiveness equaling higher scores.

2. *The California Personality Inventory Flexibility Scale.* The California Personality Inventory (CPI) is a widely used true-false personality test, also designed for relatively normal populations. One of its scales, Flexibility (Fx.), consisting of 22 items, was selected for the present study. The scale is designed to tap "the degree of flexibility and adaptability of a person's thinking and social behavior" (Gough, 1957, p. 13).

[1]Test items were read aloud to the subjects. The responses were indicated by hand gestures.

High scorers tend to be seen as "insightful, informal, adventurous, confident, humorous, rebellious, idealistic, assertive." Low scorers tend to be seen as "deliberate, cautious, worrying, industrious, guarded, mannerly, methodical, and rigid" (Gough, p. 13). Gough quotes three investigations which argue for the scale's validity: "(a) In an assessment sample of 40 University of California graduate students, Fx. correlated —.48 with staff's rating of 'rigidity.' (b) In an assessment study of 40 University of California medical school seniors, Fx. correlated —.36 with staff's rating of 'rigidity.' (c) In a college class of 180 students, Fx. correlated —.58 with the California F (authoritarian personality) scale" (Gough, p. 27). It was expected that greater flexibility might aid in learning Kay device skills, since the stimuli were probably quite new and different from anything the subject had previously experienced.

3. *The Intolerance of Ambiguity Scale.* Cohen (1966) developed a six item intolerance of ambiguity scale which was derived from the best items of three previous scales. In a recent study, ambiguity intolerance correlated with defensiveness, preference for structured perceptual stimuli, and closedness to new experience. In this project, the audio stimuli and extensive perceptual information which demand coding are likely to be experienced as very ambiguous, at least in the early phases of the project. Thus, ambiguity intolerance as a personality and cognitive trait might well obstruct ease of learning in the present project.

These three personality scales, being conceptually related, were pooled into a Personality Composite, which gave equal weight (from ranks) to each personality test.

All variables reported and summarized in this section are described in detail in the Appendix, "Code Book of Kay Device Variables." This appendix includes a listing and description of the variables' numbers, the scoring direction for all variables, and a brief description of the measures employed in this study.

V. RESULTS

This section presents a synopsis of the quantitative and qualitative analyses of major experimental variables. Part One includes a comprehensive description of the quantitative relationships among 36 operational measures, including variables representing performance and non-intellective factors: Special emphasis is given to the non-intellective correlates of Kay device skill competence. Part Two incorporates the implications of the quantitative data and adds qualitative and anecdotal material in presenting an objective evaluation of the Kay device as a potential navigational aid. In this attempt at evaluation, all relevant information from technical and electronic factors to subjects' reports, is considered salient for the purposes of a comprehensive conclusion.

PART ONE: Relationships Among Operational Measures

Introduction

In the present study, 36 experimental variables were statistically analyzed, each of which represented a performance, background, intellective, or non-intellective measure. Fourteen subjects met the criteria for inclusion in the statistical analysis; viz., they could be assigned scores on all the operational measures.

A complete description of each experimental variable, its numerical parameters, and its mode and direction of scoring are presented in the Appendix. Appropriate abbreviations for these variables will be used in the text. Statistical tests were generated through the computing and programing facilities of the Harvard University Laboratory of Social Relations and the Harvard University Computation Center. Program submissions were run on IBM 7090 Computers. The statistical analyses carried out on the data included the Kendall Tau Correlation, the Mann-Whitney U Test, the Chi-square transformation, the Wald-Wolfowitz Runs Test, and various frequency tabulations. All analyses were based on nonparametric techniques. Many of the experimental variables did not meet all the criteria for parametric data, and in the interests of standardization and conservatism, only ordinal data characteristics were assumed. Since most of the data easily met the criteria of ordinality, the Kendall correlation coefficient (Tau) was used as the principal statistic. Unless otherwise mentioned, it may be assumed that the other non-parametric tests substantiated the implications of the correlation coefficient. It is appropriate to note that correlations are reported for a relatively small sample ($N = 14$). Although this is a relevant consideration invoking caution regarding generalizability, it does not change the interpretation of statistical significance. Table 3 lists the values of Tau representing significance levels for an N of 14.

TABLE 3

Tau	Significance level	Tau	Significance level
.33	.10	.56	.005
.39	.05	.66	.001
.45	.025	.70	.0005
.51	.01	.78	.0001

In the following discussion, mention of a significance level will imply that results are significant at or beyond that level. When the word "significant" is used by itself, it assumes a significance level of .05 or beyond.

Relationships Among Performance Measures

Of the 36 experimental variables, 15 involved specific evaluation measures of a subject's skill with the Kay device. The general performance areas tapped included indoor and outdoor obstacle course traversal, ranging competence, and scanning and locating skills. Each major area was comprised of subtests as well as being represented by composite scores. If the intuitive and deductive assumptions behind the choice of evaluation measures were optimal, two empirical characteristics should be evident: 1. a reliable and consistent relationship among the subtests of each major area and among the composites of all areas, and 2. the subsequent existence of enough remaining variance to imply that the various skills, though related, are still distinct aspects of programatic learning. The following data supply evidence of such characteristics.[1]

Relationships Among Area Subtests

1. *Indoor Obstacle Performance.* The subtests of this evaluation procedure, Time and Errors correlated .54 with each other ($p < .01$). They correlated with the Composite score —.81 and —.78 respectively ($p < .001$ and $p = .001$).

2. *Ranging Performance.* The three subtests and ranging composite related as shown in Table 4. All correlations are in the expected direction and are significant with one exception.

TABLE 4. — *Intercorrelations of Ranging Subtests*

Subtest	R: Stat.	R: Mov.	R: 4–6–8	R: Comp.
R: Stat.	X	.43	.44	—.75
R: Mov.	.43	X	.28	—.64
R: 4–6–8	.44	.28	X	—.64
R: Comp.	—.75	—.64	—.64	X

3. *Scanning-Locating Performance.* The two subtests for scanning-locating correlate —.73 ($p < .0005$). They relate to the composite score —.88 and .85 respectively, as expected ($p < .0001$).

[1]A word is necessary regarding the interpretation of many of the negative correlations in this study. Since scores were transformed into ordinal data, it was often convenient to rank subjects. Often, highest scores were given a rank of one, lowest a rank of 14. Thus, there is an apparent reversal in the sign of correlations with such variables. Where the direction of the correlations is not specifically mentioned, the common sense or contextual (expected) interpretation should be inferred. If there is any remaining doubt, Appendix gives the scoring direction for each variable.

4. *Outdoor Performance.* Relationships of the performance on outdoor tasks are as shown in Table 5. Although the subtests' correlations with the composite are all highly significant, the Trees measure correlation with the outdoor obstacle course variables does not reach significance. It seems reasonable to guess that the inherent similarity of the skills demonstrated on the tree-finding task and the obstacle course traversal is not as great as the inherent level of similarity in the other evaluation areas. However, the comparable high correlation of Trees to the outdoor composite score may justify its inclusion in this subscale.

TABLE 5. — *Intercorrelations of Outdoor Subtests*

Subtest	Trees	M-Skill: Time	M-Skill: Err.	Outdoor comp.
Trees	X	.28	.27	—.56
M-Skill: Time	.28	X	.39	—.57
M-Skill: Err.	.27	.39	X	—.66
Outdoor comp.	—.56	—.57	—.66	X

Relationships Among Area Composite Scores

An obvious question to ask is whether the skill areas are related to each other and to the Overall Performance Composite. (The Overall Performance Composite—or OPC—is the single most important variable for the purposes of this investigation.)

The relevant data are as shown in Table 6. It is noted that all the relationships are statistically significant, and that none of the correlations between the four skill areas and the Overall Performance Composite (OPC) drops below the .005 level. However, the variance unexplained still implies that each skill area is conceptually and empirically distinct as well as justifying the use of the OPC as an accurate representation of each subject's performance with the Kay device.

TABLE 6. — *Intercorrelations of Performance Task Composite Scores*

Task composite	Indoor obs. comp.	Ranging comp.	Sc.-locat. comp.	Outdoor comp.	Overall comp.
Indoor obs. comp.	X	—.61	—.45	.66	.64
Ranging comp.	—.61	X	.41	—.40	—.66
Scan locat. comp.	—.45	.41	X	—.40	—.71
Outdoor comp.	.66	—.40	—.40	X	.69
Overall comp.	.64	—.66	—.71	.69	X

All the variables included involved skills involving the Kay device. However, measures were also obtained for the traversal of the indoor course with the existing mobility devices. Interestingly, performance with existing device correlated +.40 with subsequent performance on the same course with the Kay device. In addition, it correlated +.46 with the Overall Kay Performance Composite (OPC). This would imply that a generalized skill (involving learning with mobility devices in general) is present in this subject population, reflecting a more general learning competence.

Relationships Among Non-Performance Factors

The rationale behind the inclusion of 19 background, intellective, and non-intellective characteristics lies in the possibility that these variables are antecedents, predictors, or meaningful correlates of the ability to learn skills necessary for adequate utilization of the Kay device. Most of the non-performance variables are single items and will be discussed in the following section. However, there are three clusters of variables which incorporate several items. It is appropriate to examine the interrelationships within these clusters before relating them to performance measures.

1. *The Seashore Test.* This measure includes three subtests which all represent some facet of the skill in audio discrimination, comprising the elements of timbre discrimination, pitch perception, and tonal memory. It is also possible to tabulate a composite score which gives equal weight to the subscales. The relationships among the subscales and composite are as shown in Table 7. All the Tau values are significant at the .02 level at least. There is clearly a generalized factor representing audio discrimination, but again, each subtest does seem to represent a unique audio sensitivity. Unless noted to the contrary, it will be assumed that the Seashore Composite Score reflects the same direction as each of its subscales at the same general level of significance.

TABLE 7. — *Intercorrelations of Seashore Subtests*

Task	Timbre	Pitch	Tonal memory	Seashore composite
Timbre	X	.49	.55	—.77
Pitch	.49	X	.55	—.63
Tonal memory	.55	.55	X	—.75
Seashore comp.	—.77	—.63	—.75	X

2. *Personality Ratings by Staff.* Certain personality and learning attributes were rated by staff members; viz., motivation (by the psychologist

previous to training) and anxiety and concentration (by trainers at the mid-point of training). The interrelationships among these variables are as shown in Table 8.

TABLE 8. — *Intercorrelations of Staff Rating of Personality*

Rating	Motiv. Est.: Psych.	Anxiety: Tr.	Concentration: Tr.
Motiv. Est.: Psych.	X	.03	.49
Anxiety: Tr.	.03	X	—.03
Concentration: Tr.	.49	—.03	X

While the correlation between motivation and concentration is significant at the .02 level, the other Tau values are totally non-significant. This is apparently due to the low discriminating power of the anxiety rating. It would not be surprising if the trainers' anxiety ratings were relatively invalid, anxiety being such a difficult construct to operationalize even under the most sophisticated experimental conditions. In any event, there is no empirical justification for the creation of a personality rating composite score.

3. *Personality Scales.* The rationale behind the inclusion of the three personality scales was based on the hypothesis that the psychodynamic and resultant cognitive dimensions tapped would have a helpful or detrimental effect on learning a new skill. It seemed reasonable to expect that relatively defensive, inflexible, and ambiguity-intolerant individuals would find it more difficult to perceive and integrate complex cognitive information. Training for the Kay device would seem to demand openness to new experience, a suspension of massive self-criticism, and a tolerance for cognitive ambiguity. Thus, there was some expectation that the three personality measures might form a meaningful cluster. The relevant data are shown in Table 9.

TABLE 9. — *Intercorrelations of Personality Test Measures*

Test	M–C SDS	CPI: Fx	IOA	Pers. comp.
M–C SDS	X	—.46	.32	—.66
CPI: Fx.	—.46	X	—.27	.63
IOA	.32	—.27	X	—.55
Pers. comp.	—.66	.63	—.55	X

Generally, the expectation holds up, results showing highly significant relationships among the scales and composites with the exception of the Intolerance of Ambiguity Measures' correlation with the other two scales. (Despite sign direction differences, all results are in the expected direction.) The relative weakness of the IOA scale might be explained by the fact that it calls for five discriminations by the subject and for a visual or cognitive memory organization by the subject (since the item had to be read aloud). Some confusion in responses was noted during testing, and it is probable that a five point response is less valid than a true-false choice given the same item. However, the correlations are strong enough to justify the inclusion of the IOA in the Personality Composite (PC), which does seem representative of a syndrome. For labeling purposes, the Personality Composite dimension is called "defensive inflexibility."

Correlates of Kay Device Performance

Second in importance to the question of the potential utility of the Kay device is the question of the antecedents and correlates of effective learning in training. Obviously, in possible future populations, universal training with electronic navigational aids would be unlikely. It would be extremely helpful to have predictive instruments which could assist in subject selection. In this section, this question is squarely faced. What characteristics make for good Kay device performers? Are physical, sociological, or personality characteristics more influential? Or are such non-performance factors overshadowed by experiential training factors, such as the number of hours the device was used? These questions are answerable in the present study.

1. *Age.* The correlation between the subjects' age and their overall performance (OPC) was —.25. This is not significant but represents a tendency for the younger subjects to be better learners. Another possible relevant aspect of age is that age at which the subject was blinded. The relationship between age at legal blindness and overall performance was —.20, again non-significant but suggesting that the younger subjects perform better. (If age at blindness, as a linear measure, was more important than sheer age, the correlation should have been higher than the age correlation. This was not the case.) Although it is interesting to note that of the five subjects who might be considered congenitally blind (3 years or under), four were in the high performing group, no firm conclusions can be made because of the fact that all five were relatively young men at the time of the study.

2. *IQ and Previous Education.* The notion of IQ scores as representing "general intelligence" has rapidly become antiquated, especially if that notion assumes an inherent capacity which pervades all skills. However, IQ test scores do occasionally have high predictive power when the

tasks are relatively generalizable in terms of learning skills. In the present study, verbal intelligence, as approximated by scores on the comprehension and similarities subtests of the WAIS, were correlated with performance measures. The correlation of IQ with Overall Performance was +.25, non-significant, but suggesting a slight positive relationship.

One can ask whether experience in formal education might reflect a familiarity with training and proclivity towards intellectual competence—and thus relate to facility in learning Kay device rules. The correlation of previous education in grades and OPC is +.32, higher than IQ, but still not statistically significant. However, this variable is significantly related to three of the performance subtests and also correlates very highly ($p < .005$) with the Seashore Pitch measure (+.65).

3. *Previous Mobility Training.* Moving from more generalized to more specific potential predictors, previous mobility training is considered. It might have been expected that subjects who received more training with other modes might be more amenable to Kay training and thus perform better. However, the —.17 correlation with Overall Performance is not only insignificant, but in the wrong direction. Throughout the correlation matrix, the number of weeks of previous training was consistently unrelated to the performance and non-performance variables.

4. *Hours of Training.* The actual number of hours each subject trained with the Kay Device varied, first because of attendance and scheduling deviations, secondly because of the provision for exploratory field testing at home. Surprisingly perhaps, the relationship between number of hours of training and OPC was —.19, an inverse relationship. Clearly, sheer quantity of experience using the device is not an overwhelming predictive factor, given the variance and the size of the present sample.

5. *Audio Discrimination Ability.* The interpretation of sound signals is the sole basis on which the subject learns to utilize his device for environmental sensing. As might be expected, competence on the Seashore test is positively related to Overall Performance with the Kay device (.29). While this correlation with the Seashore Composite is not significant, the pitch subtest correlates +.42 with OPC, and between .33 and .40 with the four major performance subcategories. This makes great sense since pitch perception is the way in which the subject learns to determine distance with the Kay device. So far, the Seashore measures have provided the most powerful predictions of final performance.

6. *Subject Favorability Toward Device.* Trainers made estimates of each subject's attitude toward (like or dislike) the device at a time three quarters of the way through training. Again, somewhat surprisingly, the relationship between favorability and OPC was only .15, in the expected direction, but certainly not significant. This is surprising in that the favor-

ability ratings can claim some evidence of concurrent validity because of the correlation with the psychologist's estimate of their motivation (+.65).

7. *Personality Ratings.* In predicting performance measures, the anxiety measure was weakest (.07 with OPC). This corroborates the possible weakness of the rating implied above. The psychologist's rating of initial motivation correlated +.35 with OPC. While this figure is significant at only the .10 level, it does suggest what might have been expected; viz., subjects who are more enthusiastic about the project learn more easily. A highly significant correlation was found between the trainers' rating of subject's concentration and OPC — +.69 ($p < .001$). It predicted most strongly for the Ranging (.63) and Indoor Obstacle (.54) tasks. In this rating, concentration was closely allied to estimates of attention-span. It does seem reasonable that subjects who could attend to the audio information and the instructions of the trainers would best learn the most important device discriminations and thus be able to perform better. It must be cautioned, however, that the rating was made in the midst of training, and there is no justification for claiming it as an antecedent variable. In any event, the ability of the subject to concentrate on his learning techniques is positively related to his eventual performance on evaluation measures.

8. *Personality Test Scales.* Perhaps the most intriguing and exciting results of this study is the finding that "defensive inflexibility" as a personality trait is consistently predictive for Kay device performance. The M–C SDS (defensiveness), CPI (flexibility) and Personality Composite all show clear relationships to the performance measures. The exception is the IOA scale, which, e.g., correlates —.10 with Overall Performance, and which does not relate significantly with any of the 17 performance variables. It is doubtful that intolerance of ambiguity is unrelated to Kay performance, but it is likely that problems in the administration mentioned earlier, make the IOA scale unreliable in the present study.

The three other measures, however, show a wealth of significant results. Of the 17 correlations with performance measures, 8 M–C SDS Taus are statistically significant. The respective CPI figure is 7 of 17, and the Personality Composite has a striking 11 of 17 possible correlations statistically significant. (By chance, only one of 17 correlations could be significant at the .05 level or better.) Table 10 shows the correlations of these personality scales with the major performance areas.

Despite the differences in signs, all these figures are in the expected direction. The Personality Composite correlates at the .05 level or better with all the performance composites with the exception of the Outdoor Composite. (Recall that the internal correlations of the Outdoor Composite were the weakest of the performance categories.) The best correlations are among the personality scales and the Ranging Composite, ranging being

TABLE 10. — *Intercorrelations of Personality Scales and Major Performance Task Composites*

Scale or task	M–C SDS	CPI: Fx	Personality composite
Indoor course (exist. mob. aid)	—.39	.52	.46
Indoor course (Kay device)	—.33	.41	.44
Ranging composite	.47	—.50	—.49
Scanning location comp.	.49	—.30	—.42
Outdoor comp.	—.18	.27	.26
Overall performance comp.	—.41	.38	.39

perhaps the most central skill involved in Kay device navigational competence. It is important to note the comparable high relationships of the personality measures with the obstacle course performance (with existing mobility aid.) This implies that "defensive inflexibility" as a personality and cognitive characteristic is a relevant correlate of learning and competence with any navigational aid.

It is important to analyze further the possible influence of the personality cluster on Kay performance. When, for example, one notes that the Personality Composite predicts Kay device performance on the indoor obstacle course better than does performance on that same course with existing mobility aid (.46 vs. .40), we owe it a closer look. There always exists the statistical possibility that a third variable, related both to personality and performance, is responsible for much of the variance. But the evidence for this in the data is scant. In the first place, the personality measures are consistently more significantly correlated with performance than any of the other background variables. Secondly, previous research has shown that such personality characteristics are relatively long-standing and are not influenced tremendously by situational factors. Thus, it is unlikely that previous navigational competence, for example, would create "non-defensive flexibility."

It is interesting to note that the Personality Composite correlates +.54 with the IQ estimate and —.31 with Age. Since the comparable figure for IQ and Kay Performance was only .25, it is unlikely that general intelligence is the primary antecedent factor; in fact, it seems more reasonable to assert that the personality characteristics influence learning and performance measured both on IQ tests and on mobility aid evaluations. From the same line of reasoning, Age cannot be the prime determining variable since its correlation with OPC is —.25 (*lower* than its correlation with the Personality Composite).

Considering other background variables, one can dismiss the following variables as being more influential than the personality tests because of

their relatively low correlations with performance measures: previous mobility training, hours of Kay device training, favorability toward device, and personality ratings (with the exception of concentration). The only other hypothesis, though conceptually unlikely, is that audio discrimination ability is responsible for much of the variance explained by the personality tests. The comparison, shown in Table 11, helps us to test this idea.

TABLE 11. — *Comparison of Correlations with Seashore Test* (With Personality and Performance Measures)

Test	Seashore pitch	Seashore composite
CPI: Fx	.47	—.41
Ranging composite	—.38	.34
Personality comp.	.53	—.46
OPC	.42	—.29

In each case, the personality measure is a better predictor of Seashore performance than Seashore performance is of Kay device performance. If audio discrimination ability was responsible for the high correlations between the personality measures and Kay performance, these findings should have been exactly the reverse. In sum, there is no statistical evidence of a third variable or variables accounting for the personality-performance intercorrelations. Indeed, there is evidence to show that the personality scales correlate more highly with other background variables than do performance measures.

Discussion

The finding of highest prediction with the personality measures deserves some further comment. The most probable explanation for these relationships is to be found in the growing body of empirical research showing that personality characteristics are inseparably linked with cognitive styles. Defensive inflexibility, as measured in the present study, has been empirically related to cognitive characteristics such as "intolerance of cognitive ambiguity," preference for structured perceptual field, "openness to new perceptual and cognitive experience," etc. (cf. Cohen, 1966, for a review of such finding.) Furthermore, Cohen (1966) found that repressive defensiveness (associated empirically with defensive inflexibility), was a deeply embedded personality dimension which had great influence on emotional, psychodynamic, and cognitive variables. Thus, it is not unreasonable that defensive inflexibility, resultant in ambiguity-intolerance and closedness to new experience, is inversely related to the ability to perceive, categorize, and decode a plethora of new audio information, by its very nature ambiguous.

In a theoretical sense, it might be most profitable to view defensive inflexibility as part of a syndrome involving cognitive characteristics and learning facility as well. It is not necessary nor particularly meaningful to demand an interpretation that personality characteristics were antecedent to navigational aid learning facility. Since such learning involved complex perceptual and cognitive transformations, it might be more useful to think of the defensive inflexibility dimension and the learning dimension as interpenetrating. From an empirical perspective, however, these personality measures may offer a more economical predictive technique than performance measures.

Summary of Part One

This section presents results obtained from statistical analyses of the interrelationships among experimental variables, both performance and non-performance variables, as well as their interaction. Intercorrelations among subtests of the major performance categories (training and evaluation) showed high internal consistency. The major performance composites also related highly to each other and to the overall composite for Kay device performance. Among non-performance measures, the Seashore Test measures and the Personality Scales were internally consistent, while the Personality Ratings were not.

Several possible non-performance correlates were examined for their predictive or concurrent relationships to performance with the Kay device. Age and age at Blindness showed a slight, non-significant inverse relationship with performance. IQ and previous education showed a tendency to be related to higher performance, but again not significantly. Previous mobility training was inversely related to performance, at a very low level of significance. Hours of training with the Kay device had *no* significant relationship with performance—the very slight relationship was an inverse one. Performance on the Seashore Test was positively related to Kay performance, the pitch subtest reaching statistical significance with OPC.[k] Subjects' favorability toward the device was not significantly related to Kay performance. Trainers' ratings of subject anxiety were unrelated to performance. The psychologist's rating of pre-study motivation was positively related to OPC, approaching significance. Trainers' ratings of subject concentrative ability at the mid-point of training were highly significantly related to overall performance. The most striking relationships were the personality scales' consistent significant relationships with performance measures.

It is suggested that a Personality Composite dimension labelled "defensive inflexibility" is one of the most important antecedent correlates

[k]Overall Performance Composite.

of eventual mobility aid learning ability. The Personality Composite Score measures defensive cognitive styles. It included the Marlowe-Crowne Social Desirability Scale Score, the Flexibility Scale Score (from the California Personality Inventory) and the Intolerance of Ambiguity Scale Score (from the Cohen Composite Scales).[l] Statistical analyses showed that personality measures seemed to be contributing independent variance in the correlational matrix and were also highly related to some of the other background variables. Finally, it is suggested that certain personality, cognitive, and learning characteristics composed a syndrome which was relevant to the acquisition of skills pertinent to utilizing an ultrasonic aid.

PART TWO: Observations on the Kay Device Evaluation

Device Reliability

A major problem of the training program described in this report lay in technical failures with the ultrasonic device. Repeated device failures and difficulties under laboratory conditions raised certain questions regarding the adequate functioning of the Kay device under real-world-stress conditions. Our own field experimentation was too limited to give us data in this regard, but an extrapolation from our laboratory work would lead us to suggest that many problems could arise. In addition to minor repairs made by ourselves, a total of 24 defective aids was returned to the manufacturer during the course of our training program, an average of approximately two breakdowns per aid used in the program.[m]

As to reliability, three major problems arose: 1. lead breakage in the power supply cable, 2. switch failure, and 3. transducer breakdown. While these problems represented great inconveniences they could be adequately controlled in production units in the future.

A continuing problem with the Kay device was the unreliability of the pulse-rate. Upon testing it was found that there was great variance among devices along this dimension, while sometimes, due to losses of battery strength, there seemed to be independent variation btween devices. In the course of training we rotated our devices among our trainees; the inconsistency of the signals in this respect often proved confusing and required a period of special adjustment.

Another difficulty was the fluctuation in volume across the devices used in our program. This seemed to be a factor also somewhat independent of battery strength but clearly related at the extremes of full power and exhaustion. Many of our trainees found the inconsistencies in volume control to be an annoying factor in their training.

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[l]See Appendix: Code Book of Kay Device Variables, Variable 6.

[m]We wish to thank Ultra Electronics for their quick and conscientious replacement of aids with technical failures.

Even before training began, when we realized that the devices had no internal provision for voltage regulation, we planned to use Mercury batteries instead of the original Carbon-Zinc batteries, but we rejected the idea because the voltage of the Mercury batteries would fall in cold weather. The performance of the Carbon-Zinc batteries, however, left so much to be desired that shortly after the beginning of the training program, we changed to Mercury batteries which were carried in the subject's shirt pocket to keep the batteries at a favorable temperature.

Personality and Training

Our statistical data indicate a very close and significant relationship between Kay device performance and a personality dimension we have summarized as "defensive inflexibility." Our qualitative data lend strong support to this relationship. We noted that the influence of personality factors became most pronounced during evaluation sessions and particularly during the later part of the training program when the skills became more difficult. Many subjects whose early opinion of the Kay device was quite favorable lost interest later in the program when our work moved outside.

One reason for this may have been that our navigational training required more concentration than the simpler indoor exercises. With an increase in outdoor ambient noise the trainee was forced to pay closer attention to the device feedback. An inability to concentrate at this point in training could easily manifest itself in performance measures on our outdoor evaluation.

We also noted a tendency for the continued use of the device in outdoor settings to cause a certain degree of annoyance in our trainees. One of our subjects stated:

> "It seems to me that this instrument requires for its successful use a degree of concentration unmatched by any travel aid now used, and this takes some getting used to. Sometimes I get pretty annoyed with it when I try to use it in a busy area. All the noise makes it hard to keep my attention on the sound of the signal."

This trainee was one of our best subjects throughout the course of the training program. His observation was based in part on his experiences with the aid in a semi-familiar home environment.

Another trainee, one scoring quite high on the flexibility scale, reported:

> "I find that my performance with the Kay device does seem to vary somewhat from day to day. While there does seem to be a basic norm to which I return from one direction or another, I think it is important to notice that performance does vary. My strong feeling is, incidentally, that this inconsistency is, at least in my case, in the user and not in the instrument."

This report reflects an important aspect of the interaction of concentration and training performance. Specifically, this subject recognizes the inevitable fluctuations in his own performance and is cautious not to attrib-

ute his own fluctuations to problems with the device. This is in contrast to a number of subjects who would attribute their own fluctuations in mood and concentrative ability to difficulties with the device itself. However, it should be noted that device reliability is sufficiently suspect to warrant a measure of support to these claims. It is difficult to unravel the complex interaction between device reliability and subject reliability in this regard. Our observations suggest that our better subjects recognize their own fluctuations, become less anxious with these performance fluctuations (whatever their genesis), and generally level out these fluctuations over time. It may also be noted that our data indicate a correlation approaching significance between concentration and flexibility as measured by the CPI (Tau $= .34$; $p < .10$).

Device Limitations

A consistent observation of our training staff was that the Kay device was ineffective in locating ill-defined step-downs such as sloping curbs or low steps. The majority of the trainees were not able to pick up the signal of a step-down. This proved to be a source of major anxiety to almost all the trainees, especially when outdoor work was emphasized. It was inevitable that our trainees would compare this aspect of the Kay aid with the information given by the cane:

> "I find that I have little trouble in detecting and avoiding relatively high objects but low objects and step-downs remain quite a problem. These can be detected if specifically being sought but if not expected they are often missed, and in the case of stepdowns, usually missed. Probably the biggest cause of this is the necessity of moving the instrument in an arc occasionally to determine the environment on either side. This is enough to allow many low objects to escape detection. You have to use the cane this way also but the cane more easily tells you if a step-down exists."

Another subject reported:

> "In comparison to the cane I have no faith in my ability to locate small step-ups or any step-downs. The device seems to detect a drop of under a foot only when it is too late to react. This is because you have to hold the device at an angle favoring the ground and in doing this you give up everything else."

It is interesting to note that it is much easier to pick up a step-up than a step-down with the Kay device. A flight of stairs, for example, is easily detectible from the bottom through a simple vertical scanning technique. Approaching the same flight of stairs from the top is a much more difficult and dangerous matter. In this case, the aid will suggest a drop-off, but not easily or clearly the nature of the drop-off.

Similar to the step-down and drop-off problem is the difficulty of locating small objects on the ground such as toys; e.g., roller skates, potentially dangerous obstacles in a travel path. In this case, a forward sweeping motion of the Kay device will usually reveal higher objects but will usually not reveal low-to-the-ground objects with the same scanning motions. The

difficulty here is that these objects "come in under the radar" for the most part and will not be detected unless specifically looked for. The economy of motion in scanning with the device suggests the maximum information feedback a few feet above the ground in a line approximately 30 deg. to the ground ahead of the traveler. This angle will usually miss these low objects. However, again it must be stressed that the device is capable of registering the existence of an object such as this; the question for training purposes is whether the human can register this information and what types of information trade-offs are necessary in scanning.

In indoor training exercises our subjects could detect objects such as small baskets when they were specifically looking for them (cf. *scanning* and *locating,* page 133). Outside, however, in real-life situations, the complexity of the informational input made this kind of discrimination quite unlikely for a majority of our subjects.

Navigational Capability

In sum, most of our subjects spoke favorably of the Kay device in the context of using the device as an obstacle detector rather than a navigational aid. This feeling may reflect to a large extent our own training emphasis on a controlled laboratory setting and a piecemeal learning process. Other writers (Gissoni, 1966) see the utility of this device extending to full field navigation, but there is little in our own data which suggests an immediate extrapolation to this application. A few of our subjects felt that with continued training such a use of the device might become possible; however, this was a cautioned optimism and probably reflected many of the difficulties such as step-down discrimination and low object detection. Commenting on the use of the device as a navigational aid under snow conditions one of our trainees reported:

> "I found the instrument to be at its maximum usefulness when there was snow on the ground. I was able to use snow banks as guides in walking a straight line when the sidewalks were well shoveled, and when they were not the device was excellent at finding the piled snow so that I could go around it or over it. It may be a great help in finding paths through snow banks also."

Some of our trainees suggested that continued intensive training might help to develop great proficiency in discrimination and that their hesitancy to use the aid as a navigational device reflected more on their present level of competence than on inherent difficulties with the device itself. It should be remembered that our training program had a maximum of 100 hours, a training period too small to develop adequate navigational skills. One of our trainees, quite high in measured flexibility and considered the best subject by our training staff, reported:

> "I think that with more time and careful study I could eventually develop great proficiency with this device. I think that it takes a long while to adapt to this novel system of stimuli and it takes a hell of a lot of practice."

This same subject suggested that the best use of the Kay device might be in combination with another mobility aid like the cane, the Kay device giving "long-range" information and the cane giving reliable information on low objects and step-ups and step-downs. The problem with this suggestion lies in the simple fact that with the currently available model, the user must employ both hands for this purpose. This subject suggested some design improvements which would attempt to build an ultrasonic sensing device into the cane itself.

Four of our trainees used the device in home settings approximating navigational use of the aid. Some of their comments lend support to our observation that continued and specialized navigational training is necessary in order more fully to evaluate the utility of the Kay device for this purpose:

> "When you are walking down the street the cane gives the necessary and immediate contact; with the device you receive a lot of irrelevant information as well. I slowly began to be able to distinguish the sounds I needed from those that were not important to my travel path. I guess that with more practice I could get better at this."
>
> "I would say that I spend about one to two hours a week at home with the device. Though I do take the device with me almost everywhere I go, it is often not in use since I find myself relying on the white cane when time is a factor. Walking with the device is a slow business and I feel I have to be more on the alert and more careful with it. Maybe with more work I could rely on it more comfortably."
>
> "For the past two weeks I have used the device most of the time in traveling to and from work; about a half-hour a day. I found that my confidence in my ability to detect objects in my path slowly increased and at this point I feel quite assured in this aspect of the device."
>
> "Most of the time I am just confused by all the jumble of sounds I hear when I am in the street. The sounds I usually depend on are more difficult to hear when the device is on; although this gets better the more used to it I get. I really would be afraid to depend on this alone."

Given the amount of emphasis to navigational training in this program, our obstacle course data provide an initial estimate of the relative effectiveness of the Kay device as a navigational aid.

An obvious comparison is the difference between each subject's performance on the indoor obstacle course with his existing mobility device before training was initiated and his performance with the Kay device after training ended.

Thus subjects took about twice as long to traverse the course with the Kay device. The difference in performance is statistically significant ($p < .01$, t-test). Much more striking however, is the difference in number of errors made. Kay subjects made, on the average, 6 times as many errors. The difference is significant beyond the .0005 level (t-test). Certainly, it is no surprise that subjects perform better with the technique they may

TABLE 12. — *Performance on Indoor Obstacle Course with Existing Aid and Kay Device*

Measure	Existing aid		Kay device	
	Mean	Median	Mean	Median
Total time (two trials)	4.7 min.	4.5 min.	9.1 min.	9.8 min.
Number of errors (two trials)	5.4	5.0	31.5	32.0

have been using for years. However, if the Kay device were a comparable navigational aid, one might have expected the differences to manifest themselves in the time taken rather than in the number of errors made. It is clear that the subjects' level of proficiency for detecting and navigating around obstacles with the Kay device is clearly inferior.

Training Recommendations

It is our opinion that future research on the Kay device should emphasize the following points:

1. Subjects should be selected who demonstrate the personality dispositions conducive to training programs of this kind. Specifically, subject screening should emphasize the selection of individuals who are flexible and tolerant of ambiguity. Training regimens should be more easily learned by this group and they should more easily acquire the skills relevant to using an ultrasonic aid.

2. Training for navigation should be a special program of field work with intensive use of the aid the primary goal of training. We would recommend at least two hours per day of training in this respect.

3. Training for navigation should emphasize particularly recognition of step-ups and step-downs and the detection of low objects in the travel path. Training should be conducted initially in semi-familiar territory moving quickly to training in unfamiliar territory.

4. Special evaluation methods should be developed to measure the acquisition of navigational skills. The imposition of laboratory measures may not tap the same skill dimension as those required for navigation.

5. Particular attention should be paid to the re-design of the ultrasonic aid so that it could be used in conjunction with a cane. Evaluation of the cane-device system could compare performance with the Kay device alone and the cane alone under field conditions.[n]

[n]An adaptation of the Kay system to a head-worn "spectacles" unit is now in research by Dr. Leslie Kay.

VI. SUMMARY

This report describes a training and evaluation program for the Kay ultrasonic mobility device. The rationale for laboratory testing and field testing is discussed against the background of the requirements for careful assessment procedures. Some of the information requirements for any mobility device are examined and the Kay aid is discussed in this context. The research objectives of this study are examined in light of background variables and training evaluation procedures.

Fourteen trainees completed a 20-week training and evaluation program with the Kay aid. Skill parameters were determined and training procedures were designed around these skills. Evaluation followed closely the training procedures in almost all cases. Evaluation included obstacle course performances before and after Kay training, and specific skills such as ranging and locating objects. Outdoor work emphasized navigational skills and evaluation was based on mobility course using "harm events" and time as measures of skill.

Background data including age, IQ, hearing and vision, age of blindness, previous education, hours spent in training, trainee favorability toward training, anxiety, concentration, and personality test data were taken on all subjects and these measures were related to performance.

Data from this study indicate that the major performance composites related highly to each other and to the personality scale composite scores. It is suggested that "defensive inflexibility" was one of the most important correlates of mobility aid learning. The data strongly suggest that certain personality dimensions, cognitive and hearing abilities such as pitch discrimination compose a syndrome which is extremely relevant to the acquisition of skills relevant to using an ultrasonic aid.

However, many difficulties in navigational use of the Kay device could not be approached directly in this study. Our subject reports and data suggest certain training recommendations for full field research on the Kay device which appears to be promising if certain trainee selection and training methods are established. Our research suggests certain recommendations to this effect.

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APPENDIX

Code Book of Kay Device Variables

Variable	Column	Item, measure and scoring direction
	1	Item: Card Number. Measure: IBM card number for each subject. Scoring: All subjects receive score 1.
	2, 3	Item: Subject Identification. Scoring: From 01 to 19 with the following notes: Subjects 15, 16, 18, and 19 excluded from final sample because of early project termination. Subject 17 excluded from final sample because of early project termination (deceased).
	4	Item: Availability of all data. Scoring: 1 = all data available. 2 = data incomplete. Final sample of N = 14 score 1. Early terminations N = 5 score 2.
1	5, 6	Item: Age in years. Scoring: Self-explanatory. Scoring range: 21 to 57.
2	7, 8	Item: Verbal IQ estimate minus 100. Measure: Estimates of verbal IQ from WAIS. Projections from scores on Comprehension and Similarities Subscales. Scoring: Based on a mean of 100, standard deviation of 15. Regular interpretation. Add 100 to Var. 2 to derive estimate.
3	9, 10	Item: Marlowe-Crowne Social Desirability Scale Score. Measure: Personality estimate of defensiveness (approval dependence). Scoring: Higher scores = higher defensiveness. Range: 3 to 27. Highest possible score = 33, lowest possible score = 0.
4	11, 12	Item: Flexibility Scale Score (from California Personality Inventory). Measure: Personal flexibility. Scoring: Higher scores = greater flexibility. Range: 3 to 20. Highest possible score = 22. Lowest possible score = 0.
5	13, 14	Item: Intolerance of Ambiguity (from Cohen Composite Scale) Scale Score.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
5	13, 14	Measure: Intolerance of Ambiguity (6 items). Scoring: Higher scores = higher intolerance of ambiguity. Lower scores = lower intolerance of ambiguity. Range: 10 to 27. Highest possible score = 36. Lowest possible score = 6.
6	15, 16	Item: Personality Composite Rank. Measure: A Composite score, expressed in total ranks, of defensive cognitive style. Includes ranks on Defensiveness (Var. 3), Flexibility (Var. 4) and Intolerance of Ambiguity (Var. 5). Scoring: Ranks on each of the component scales (lower rank number representing higher defensiveness) totaled. Thus, high scores = low defensiveness, low scores = high defensiveness. Range of rank totals: 5 to 40. Highest possible score = 42. Lowest possible score = 3.
7	17, 18	Item: Motivation Estimate (Psychologist). Measure: Estimate by psychologist, through interview, of subject's positive motivation and interest in participation in Kay research project. Scoring: In ranks, higher scores = high motivation, low-scores = low motivation. Range and possible scores: 1 to 4.
8	19, 20	Item: Obstacle Course: Pre-Kay (TIME). Measure: Subjects' performance on indoor obstacle course, previous to Kay training, using their usual mobility aid. Data represent number of minutes taken in two trials (expressed in tenths of mins.). Scoring: Higher scores = longer time, lower scores = less time. E.g. 51 = five point one minutes or five min. ten seconds. (Second digit represents the nearest tens of seconds — from one to six tens of seconds.) Range: 2 minutes 40 seconds to 9 minutes 20 seconds.
9	21, 22	Item: Obstacle Course: Pre-Kay (ERRORS). Measure: Subjects' performance on same indoor obstacle course, previous to Kay training, using their usual mobility aid. Data represent number of errors made in two trials. Scoring: Higher scores = more errors. Lower scores = less errors. Range: Zero errors to 15 errors.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
10	23, 24	Item: Obstacle Course: Pre-Kay (COMPOSITE). Measure: Subjects' performance on same indoor obstacle course previous to Kay training, using their usual mobility aid. Data represent competence on course, with equal weight given to time and errors. Data represent total ranks. Scoring: Higher scores = greater competence. Lower scores = less competence. Scores = rank totals on the two component items. Possible range: 2 to 28. Actual range: 4 to 24.
11	25, 26	Item: Obstacle Course: Kay Device (TIME). Measure: Subjects' performance on same indoor obstacle course after training with Kay device. Data represent minutes taken for traversal on two trials of the course minus 4.0 minutes. Scoring: Higher scores = more time needed. Lower scores = less time needed. Actual range: 4.0 minutes to 13.9 minutes.
12	27, 28	Item: Obstacle Course: Kay Device (ERRORS). Measure: Subjects' performance on same indoor obstacle course after training with Kay device. Data represents number of errors made in traversing the course twice. Scoring: Higher scores = more errors. Lower scores = less errors.
13	29, 30	Item: Obstacle Course: Kay Device (COMPOSITE). Measure: Subjects' performance on same obstacle course after training with Kay device. Data represents competence with device, giving equal weight, through ranks, to time and errors. Scoring: Higher scores = greater competence. Lower scores = lesser competence. Scores represent the totaling of ranks on the two component measures, ranked in terms of competence, higher numbers equaling greater competence. Possible range: 2 to 28. Actual range: 3 to 25.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
14	31, 32	Item: Seashore Test (TIMBRE). Measure: Subjects' performance on the Seashore Audio Perception Test — the Timbre scale. The data represent the total number of trials correct of a possible 50. Scoring: Higher scores = high performance. Lower scores = lower performance. Possible range: zero to 50. Actual range: 31 to 50.
15	33, 34	Item: Seashore Test (PITCH). Measure: Subjects' performance on the Pitch section of the Seashore Audio Perception Test. The data represent the total number of trials correct of a possible 50. Scoring: High scores = high performance. Low scores = low performance. Possible range: 0 to 50. Actual range: 32 to 48.
16	35, 36	Item: Seashore Test (TONAL MEMORY). Measure: Subjects' performance on the tonal memory section of the Seashore Audio Perception Test. The data represent the total number of trials correct of a possible 30. Scoring: High scores = high performance. Low scores = low performance. Possible range: zero to 30. Actual range: 5 to 30.
17	37, 38	Item: Seashore Test (COMPOSITE). Measure: Total performance on the timbre, pitch, and tonal memory sections, expressed in composite ranks: equal weight given to each component section. Scoring: Higher scores = poorer performance. Lower scores = greater performance. Possible range: 3 to 42. Actual range: 7 to 41.
18	39, 40	Item: Hours in Training. Measure: Numbers of hours in training with Kay device; includes hours of practice at home. Scoring: Data represent number of hours. Higher scores = more hours. Lower scores = less hours.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
19	41, 42	Item: Subject Favorability Toward Device. Measure: Rank estimates by trainers regarding the attitude toward the Kay device rated during their training. Rating considerations both verbalizations and behavior. Rated independently by both trainers. (Interrater reliability: .85 Kendall rank order correlation). Scoring: Higher scores = greater favorability. Lower scores = lesser favorability. Actual range: 1 to 14.
20	43, 44	Item: Subject Anxiety. Measure: Trainer's rating of clinical evidence of anxiety in subjects. Criteria include verbalizations, behavior and intuitive judgment. Rated independently by trainers. (Interrater reliability: .78 Kendall rank order correlation.) Scoring: High scores = high anxiety. Low scores = low anxiety. Actual range: 1 to 14.
21	45, 46	Item: Subject Concentration. Measure: Trainers' ratings of subjects concentration and attention span with regard to learning about Kay device. Behavioral observations. Rated independently by trainers. (Interrater reliability: .85 Kendall rank order correlation.) Scoring: High scores = high concentration. Low scores = low concentration. Scoring in ranks.
	47, 48	Not used.
22	49, 50	Item: RANGING-A: STATIONARY. Measure: Evaluation of ranging with the device. Scoring: Data represent number of trials correct (of 50 total trials). Higher scores = higher performance. Lower scores = lower performance. Possible range: 0 to 50. Actual range: 36 to 49.
23	51, 52	Item: RANGING-B MOVING. Measure: Second phase of ranging evaluation. Scoring: Data represent number of trials correct (of 15 total trials). Higher scores = better performance. Lower scores = worse performance. Possible range: zero to 15. Actual range: 6 to 13.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
24	53, 54	Item: RANGING-C: MOVING (4–6–8). Measure: Third phase of ranging evaluation. Scoring: Data represent the number of points (of 27 possible points). Higher scores = higher performance. Lower scores = poorer performance Possible range: zero to 27. Actual range: 13 to 27.
25	55, 56	Item: RANGING COMPOSITE. Measure: Measures ranging performance: consists of variables 23, 24 and 25; giving equal weighting to each through ranks. Data represents total ranks. Scoring: Higher scores = poorer performance. Lower scores = better performance. Computed through totaling ranks on 3 component ranging measures. Possible range: 3 to 42. Actual range: 5 to 40.
26	57, 58	Item: PREVIOUS MOBILITY TRAINING. Measure: Previous mobility training, before Kay project, irrespective of mobility aid. Data are expressed in weeks. Scoring: Higher scores = more previous training. Lower scores = less previous training. Actual range: zero to 24 weeks.
	59, 60	Item: See Var. 36. Measure: See Var. 36. Scoring: 1 = Lower 7 scores on Var. 36. 2 = Higher 7 scores on Var. 36.
27	61, 62	Item: SCANNING—LOCATING: POINTS. Measure: Evaluation of scanning-location competence. Scoring: Data represent number of points from 3 separate tests (of a possible 26 points). High scores = higher competence. Low scores = lower competence. Possible range: 0 to 26. Actual range: 10 to 25.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
28	63, 64	Item: SCANNING—LOCATING: WALKING CIRCLE (TIME). Measure: The second of the scanning-locating evaluations. Scoring: Data represent the time taken to complete the task. Higher scores = lower competence. Lower scores = higher competence. Actual range: 25 to 99.
29	65, 66	Item: SCANNING—LOCATING COMPOSITE. Measure: Composite of competence in scanning-locating evaluation exercise, giving equal weight to Var. 27 and Var. 28. Data are expressed in ranks; totaling ranks on Var. 27 and 28. Scoring: High scores = poorer performance. Low scores = better performance. Possible range: 2 to 28. Actual range: 2 to 27.
30	67, 68	Item: OUTDOOR EVALUATION: TREES (TIME). Measure: Subject's competence in finding 5 trees in prescribed order. Data represent the time taken by the subject to do this task correctly—expressed in minutes (first digit) and tens of seconds rounded off the nearest ten (second digit). Scoring: Higher scores = poorer performance. Lower scores = better performance. Actual range: 3 to 31.
31	69, 70	Item: AGE AT ONSET OF BLINDNESS. Measure: The age at which subject became legally blind. Scoring: Self-explanatory. Scores of zero represent blindness at birth. Actual range: 0 to 44.
32	71, 72	Item: PREVIOUS EDUCATION. Measure: Previous formal education of subject. Expressed in the number of grades. Scoring: High scores = more education. Low scores = less education. Actual range: 9 to 16.

Code Book of Kay Device Variables (Continued)

Variable	Column	Item, measure and scoring direction
33	73, 74	Item: OUTDOOR EVALUATION: MULTI-SKILL (TIME). Measures: Competence in covering an outdoor pre-set course. Data expressed in time taken to traverse the course. Time expressed to the nearest minute. Scoring: Higher scores = poorer performance. Lower scores = better performance. Actual range: 4 to 17 minutes.
34	75, 76	Item: OUTDOOR EVALUATION: MULTI-SKILL (ERRORS). Measure: Competence in traversing outdoor course. Data expressed as number of errors. Scoring: Higher scores = poorer performance. Lower scores = better performance. Actual range: 5 to 17 errors.
35	77, 78	Item: OUTDOOR EVALUATION: COMPOSITE. Measures: Competence of subject in outdoor exercises; including tree exercise and outdoor course traversal. Data expressed in the summation of ranks for variables in 30, 33, and 34. Scoring: Higher scores = better performance. Lower scores = worse performance. Possible range: 3 to 42. Actual range: 7 to 39.
36	79, 80	Item: EVALUATION COMPETENCE: COMPOSITE. Measures: Overall performance with consideration of Ranging, Scanning—Location, and Outdoor evaluation. Data expressed in ranks taken from the composite scores for the three component types of tasks. The total score thus takes all evaluation tests into consideration. Equal weights, expressed by ranks, are given to each of the three types of tasks. Scoring: High scores = high overall competence. Low scores = low overall competence. Possible range: 3 to 42. Actual range: 9 to 37.