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ABSTRACT

Twenty-four congenitally visually handicapped infants, aged 6-24 months, participated in a study to determine (1) those stimuli best able to elicit visual attention, (2) the stability of visual acuity over time, and (3) the effects of binaural sensory aids on both visual attention and visual acuity. Ss were dichotomized into visually handicapped only and multihandicapped groups for purposes of analysis. Results indicated that visually handicapped only infants spent more time attending to stimuli, but no preference was shown by either handicapped group for type of stimulus or method of presentation. In addition, Ss improved on the visual acuity measure over an 8-week period, regardless of handicapped group or an 8-hour exposure to binaural sensory aids. Finally, a disordinal interaction occurred among binaural sensory aid, stimulus type, and handicapped group; and mere exposure to the binaural sensory aid without specific training was judged not to be effective in a program of visual efficiency training for infants 6-24 months old. Visual stimulation procedures as utilized with older visually handicapped children are questioned as applied to infants 6-24 months old. (Author)

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Twenty-four congenitally visually handicapped infants, aged 6 - 24 months, participated in a study to determine (1) those stimuli best able to elicit visual attention, (2) the stability of visual acuity over time, and (3) the effects of binaural sensory aids on both visual attention and visual acuity. Subjects were dichotomized into visually handicapped only and multihandicapped groups for purposes of analysis.

Results indicate that visually handicapped only infants spent more time attending to stimuli, but no preference was shown by either handicapped group for type of stimulus or method of presentation. In addition, subjects improved on the visual acuity measure over an 8-week period, regardless of handicapped group or an 8-hour exposure to binaural sensory aids. Finally, a disordinal interaction occurred among binaural sensory aid, stimulus type, and handicapped group, and mere exposure to the binaural sensory aid without specific training was judged not to be effective in a program of visual efficiency training for infants 6 - 24 months old. Visual stimulation procedures as utilized with older visually handicapped children are questioned as applied to infants 6 - 24 months old.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

THE EFFECTS OF BINAURAL SENSORY AIDS ON THE DEVELOPMENT OF VISUAL PERCEPTUAL ABILITES IN VISUALLY HANDICAPPED INFANTS

INTRODUCTION

Vision plays a predominant role in early child development. It serves as an organizer of experience, as a primary feedback mechanism, and as the one sensory system which integrates all the others (Fraiberg, 1977). Gratch (1972) has called vision the most dominant sense we possess, while Piaget and Inhelder (1969) refer to its primary role in sensorimotor development.

During the past decade, the development of research techniques to measure infant perception has resulted in a rapidly expanding body of knowledge which suggests that infants are using quite sophisticated visual abilities at birth. Visual cortical evoked potentials have been demonstrated at 22 weeks' gestational age (Engel, 1967). Preterm infants of 31 weeks' gestation show visual memory even before it has any demonstrable value to the baby (Miranda & Hack, 1979). Infants show definite preferences for pattern and complexity from the earliest months after birth, and by five months have developed such sophisticated visual abilities that they discriminate line drawings of real faces (Cohen, DeLoache, & Strauss, 1979). The relative stability of neonatal visual-perceptual abilities has led some researchers to suggest the use of visual fixation, tracking and preference responses in infancy as predictors of high risk status (Miranda & Hack, 1979).

The implications for an infant born with a visual handicap are clear. Physiological problems which interrupt or cut off completely the normal process of visual development also affect motor, social, and psychological development. Fraiberg (1977) has documented delays in locomotion, ego development, reach to sound, and aggression. She has also stated,

> It is not blindness alone that imperils the child's development, but the absence of vision as an organizer of experience, the absence of vision as the facilitator of gross motor achievements and prehension, the absence of vision in constructing a stable mental representation, and the obstacle to finding motor pathways for aggression that can lead to defense and neutralization of aggression in the service of the ego. (Fraiberg, 1968, p. 299)

Thus, infants born with a visual impairment are at a distinct disadvantage in terms of developmental and experiential growth. They constitute a high risk category with unique educational needs.

Hubel and Weisel demonstrated in 1963 that providing visual opportunities in infancy results in greater growth of the visual cortex and, by implication, increased visual functioning. The pioneer work with visually handicapped children was done by Barraga (1964). She demonstrated that the visual efficiency of school age children could be increased through a sequenced training program of visual skills. Her work has been replicated by Ashcroft, Halliday, & Barraga (1965), Holmes (1967), and Tobin (1972). No research has been conducted which investigates increased visual efficiency during the infancy of visually handicapped children.

Animal research provides some rationale for working with young visually handicapped children. Kittens exposed to constant illumination at birth evidence a threefold increase in visual evoked potential amplitudes (Rose & Gruneau, 1973). Rats whose visual cortex has been surgically removed and who were subsequently reared in a lighted environment evidence an increase in dendritic spine density in their visual cortex area (Parnavelas, Globus, & Kaups, 1973). In another experiment with kittens, one was placed immobile in a sling, without its feet touching the ground. The sling was connected, however, to a similar device which carried another kitten. The second kitten was free to move around the testing device, but passively moved the first kitten as it did so. The vision of the second kitten developed normally, but the first kitten, who lacked direct motor experience, was functionally blind (Held, 1973). Since kittens and rats have neurological systems which closely resemble those of human neonates (Rose, 1981), it is possible that sensory stimulation of some type, visual or otherwise, might provide the opportunity for increased visual utilization in visually handicapped infants.

Bower (1977b) has suggested that visually handicapped infants might be able to extract information from an artificial sensory source.

> If the blind child is born with a perceptual system ready to seize on abstract information of a certain form, no matter what its method of presentation, the baby should be able to use a wholly artificial source of information, provided it had the same formal properties as natural information. (Bower, 1977b, p. 256)

Binaural sensory aids, initially introduced in this country in the early 1970s as a mobility device for blind adults, have been suggested as one means of providing this new perceptual system (Bower, 1977a, 1977b). The device, mounted in a pair of spectacle frames for adults, works by transmitting ultrasound into the environment, which is then reflected off objects back to the device, converted to audible sound, and channeled into the ears of the wearer in stereo, through small eartubes. At no time is ambient sound occluded. The perceptual information thus produced by the device gives information as to distance, size, location, and surface characteristics of objects not otherwise in direct sensory contact with the user.

Binaural sensory aids have been used as concept development tools with school age children and adults, and their application as vision stimulation devices has been suggested (Carter & Carter, 1980; Baird, 1977). Reports of such efforts have been anecdotal and unsupported by hard data. No controlled research has addressed the development of visual abilities in visually handicapped infants.

Bower, however, has conducted several pilot studies with modified binaural sensory aids and infants (Bower, 1977a, 1977b). A four month old baby in California, diagnosed as having retrolental fibroplasia, was fitted with a specially modified sensory aid and shortly thereafter exhibited behaviors previously unobserved for that particular child -- two-handed reaches, placing exercises, and selection of preferred objects without touch. During the first session with the sensory aid, the baby's eyes converged on an object as it was moved slowly toward and away from the face. Three trials later, the infant interposed his hands between his face and the object. When presented with objects moving to right and left, he tracked them with head and eyes and swiped at small objects. The smallest object presented was a one-centimeter cube dangling on the end of a wire, which the baby succeeded in hitting four times.

Bower returned to Scotland when this baby was approximately nine months old, but information received in 1977 indicated that the baby had begun to evidence more and more visual functioning until, at 14 months, he refused to wear the sensory aid and was considered by medical and educational personnel alike to be partially seeing (Texley, 1977). Bower continues to work with other blind babies, all of whom have shown the same eye movements and visual-motor coordination almost immediately upon introduc io (1976; 1977b). Unfortunately, little information is available about the infants' visual conditions prior to the introduction of the device. The issue is not so much whether the infant had any residual vision; what is important is whether or not the binaural sensory aid provided an amount and type of perceptual information that was able to supplement, expand, and give meaning to whatever visual stimuli the children were receiving in the first place.

A doctoral candidate at the University of Michigan has also used binaural sensory aids with young blind children. Her results with one infant are particularly interesting. The child was born with a visual encepholocele (a protrusion of the visual cortex outside the skull cavity) which was subsequently surgically removed. The child appeared to be and had been medically diagnosed as totally blind. After e posure to the device, the child made the same eye movements Bower described -- tracking, convergence, visual-motor coordination -- behaviors which persisted even when the device was not worn (Weihl, 1977). Again, stimulation of the brain by a means other than visual information may have resulted in the enhancement of residual vision.

Ferrell (1980) conducted an investigation int the use of binaural sensory aids in a homebased program of educational intervention for four infants, aged 6 months to 2½ years. While developmental changes could not be attributed to sensory aid use alone, all children in that study displayed some of the same types of behaviors -- brightening to the first sound of the device, apparent fixation, and convergence. In Ferrell's study, however, electrophysiological testing was performed on all subjects in the pre-experimental phase and periodically thereafter. Extremely abnormal visual evoked responses to light stimuli were found in all infants. One subject, however, showed a measurable improvement over pretreatment conditions.

It has thus been suggested that binaural sensory aids will increase the visual efficiency of visually handicapped infants by providing an auditory orientation and thus a reason to focus on visual stimuli. But visually handicapped infants' independent responses to either visual or visual - auditory stimuli have never been systematically studied. Because of the expense of binaural sensory aids and their relative unavailability to the general population of visually handicapped infants, it seems particularly germane to determine whether the eye movements reported in the literature are the effects of the particular perceptual qualities of the binaural sensory aid, or the response to a sound stimulus alone. Should the binaural sensory aid prove to be a critical factor in the development of infants' eye orientation movements, it follows that increased exposure to the device would result in increased opportunities to utilize whatever residual vision was present.

Accordingly, this study was conducted in two phases. Study I examined visually handicapped infants' eye orientations to two types of stimuli, presented in two ways, under both binaural sensory aid and no binaural sensory aid conditions. Study II looked at changes in the visual perceptual abilities of visually handicapped infants over an eight-week period, and how those abilities were affected by repeated exposure to binaural sensory aid information.

OBJECTIVES

The presence of distinct eye orientations -- primarily fixation and tracking -- has never been systematically studied in visually handicapped infants in relation to how the infant responds to auditory and visual stimulation in general. Nor has there been any effort to document changes in visual perceptual abilities as a result of binaural sensory aid intervention. This study addressed both needs.

Study I - Eye Orientations

In Study I, visually handicapped infants were presented with stationary and moving objects both with and without an attached sound stimulus, and with and without the presence of binaural s[illegible]y aid information. The duration of fixation and tracking under each condition was calculated. Study I thus attempted to discriminate the effects for binaural sensory aids, if any, from the effects of type and method of stimulus presentation. The objectives of Study I were:

Objective 1. To examine visually handicapped infants' visual orientation responses to visual and combined visual - auditory stimuli.

1.1 Do visually handicapped infants exhibit significantly different eye orientations in response to a visual stimulus than they do to a combined visual-auditory stimulus?

1.2 Research hypothesis: There will be differences in eye orientation responses between stimulus presentations using a combined visual-auditory stimulus and those using a visual stimulus alone.

Objective 2. To examine visually handicapped infants' visual orientation responses to stationary and moving stimuli.

2.1 Do visually handicapped infants exhibit significantly different eye orientations in response to a stationary stimulus than they do to a moving stimulus?

2.2 Research hypothesis: There will be differences in eye orientation responses between stimulus presentations using a moving stimulus and those using a stationary stimulus.

Objective 3. To examine the effects of binaural sensory aids on the visual orientation responses of visually handicapped infants when presented with either stationary or moving visual or combined visual - auditory stimuli.

3.1 Do visually handicapped infants exhibit significantly different eye orientations when binaural sensory aid information is available than they do when it is not available?

3.2 Research hypothesis: For all stimulus presentations there will be differences in eye orientation responses when binaural sensory aid information is available and when it is not.

Objective 4. To examine the visual orientation responses of visually handicapped infants with and without a multihandicapping condition.

4.1 Are there differences in the eye orientation responses of infants who are visually handicapped only and those who are multihandicapped?

4.2. Research hypothesis: There will be differences between visually handicapped only and multihandicapped groups across all stimulus presentations.

Study II - Visual Perceptual Abilities

Study II occured as a followup to Study I. In this study, a smaller number of visually handicapped infants were selected for binaural sensory aid exposure for an eight-week period. Repeated measures of visual perceptual abilities, obtained through a forced-choice visual preference test, were obtained on two occasions.

Study II thus attempted to document changes in visual perceptual abilities overtime as a result of sensory aid intervention. The objectives of Study II were:

Objective 5. To determine the visual perceptual abilities of visually handicapped infants (n=24) using a forced-choice visual preference test to estimate visual acuity.

Objective 6. To provide several visually handicapped infants with an eight-week period of exposure to the binaural sensory aid.

Objective 7. To examine the effects of binaural sensory aid treatment on visual perceptual ability as measured by the forced-choice visual preference test.

7.1 What differences in visual perceptual performance occur after an 8-hour exposure to binaural sensory aids?

7.2 Research hypothesis: Infants receiving 8 hours of binaural sensory aid exposure will demonstrate a greater change in visual perceptual performance than infants who have received only limited exposure.

Objective 8. To examine changes in the visual perceptual ability of visually handicapped infants who have not had prolonged exposure to the binaural sensory aid over an eight-week period.

8.1 What differences in visual perceptual performance occur over time in visually handicapped infants?

8.2 Research hypothesis: There will be no changes in visual acuity over time.

8.3 Research hypothesis: There will be differences in visual acuity between handicapped groups.

Objective 9. To provide parents of all visually handicapped infants in Studies I and II with reports on their child's performance on the forced-choice visual preference test and, if requested by parents, to provide copies of this report to the infant's eye specialist and/or educational program.

Objective 10. To disseminate results of both studies through professional literature, and conferences of professional organizations.

Limitations

1. The range and variety of additional handicaps found in the visually handicapped population prohibited the grouping of subjects into distinct categories based on specific multihandicapping conditions. It is possible that certain handicaps are more amenable to sensory stimulation than others. Future studies should incorporate larger groups so that these differences can be systematically studied.

2. Many multihandicapping conditions are not readily identifiable in infancy, and subjects who initially appeared to be visually handicapped only may later be identified as multihandicapped.

Delimitations

1. This study was limited to visually handicapped infants aged 6 - 24 months. No attempt was made to generalize results to visually handicapped children younger than six months or older than two years.

2. No attempt was made to train visually handicapped infants to utilize or interpret the binaural sensory aid information. While specific training activities might have provided useful information, such procedures were outside the scope of this study. Exposure without training was provided in an effort to circumvent many of the confounding variables discussed in Ferrell (1980) (e.g., experimenter bias, amount of intervention, level of social interaction).

Definitions

Congenitally visually handicapped for purposes of this study referred to visual disabilities occurring pre- or perinatally and manifested within 6 months after birth.

Corrected chronological age (CCA) was the estimated age of the child, dating from the day of conception. This information was only collected for subjects with a history of preterm birth.

Eye orientations referred to a group of behaviors including fixation (eye contact with stimulus) and tracking (eye contact accompanied by lateral movement of the eyes in the same direction as the moving stimulus, with or without head movement).

Light perception, in the absence of a specific medical diagnosis, referred to a behavioral response to a light stimulus, such as a change in respiration or body tone; eyes or head turning to the source of light; or a blink in bright sunlight.

Visual acuity for this study was defined as the estimated visual acuity obtained from a forced-choice visual preference test (FCVPT) as practiced by the Infant Development Laboratory at the University of Pittsburgh. FCVPT involved determining the minimal width of a striped pattern that will elicit a visual attentional preference when the striped pattern is paired with a homogeneous gray pattern of the same overall brightness. The FCVPT method measures the optical, subcortical, and cortical transmission of visual information by examining the voluntary behavioral response which results. Further information on this technique is available in Appendix A.

PROCEDURES

This study was conducted in two parts. Phase I examined visually handicapped infants' eye orientation responses to two types of stimuli, visual and combined visual-auditory. Each of these were presented in two ways, stationary and moving. All four possible combinations of stimuli and presentation method were subjected to binaural sensory aid and no binaural sensory aid conditions, resulting in eight testing situations. Phase 2 of the study examined both changes in the visual perceptual performance of visually handicapped infants over an 8-week period, and how that performance was affected by repeated exposure to binaural sensory aid information.

Subjects

Twenty-four congenitally visually handicapped infants between the ages of 6 - 24 months were identified through the Western Pennsylvania School for Blind Children's VIFTY Project, Pittsburgh, Pennsylvania; the Gertrude A. Barber Center, Erie, Pennsylvania; and Dallas Services for Visually Impaired Children, Dallas, Texas. Parents of these infants were asked to participate in both phases of the study by means of one of the cover letters found in Appendix B. Those parents who agreed to participate signed and returned one of the permission forms also found in Appendix B. Parents were also asked to participate in a third research component, cross-modal transfer, which was not a part of this grant.

All subjects met three criteria: (a) between 6 - 24 months CCA; (b) evidence of at least light perception; and (c) hearing loss no greater than 60 dB.

Because the presence or absence of any additional handicaps might have affected an infant's ability to integrate sensory information, medical records were consulted to determine if a diagnosis of one or more handicaps in addition to visual impairment -- e.g., brain damage, syndrome-related mental retardation, developmental disabilities -- had been made. Parent permission forms requesting access to these records is also found in Appendix B. Table 1 shows the demographic data collected on all subjects.

Subjects were dichotomized for data analysis into two groups: (a) Visually handicapped only -- i.e., no disabilities present other than visual impairment; and (b) Multihandicapped -- i.e., the presence of one or more handicaps in addition to visual impairment. Two additional subjects (S_{15} and S_{17} in Table 1) were tested at the request of the Barber Center, but were not included in subsequent analyses.

All children identified through the VIFTY Project in Pittsburgh, Pennsylvania were asked to participate in the extended binaural sensory aid exposure component of Phase 2. Parents of seven subjects chose to participate.

A summary of the three educational programs by subject characteristics is found in Table 2.

Binaural Sensory Aid

The binaural sensory aid currently available in this country is the Infant Sonicguide[TM], manufactured by Wormald International Sensory Aids Corporation and distributed and serviced by an office in Chicago. The components of the device are mounted on a flexible plastic headband.

Table 1

Demographic Information on Subjects

Subject Number	BSA[a]	Educational Program	Birthdate	Sex	Visual Diagnosis	Other Handicaps	CA/CCA at Phase 1[b]	CA/CCA at Phase 2[b]
S_1	yes	VIFTY	11-26-81	M	Optic nerve hypoplasia	None	5.75	8.25
S_2	yes	VIFTY	7-17-81	F	Retrolental fibroplasia	None	10.5/7.0	13.0/9.5
S_3	yes	VIFTY	9-27-80	M	Retinal detachment, O.S.; retinal dysplasia	None	21.0	23.5
S_4	yes	VIFTY	4-30-81	M	Bilateral coloboma, microphthalmia	None	12.25	14.5
S_5	yes	VIFTY	11-30-80	F	Retrolental fibroplasia	None	18.25/14.75	20.75/17.25
S_6	no	VIFTY	11-16-80	F	Bilateral cavernous optic atrophy	Seizure disorder, hydrocephalus	17.75/15.75	20.25/18.25
S_7	yes	VIFTY	8-3-81	F	Cortical blindness	Seizure disorder, encephalopathy	9.25	11.75
S_8	no	VIFTY	9-29-81	M	Bilateral cataracts	None	7.25	9.75
S_9	no	VIFTY	7-14-80	F	Optic nerve hypoplasia	None	21.75	24.25
S_{10}	yes	VIFTY	4-23-81	M	Anophthalmia	None	12.5/11.75	15.0/14.25
S_{11}	no	Barber Ctr.	2-14-81	F	Optic nerve hypoplasia	Diabetes	15.5	17.5
S_{12}	no	Barber Ctr.	7-16-80	F	Damaged optic nerves	Hydrocephalus	22.5	24.5
S_{13}	no	Barber Ctr.	4-27-80	F	Bilateral cataracts	None	25.0/24.0	27.0/26.0

Table 1 (cont'd)

Subject Number	BSA[a]	Educational Program	Birthdate	Sex	Visual Diagnosis	Other Handicaps	CA/CCA at Phase 1[b]	CA/CCA at Phase 2[b]
S_{14}	no	Barber Ctr.	1-28-81	M	Glaucoma, cataracts	Rubella, seizure disorder	16.0	18.0
S_{15}	no	Barber Ctr.	3-29-80	F	Questionable	Seizures, hearing loss, cleft palate	26.0	28.0
S_{16}	no	Barber Ctr.	10-2-80	M	Cortical blindness	Seizure disorder, heart murmur	19.75	21.75
S_{17}	no	Barber Ctr.	5-9-78	F	Questionable	Seizure disorder, developmental delay	48.75	50.75
S_{18}	no	Barber Ctr.	7-7-81	F	Septo-occular dysplasia	Diabetes, hypotonia, left hemiplegia	10.75/9.25	12.75/11.25
S_{19}	no	Dallas	9-19-80	F	Retrolental fibroplasia, retinal detachment.	None	23.75/21.0	25.75/23.0
S_{20}	no	Dallas	9-27-80	M	Bilateral optic nerve hypoplasia	None	23.5	25.5
S_{21}	no	Dallas	8-18-81	M	Gonococcal ophthalmitis, glaucoma, clouded corneas	Hydrocephalus, Peter's anomaly, heart murmur	12.75/12.25	14.75/14.25
S_{22}	no	Dallas	2-24-82	F	Bilateral coloboma of optic nerve	None	6.5	8.5
S_{23}	no	Dallas	2-17-82	M	Bilateral cataracts	None	6.75	8.75
S_{24}	no	Dallas	6-26-81	F	Optic atrophy	Hydrocephalus, cerebral dysgenesis syndrome	14.5	16.5

Table 1 (cont'd)

Subject Number	BSA[a]	Educational Program	Birthdate	Sex	Visual Diagnosis	Other Handicaps	CA/CCA at Phase 1[b]	CA/CCA at Phase 2[b]
S_{25}	no	Dallas	8-25-81	M	Bilateral microphthalmia, prosthesis O.D.	Multiple congenital anomalies	12.5/12.0	14.5/14.0
S_{26}	no	Dallas	9-9-81	F	Retinal hemorrhages	Trauma brain damage	12.0	14.0

[a]Yes indicates subject participated in extended BSA exposure component of study.
[b]In months.

Table 2

Comparison of Educational Programs
by Subject Characteristics

		6 - 12 months			13 - 24 months		
	Grand Total	VH only	MH	Total	VH only	MH	Total
VIFTY Project	10	5	1	6	3	1	4
Barber Center	6	0	1	1	1	4	5
Dallas Services	8	2	3	5	2	1	3
TOTALS	24	7	5	12	6	6	12

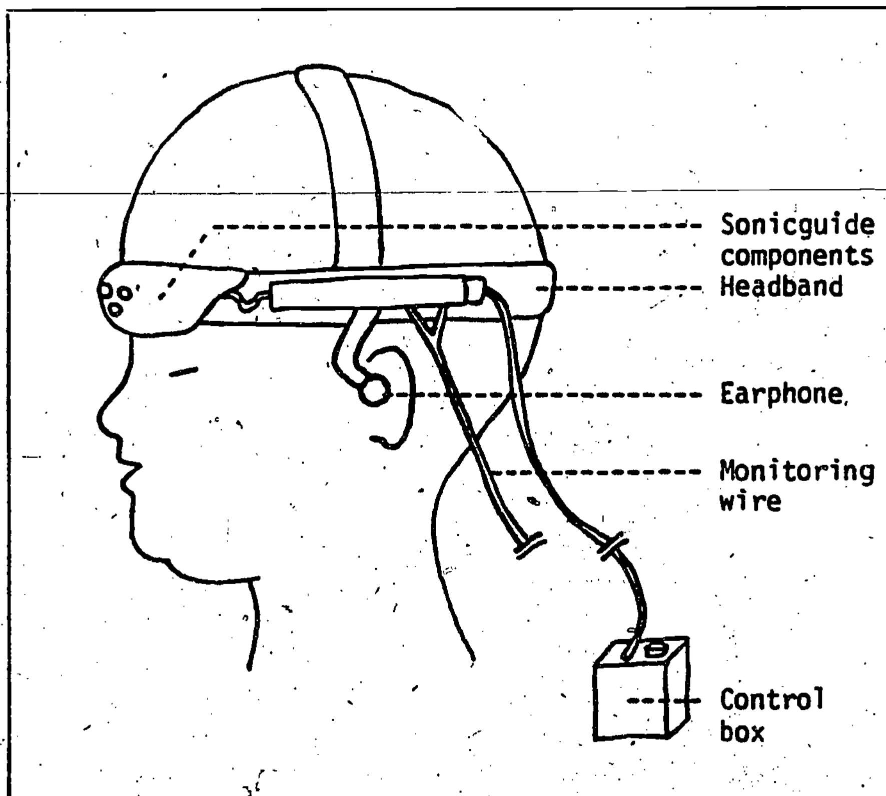

Figure 1. Infant Sonicguide™.

The aid is worn so that the triangular portion containing the electronic components is centered directly above the bridge of the nose; external earphones are directed toward the ear at the level of the ear canal. Figure 1 provides a schematic idea of how the Sonicguide^{TM} is worn by the infant. Further information on the operation of the Sonicguide^{TM} is found in Appendix C.

The range of signals transmitted by the device can be preset at varying distances from .5 to 4 meters. The 2-meter range appears to be the most appropriate for use in home environments (Ferrell, 1980) and was utilized in this study.

Infants' eye orientation responses were examined under two conditions identified as: (a) Binaural sensory aid (BSA) -- wearing the device, with the volume knob turned one-fourth revolution, while parent and/or investigator simultaneously monitored the sound; and (b) no binaural sensory aid (No BSA) -- wearing the device, with the volume knob turned off.

Procedures for Study 1: Eye Orientations

Phase 1 of the study was conducted at the VIFTY Project House in Pittsburgh on May 6-7, 1982; at the Gertrude A. Barber Center in Erie on May 27, 1982; and at Dallas Services for Visually Impaired Children on September 9, 1982. Procedures followed at this time included the administration of (a) a forced-choice visual preference test, and (b) the experimental protocol.

Forced-choice visual preference test. The forced-choice visual preference test (FCVPT) was administered first, following the procedures outlined in Appendix A. The analysis of these results occurred as part of Study II. Although the original research proposal had required a second FCVPT immediately following the experimental protocol, this was eliminated from the study because of subject fatigue.

Experimental Protocol. Infants' eye orientation responses to the following four types of stimulus presentations were observed under both BSA and No BSA conditions. The stimulus, a yellow, sound-producing toy shaped like a bird and about 13 cm. in length, was mounted on a .3 cm. dowel rod held by the investigator, standing next to the infant.

1. Stationary visual stimulus -- The stimulus was presented at eye level in midline, 26 cm. from the subject's face, for 15 seconds.
2. Stationary visual-auditory stimulus -- The stimulus, with auditory output turned on, was presented at eye level in midline, 26 cm. from the subject's face, for 15 seconds.
3. Moving visual stimulus -- The stimulus was presented at eye level in midline, 26 cm. from the subject's face, and moved horizontally in a continuous back-and-forth motion, for a total duration of 15 seconds.
4. Moving visual-auditory stimulus -- The stimulus, with auditory output turned on, was presented at eye level in midline, 26 cm. from the subject's face, and moved horizontally in a continuous back-and-forth motion.

A total of 8 presentations -- two of each of the above in BSA and No BSA conditions -- were thus included in the protocol. Each stimulus presentation was followed by a 10-second pause, for a total administration time of 100 seconds. The order of stimulus presentations was balanced across subjects by using a table of random digits (See Table 3). Subjects were assigned to a presentation sequence in the order in which they were tested.

Administration of the experimental protocol was conducted by the investigator, who controlled the on-off auditory switch of the stimulus,

Table 3

Order of Stimulus Presentations in Experimental Protocol

	Stationary				Moving			
	Visual		Visual-Auditory		Visual		Visual Auditory	
	BSA	No BSA	BSA	No BSA	BSA	No BSA	BSA	No BSA
S_1	3	6	8	4	5	7	2	1
S_2	4	8	1	2	3	7	6	5
S_3	1	4	6	8	3	5	2	7
S_4	5	7	1	4	2	6	3	8
S_5	3	5	7	8	6	4	2	1
S_6	8	7	4	1	3	6	2	5
S_7	7	4	6	3	1	8	5	2
S_8	8	3	4	7	6	2	5	1
S_9	1	3	5	6	7	8	4	2
S_{10}	7	3	6	4	5	8	1	2
S_{11}	1	8	6	3	7	4	5	2
S_{12}	1	5	3	2	6	7	8	4
S_{13}	1	3	8	4	2	6	5	7
S_{14}	8	4	6	2	3	5	1	7
S_{15}	8	6	4	1	3	5	7	2
S_{16}	4	2	6	3	1	5	7	8
S_{17}	6	1	5	2	7	3	4	8
S_{18}	5	6	7	1	4	8	2	3
S_{19}	5	7	1	6	3	2	4	8
S_{20}	4	2	1	7	5	3	8	6
S_{21}	2	8	3	1	5	4	6	7
S_{22}	7	8	1	3	4	5	2	6
S_{23}	8	3	2	5	7	4	1	6
S_{24}	7	3	2	1	5	6	4	8
S_{25}	6	2	4	5	7	1	8	3
S_{26}	1	5	3	2	6	7	8	4

the method of presentation, and the volume knob on the binaural sensory aid. Parents and other adults present during the experimental protocol assisted by holding the subject and by turning off the overhead lights at the investigator's request, but were instructed not to offer any verbal or tactual reinforcement to the subject.

The experimental protocol was videotaped for later coding of eye orientation responses. In order to avoid interference with the stimulus presentation, the video camera was positioned slightly higher and to the right of the subject's midline.

Coding of videotapes. Data were collected from the experimental protocol videotapes by independent observers (graduate student assistants) trained to .94 agreement with the investigator. Observers viewed each tape simultaneously, utilizing stopwatches to record fixation. Fixation was defined as the total amount of time the infant achieved eye contact with the stimulus during any 15-second presentation period. Observers recorded as fixation both direct and indirect eye contact, providing eye movements were coordinated with stimulus movement. Behavioral responses -- such as quieting -- were interpreted as fixation markers when accompanied by subsequent eye contact. At the end of each 15-second presentation period, signalled on the videotape by the movement of the stimulus up and out of camera range, the observers entered the accumulated time for that presentation on the data collection form found in Appendix D. The investigator transferred this data to Table 3, using the mean for the two observations, and computed interobserver agreement. Interobserver agreement was calculated by dividing the number of agreements (± 1 second) by the number of agreements (± 1 second) plus the number of disagreements (> 1 second), multiplied by 100. Interobserver agreement ranged from 70 to

100 percent, with a mean of 85 percent.

Three subjects did not complete the experimental protocol, and three could not be used in the analysis because of the poor quality of the videotapes.

Procedures for Study II: Visual Perceptual Abilities

During Study II twenty-four subjects received a second forced-choice visual preference test, administered at the three educational centers at least 8 weeks, but no more than 10 weeks, after the initial Study I testing. Those subjects who agreed to the extended binaural sensory aid exposure component received BSA exposure during the interim between Study I and Study II testing.

VIFTY Project posttests were administered on July 16, 1982; Barber Center, on July 23, 1982; and Dallas Services, on November 8, 1982. Six subjects were unable to participate in the Study II testing.

Extended exposure to binaural sensory aids. The seven infants from the VIFTY Project between the ages of 6 - 24 months who agreed to participate in this component of the study wore the binaural sensory aid for one hour per week in the time period between testing for Studies I and II. A graduate student assistant visited the children at home and placed a binaural sensory aid on the infant and assured its proper operation. No training occurred. Infants wore the device during normal interactions with adults and in independent play routines. During this component of Study II, the investigator had no direct contact with the subjects and acted only as a consultant to the graduate student assistant. The total amount of time each subject was exposed to the binaural sensory aid did not exceed 8 hours. Since one subject was unable to make the Phase 2 testing, only six of the extended BSA exposure subjects were included in the data analysis.

Forced-choice visual preference test. The FCVPT was again administered at the Study II testing, following the procedures outlined in Appendix A, at least 8, but no more than 10 weeks following Study I testing. Six subjects were unable to participate in the Study II post-test.

RESULTS

Study I -- Eye Orientations

Videotapes of the administration of the experimental protocol were coded by two observers trained to 94 percent agreement with the investigator. Interobserver agreement ranged from 70 - 100 percent (mean = 85 percent) for videotapes of 26 subjects. Administration difficulties resulted in the loss of six subjects, and two Barber Center subjects over two years of age were not included in the analysis.

Thus, data from 18 subjects were compiled and analyzed with a four-factor fixed effects analysis of variance with repeated measures on three factors by utilizing a BMDP2V computer program for analysis of variance and covariance with repeated measures. The results of this analysis are found in Table 4. Both handicapping condition and the interaction of type of stimulus, binaural sensory aid condition, and handicapping condition were significant at $p<.05$. Means and standard deviations for all stimulus presentations are shown in Table 5. Means and standard deviations for each independent variable are given in Table 6.

Table 4

Analysis of Variance: Study I -- Eye Orientations
(by handicapping condition)

Source	SS	df	MS	F-ratio	*p*
Handicapping condition (H)	435.55556	1	435.55556	4.63	.0471
Subjects (I):H	1506.22000	16	94.13875		
Method of presentation (M)	.11501	1	.11501	.01	.9362
MH	18.08168	1	18.08168	1.04	.3230
IM:H	278.16637	16	17.38540		
Type of stimulus (S)	4.52835	1	4.52835	.47	.5048
SH	3.45835	1	3.45835	.36	.5593
IS:H	155.61888	16	9.72618		
MS	2.96450	1	2.96450	.16	.6988
MSH	21.28672	1	21.28672	1.11	.3068
IMS:H	305.63300	16	19.10206		
BSA condition (B)	4.06501	1	4.06501	.41	.5287
BH	.72835	1	.72835	.07	.7[illegible]86
IB:H	156.79887	16	9.79993		
MB	.32089	1	.32089	.02	.8872
MBH	7.85422	1	7.85422	.51	.4861
IMB:H	247.15550	16	15.44722		
SB	5.30450	1	5.30450	1.12	.3065
SBH	24.12672	1	24.12672	5.07	.0387
ISB:H	76.06550	16	4.75409		
MSB	12.14201	1	12.14201	.54	.4723
MSBH	.04201	1	.04201	.00	.9660
IMSB:H	358.43938	16	22.40246		

Table 5

Mean Fixation Per Stimulus Presentation
(in seconds)

	Stationary				Moving				
	Visual		Visual-Auditory		Visual		Visual-Auditory		Total for Group
	BSA	No BSA	BSA	No BSA	BSA	No BSA	BSA	No BSA	
Visually hdcpd. only n = 10	x=4.36 s=4.99	x=6.49 s=4.58	x=6.65 s=5.28	x=5.26 s=5.74	x=6.73 s=6.45	x=6.63 s=6.21	x=6.95 s=6.24	x=5.53 s=6.08	x=6.08
Multihandicapped n = 8	x=3.44 s=3.97	x=2.76 s=3.10	x=3.23 s=4.24	x=2.19 s=1.99	x=1.96 s=3.26	x= .80 s= .95	x=[illegible].64 s=4.21	x=3.59 s=5.14	x=2.58
Total for each presentation	x=3.95	x=4.83	x=5.13	x=3.89	x=4.61	x=4.04	x=5.03	x=4.67	x=4.52

Table 6

Mean Fixation per Independent Variable [a]

Independent Variable	Mean	Standard Deviation
<u>Method of Presentation:</u>		
Stationary	4.45	4.55
Moving	4.59	5.51
<u>Type of Stimulus:</u>		
Visual	4.36	4.92
Visual-Auditory	4.68	5.18
<u>BSA Condition:</u>		
BSA	4.68	5.16
No BSA	4.36	4.94

[a] In seconds.

<u>Research hypothesis 1.2</u>:

> There will be differences in eye orientation responses between stimulus presentations using a combined visual-auditory stimulus and those using a visual stimulus alone.

Type of stimulus was not significant at *p= .05*, and the null hypothesis was therefore not rejected. The interaction of type of stimulus, binaural sensory aid condition, and handicapping condition was significant *(p= .0387)*, however. Examination of Table 5 indicates that infants who were visually handicapped only spent more time fixating on the visual stimulus when no BSA information was present, and on the visual-auditory stimulus when BSA information was present.

Research hypothesis 2.2:

> There will be differences in eye orientation responses between stimulus presentations using a moving stimulus and those using a stationary stimulus.

The method of stimulus presentation was not significant at $p = .05$, and the null hypothesis was therefore not rejected.

Research hypothesis 3.2:

> For all stimulus presentations, there will be differences in eye orientation responses when binaural sensory aid information is available and when it is not.

Binaural sensory aid condition was not significant at $p = .05$, and the null hypothesis was therefore not rejected.

Research hypothesis 4.2:

> There will be differences between visually handicapped only and multihandicapped groups across all stimulus presentations.

Handicapped group was significant at $p = .0471$, and the null hypothesis was rejected. The visually handicapped only group demonstrated a mean fixation which was 3.5 seconds greater than the multihandicapped group.

In order to examine the effect of handicapping condition more closely, the data were subjected to a supplementary analysis by age groups within each handicapping condition. Six to 12 month olds comprised one group; 13 - 24 month olds comprised the second. Under this analysis (see

Table 7), significance was again obtained for the interaction of type of stimulus, binaural sensory aid conditon, and handicap group. Means and standard deviations under this analysis are presented in Table 8.

To obtain a closer look at this interaction effect, mean responses were calculated under all stimulus, BSA, and handicapping conditions, without regard to method of presentation. The results are shown in Table 9 and graphed in Figure 2.

Table 7

Analysis of Variance: Study I -- Eye Orientations
(by age and handicap)

Source	SS	df	MS	F-ratio	*p*
Age (A)	48.89289	1	48.89289	.55	.4695
Handicapping condition (H)	247.04465	1	247.04465	2.79	.1169
AH	213.57826	1	213.57826	2.41	.1426
Subjects (I): AH	1238.60485	14	88.47178		
Method of presentation (M)	.74490	1	.74490	.04	.8440
MA	11.81269	1	11.81269	.64	.4381
MH	8.37660	1	8.37660	.45	.5125
MAH	6.28293	1	6.28293	.34	.5698
IM:AH	259.63949	14	18.54568		
Type of stimulus (S)	1.97866	1	1.97866	.19	.6722
SA	.30669	1	.30669	.03	.8673
SH	5.86720	1	5.86720	.55	.4691
SAH	6.91303	1	6.91303	.65	.4327
IS:AH	148.32378	14	10.59456		
MS	1.29178	1	1.29178	.06	.8099
MSA	0.20314	1	.20314	.01	.9239
MSH	24.46983	1	24.46983	1.14	.3040
MSAH	4.54777	1	4.54777	.21	.6525
IMS:AH	300.83235	14	21.48803		
BSA condition (B)	1.65293	1	1.65293	.17	.6888
BA	.90408	1	.90408	.09	.7668
BH	2.16001	1	2.16001	.22	.6474
BAH	17.65725	1	17.65725	1.79	.2027
IB:AH	138.42152	14	9.88725		
MB	1.97148	1	1.97148	.12	.7373
MBA	1.36045	1	1.36045	.08	.7804
MBH	12.61050	1	12.61050	.75	.4015
MBAH	9.82509	1	9.82509	.58	.4577
IMB:AH	235.78485	14	16.84178		
SB	6.96690	1	6.96690	1.38	.2599
SBA	.02704	1	.02704	.01	.9427
SBH	26.46446	1	26.46446	5.24	.0382
SBAH	5.31143	1	5.31143	1.05	.3226
ISB:AH	70.74235	14	5.05303		
MSB	9.11211	1	9.11211	.36	.5567
MSBA	.68582	1	.68582	.03	.8711
MSBH	.27455	1	.27455	.01	.9182
MSBAH	6.07118	1	6.07118	.24	.6307
IMSB:AH	351.77795	14	25.12700		

Table 8

Mean Fixation per Stimulus Presenta
Age x Handicap
(in seconds)

		Stationary				Moving				Total for Group
		Visual		Visual-Auditory		Visual		Visual-Auditory		
		BSA	No BSA	BSA	No BSA	BSA	No BSA	BSA	No BSA	
Infants 6 - 12 months	Visually hdcpd. only n = 7	x=5.57 s=5.55	x=6.86 s=5.00	x=7.87 s=5.35	x=5.74 s=6.77	x=8.01 s=7.14	x=7.63 s=7.19	x=8.44 s=6.68	x=7.53 s=6.30	x=7.21
	Multihdcpd. n = 4	x=2.17 s=1.58	x=2.60 s=1.01	x=1.75 s=2.40	x=2.10 s=2.56	x= .92 s= .61	x=1.32 s=1.11	x=1.95 s=1.38	x=2.45 s=2.85	x=1.91
Infants 13-24 months	Visually hdcpd. only n = 3	x=1.53 s=1.60	x=5.63 s=4.21	x=3.80 s=4.69	x=4.13 s=2.77	x=3.73 s=3.84	x=4.30 s=2.57	x=3.47 s=3.91	x= .87 s= .78	x=3.43
	Multihdcpd. n = 4	x=4.70 s=5.47	x=2.92 s=4.61	x=4.70 s=5.51	x=2.27 s=1.63	x=3.00 s=4.65	x= .27 s= .34	x=3.32 s=6.19	x=4.72 s=7.07	x=3.24

Table 9

Mean Responses for Interaction Variables

		Visually handicapped only			Multihandicapped		
		6-12 mos.	13-24 mos.	Total	6-12 mos.	13-24 mos.	Total
Visual	BSA	6.79	2.63	4.71	1.55	3.85	2.70
	No BSA	7.25	4.97	6.11	1.96	1.60	1.78
Visual Auditory	BSA	8.16	3.64	5.90	1.85	4.01	2.93
	No BSA	6.64	2.50	4.57	2.28	3.50	2.80

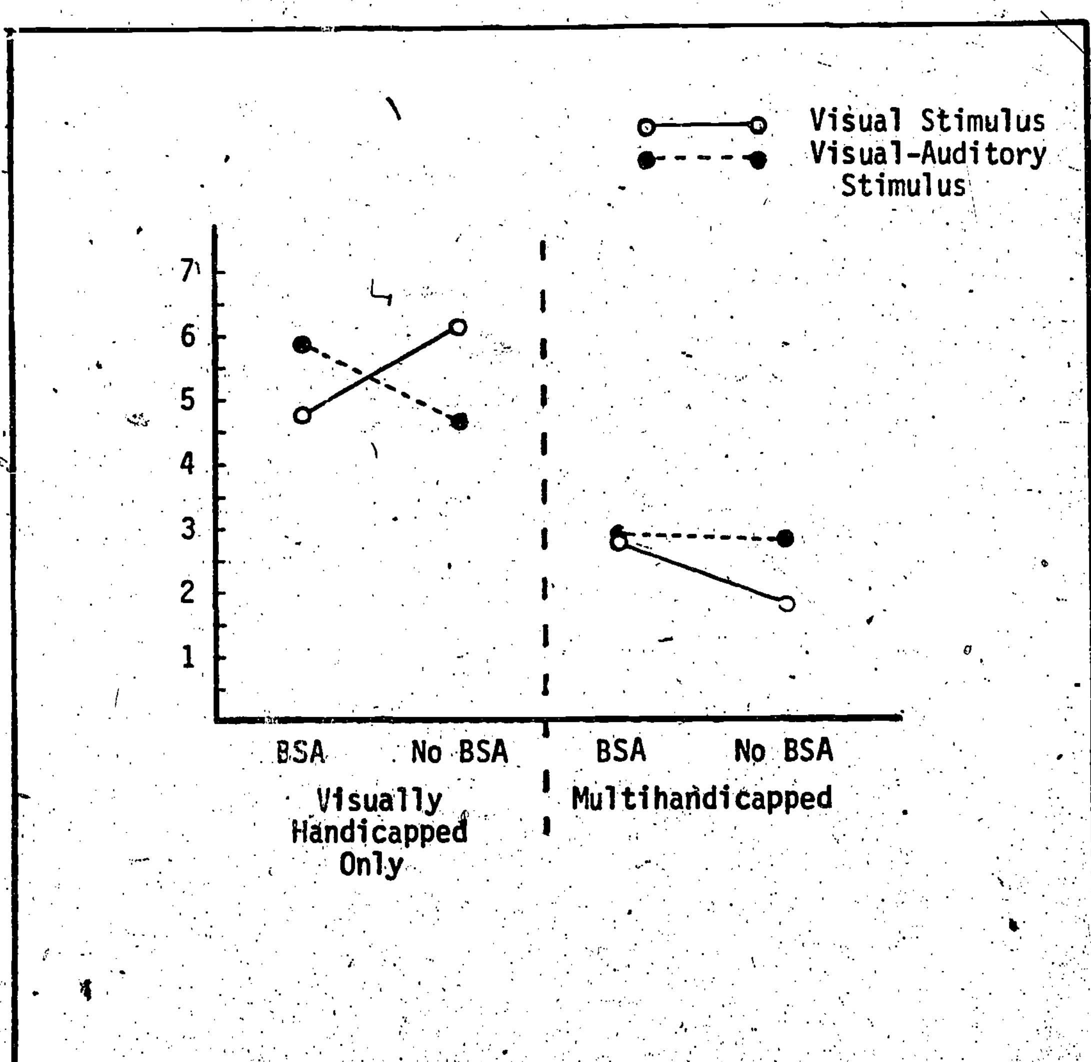

Figure 2. Interaction of BSA treatment with type of stimulus and handicapped group.

From these results, it appears that for visually handicapped only subjects, binaural sensory aid information detracted from orientation responses to visual stimuli, but supplemented responses to visual-auditory stimuli. For multihandicapped subjects 13-24 months old, binaural sensory aid information supplemented visual stimuli but only slightly supplemented visual-auditory stimuli.

Study II -- Visual Perceptual Abilities

Measures of visual acuity were obtained from 20 subjects prior to administration of the experimental protocol and again at a posttest at least 8, but no more than 10, weeks later. Results were converted to standard distance visual acuity measurements. Results for one subject were indeterminable; two subjects were excluded from the analysis because they were older than 24 months. Data on a total of 17 subjects were thus subjected to a two-way analysis of variance with repeated measures on one factor. Cell means and standard deviations are presented in Table 10 and the analysis of variance summary table in Table 11.

Table 10

Mean Distance Visual Acuity[a]

	Pretest	Posttest	Group Means
Visually hdcpd. only n = 8	X̄ = 693.75000 s = 553.19688	X̄ = 234.37500 s = 87.56375	X̄ = 464.06250
Multihdcpd. n = 9	X̄ = 511.11111 s = 536.64337	X̄ = 283.33333 s = 125.00000	X̄ = 260.29412
Test means N = 17	X̄ = 597.05882	X̄ = 260.29412	X̄ = 428.67647

[a]In feet.

Table 11

Analysis of Variance: Study II — Visual Acuity
(by handicapping condition)

Source	SS	df	MS	F-ratio	*p*
Handicapping condition (H)	37843.39257	1	37843.39257	.21	.6497
Subjects (I):H	2643259.54861	15	176217.30324		
Test administration (T)	999908.34355	1	999908.34355	7.57	.0148
TH	113584.81413	1	113584.81413	.86	.3685
IT:H	1981488.71528	15	132099.24769		

To determine the effect of binaural sensory aids on the visual acuity of visually handicapped infants, the performance of the six subjects receiving extended binaural sensory aid exposure was compared to six other randomly-selected subjects using a two-factor analysis of variance with repeated measures on one factor. Cell means and standard deviations for standard distance acuity are found in Table 12. The analysis of variance summary is presented for standard distance acuity in Table 13.

Table 12

Mean Distance Visual Acuity[a]
With and Without Extended Binaural Sensory Aid Exposure

	Pretest	Posttest	Group Means
Extended BSA Group n = 6	$\bar{X}$ = 741.66667 s = 606.97337	$\bar{X}$ = 245.833333 s = 100.51948	$\bar{X}$ = 493.75000
Control Group n = 6	$\bar{X}$ = 433.33333 s = 361.47845	$\bar{X}$ = 241.66667 s = 102.06207	$\bar{X}$ = 243.75000
Test means N = 12	$\bar{X}$ = 587.50000	$\bar{X}$ = 243.75000	$\bar{X}$ = 415.62500

[a]In feet.

Table 13

Analysis of Variance: Study II - Visual Acuity With and Without Extended Binaural Sensory Aid Exposure

Source	SS	df	MS	F-ratio	p
BSA Group (B)	146484.37500	1	146484.37500	1.10	.3185
Subjects (I):B	1329218.75000	10	132921.87500		
Test administration (T)	708984.37500	1	708984.37500	5.59	.0397
TB	138776.04167	1	138776.04167	1.09	.3203
IT:B	1268802.08333	10	126880.20833		

Research hypothesis 7.2:

Infants receiving 8 hours of binaural sensory aid exposure will demonstrate a greater change in visual perceptual performance than infants who have received only limited exposure.

There was no effect for extended binaural sensory aid exposure (Table 13).

Research hypothesis 8.2:

There will be no changes in visual acuity over time.

The effect of time was significant at *p*= *.0148* (Table 8), and the null hypothesis was therefore rejected. All visually handicapped and multihandicapped infants performed better on the posttest than on the pretest. The effect of time was also significant *(p= .0397)* for the extended BSA and control groups (Table 13).

Research hypothesis 8.3:

There will be differences in visual acuity between handicapped groups.

Handicapped group was not significant at $p= .05$, and the null hypothesis was therefore not rejected.

Summary

In Study I -- Eye Orientations, subjects who were visually handicapped only responded significantly better to all stimulus presentations, regardless of method of presentation, type of stimulus, or binaural sensory aid condition. Additionally, type of stimulus (visual or visual-auditory), binaural sensory aid condition (on or off) and handicapping condition (single or multiplyhandicapped) interacted such that, for visually handicapped only subjects, visual presentations were not enhanced by binaural sensory aid information, while visual-auditory presentations were. Neither type of stimulus, method of presentation, nor binaural sensory aid condition were significant in and of themselves to elicit greater orientation responses in infants.

In Study II -- Visual Perceptual Abilities, all subjects, regardless of handicapping condition and extended exposure to binaural sensory aids, evidenced improvement in visual acuity over a two-month period.

DISCUSSION

This study has reached the following major conclusions:

1. All subjects increased their performance on measures of visual acuity over a two-month period.

2. No single stimulus factor affected the duration of fixation and visual attention in either visually handicapped only or multihandicapped subjects.

3. The binaural sensory aid in and of itself was not an effective aid in the development of either visual orientation responses or visual acuity in this study.

4. The binaural sensory aid interacts with stimulus type to produce differing responses in handicapped groups.

Visual Acuity

An analysis of visual acuity as measured by the Forced Choice Visual Preference Test (FCVPT) was significant for test administration. Overall, subjects in this study performed better on the posttest than on the pretest, regardless of handicapping condition.

Visual acuity had not been expected to change during the course of this study. It was viewed as a static measure that was not dependent on an infant's behavior or training. As measured by the FCVPT, however, visual acuity was anything but static. Certainly the group total for the first FCVPT was inflated because of the extreme scores (20/1800) of two subjects, but the fact remains that nine subjects improved their performance by at least one octave (a halving of the distance measure), and nine other subjects performed at the same level (see Table 14, Appendix E).

The FCVPT technique appears to provide useful information on how well infants actually use their vision. While results are somewhat dependent on the individual subject's behavior and attention patterns, the subject would not respond at all if he could not see the striped stimulus. Subjects responded unequivocally to the striped stimuli, however, in spite of the fact that traditional medical examinations had been unable to determine visual acuity. Since the FCVPT is dependent on behavior, individual results can be considered the minimum response possible from any subject on a given day -- if a child was not feeling well or was reacting to the testing situation poorly, his response would be deflated; on a day when the child responded well to the testing situation, his response can be assumed to be better. Thus, subjects in this study had considerably more useful vision than was previously thought, and they may even have better vision than results of this study indicate.

Much of the literature on development of vision in handicapped children focuses on the practice of "vision stimulation," a process in which lights and objects are presented to infants and young children following generalized principles of contrast, movement, and brightness (see, for example, Barraga, 1980; Jose, Smith, & Shane, 1980; and Smith & Cote, 1982). Success for these procedures is often claimed on subjective measures. In this study, subjects' visual perceptual abilities improved regardless of whether or not a structured program of visual stimulation was provided, and regardless of whether or not a teacher of the visually handicapped, supposedly trained in visual stimulation procedures, was involved in the child's programming. Furthermore, many of the subjects were considered totally blind or severely visually handicapped, and their educational plans reflected a tactual and not a visual approach to training. While intervention itself may have been a factor, subjects were involved in early intervention programs that provided direct contact services ranging from four times weekly to one time per month, and yet gains occurred across all programs. It is highly probable that these gains occurred as a result of the natural process of growth and development and were unrelated to what has been known in the field as "vision stimulation."

Eye Orientations

In the eye orientations study, better overall performance was exhibited by subjects who were visually handicapped only. In the supplementary analysis by age, however (Table 8), it is apparent that this advantage was best encountered by the 6 - 12 month old visually handicapped subjects. In the 13 - 24 month age group, performance of visually handicapped and multihandicapped subjects was about equal. It should also be noted that data for the visually handicapped only group might be affected by the larger number of subjects and the consistently reliable performance of three subjects (S_4, S_{22}, S_{23}; see Table 15 in Appendix E).

Other than the interaction between binaural sensory aid, stimulus, and handicapped group (discussed below), there was no significant effect for either method of presentation, type of stimulus, or binaural sensory aid input. While moving stimuli that utilize two or more sensory inputs have been suggested in the literature as good procedures to develop visual attention in older visually and multiply handicapped children (Barraga, 1980; Jose, Smith, & Shane, 1980; Smith & Cote, 1982), these procedures do not appear to hold for infants between the ages of 6 - 24 months. Subjects responded individually to the stimulus presentations -- each exhibited a personal preference or showed no preference at all, but no group preference was evident. Within subjects, responses were highly variable -- some subjects responded to only one of the eight presentations; some responded consistently to all presentations. Mean responses for each 15-second presentation ranged from 2.58 seconds for the multihandicapped group, to 6.08 seconds for the visually handicapped only group; subjects on an average thus attended only 17 - 41% of the time (individual subjects ranged from 1 - 80%).

Visual attention in the eye orientations study did not appear to be related to visual acuity as measured by the FCVPT pretest. Subjects with the best performance in the experimental protocol (S_4, S_{22}, and S_{23}) had visual acuities of 20/200, 20/900, and 20/200 respectively. But among other subjects who had visual acuities of 20/200, mean attention ranged from 1.18 - 3.29 seconds, and among other subjects with very low acuities (20/900 - 20/1800), mean attention ranged from .16 - 7.84 seconds. Since the experimental protocol was administered after the FCVPT, subject fatigue might account for the poor performance of some of the 20/200 subjects, and a practice effect might account for the better performance of some of the low acuity subjects -- but once again, no pattern is evident.

These data have several implications. First, visual attention in handicapped infants is highly variable and individualized; there is no set formula for attempting to increase visual attention. Second, multihandicapped infants in the 13 - 24 month age range appear to be better able to respond or attend to stimuli than do 6 - 12 month old multihandicapped infants. And third, visual attention to stimuli presented in the traditional notion of visual stimulation appears to be unrelated to separate measures of visual acuity.

Binaural Sensory Aids

The binaural sensory aid (BSA), in and of itself, did not significantly increase either the visual attention of subjects or their performance on the FCVPT for visual acuity. Subjects receiving eight hours of exposure to the binaural sensory aid did not improve in visual perceptual performance any more than subjects without such exposure.

The failure to establish the binaural sensory aid as a tool in the development of residual vision should be viewed in the context of (a) the eye orientations study, and (b) the fact that no training was provided to subjects while they were wearing the binaural sensory aid during the eight-week followup period. An analysis of eye orientation responses indicates that the binaural sensory aid did not precipitate overall greater fixation to stimuli, and that response to the binaural sensory aid appears to be highly individualized.

Second, one of the purposes of this study was to distinguish the effects of the binaural sensory aid from the teacher variable -- i.e., how much of previously reported binaural sensory aid success in infancy has resulted from the involvement and interaction of an individual trained in and supportive of the use of binaural sensory aids, and thus able to reinforce and build on infant behaviors in response to the device? This study has shown that once the element of the instructor is removed -- when the infant is, in effect, left to explore the device's capabilities independently -- the binaural sensory aid has no effect on the visual perceptual performance of visually handicapped infants between the ages of 6 - 24 months. But this study has not addressed questions of the device's effect when systematic training is provided, or when developmental measures other than visual perceptual performance on the forced-choice visual preference test are examined, or when the binaural sensory aid is employed with older children. While the binaural sensory aid does not appear to be a prosthetic device universally useful to all visually handicapped infants, the possibility remains that it can be a useful training aid for purposes other than promoting visual attention when used within a regular program of educational intervention.

The only significant effect associated with the binaural sensory aid was in its disordinal interaction with type of stimulus and handicapped group. It appears that BSA information in conjunction with a visual stimulus depresses eye orientation responses in visually handicapped infants, yet augments responses in the same group when presented in conjunction with visual-auditory stimuli. This suggests that the auditory output of the BSA may cause confusion for the visually handicapped infant. Visually handicapped infants are known to turn their eyes toward the source of sound (Burlingham, 1964; Freedman, 1964), but are generally thought not to localize sound until late in the first year of life (Fraiberg, 1977; Warren, 1977). Studies of discrepant auditory information -- i.e., where sound originates from a source other than its apparent visual or temporal presentation -- indicate that older visually handicapped children are aware of the discrepancy between time and space (O'Connor & Hermelin, 1971, 1972), but studies have not been attempted with visually handicapped infants. Sighted infants, however, have been known to make this discrimination at four months (Spelke, 1976). It is possible that the auditory output of the binaural sensory aid was perceived by the visually handicapped subjects in this study as spatially incongruent with the visual stimulus presented 26 cm. in front of them. In so doing, it caused confusion and resulted in subjects' searching for other sources of the sound. The BSA information in effect competed with the visual stimulus for the subjects' attention.

With the visual-auditory stimuli, however, competition apparently was not a factor, and visual orientation was greater when BSA information was present. The reasons for this are not clear. Perhaps in this instance, BSA information added another dimension to visually handicapped infants' perception of the visual-auditory stimulus; but it is also possible that BSA sound, added to the stimulus sound, was louder overall and thus more capable of maintaining attention. As Warren (1977, p. 64) has stated, "Given the importance of auditory functions for the blind infant, it seems clear that much more effort should be expended in this area."

While BSA information resulted in disordinal interaction for visually handicapped infants, interaction was ordinal, though less clear, for multihandicapped infants. Although multihandicapped infants had a mean attention duration of at least two seconds less than that of visually handicapped infants, the 13 - 24 month olds performed better with BSA input. However, their performance with visual-auditory stimuli was also greater than with visual stimuli, regardless of age or BSA input. This suggests that 6-12 month old multihandicapped infants are confused by BSA input, whereas 13 - 24 month olds are not. Preference for visual-auditory stimuli, on the other hand, suggests that multihandicapped infants respond better to stimuli with two simultaneous sensory qualities. Multihandicapped infants are often physically assisted in the performance of various activities so that they receive simultaneous tactual, visual, auditory, and kinesthetic input, because they are generally assumed to require several different types and methods of sensory input due to the greater extent of sensorimotor impairment. It appears that this practice is most successful in older multihandicapped infants, either because they have had more practice with the procedure or, simply, because they are older and better able to integrate sensory information.

Conclusions

This study sought to address several aspects of the education of visually handicapped infants:

1. The definition of visual stimulation generally;
2. The process of visual efficiency training with infants;
3. The efficacy of visual preference testing to assess visual acuity and the stability of visual acuity over time; and

4. The efficacy of binaural sensory aids in visual efficiency training.

The results indicate that:

1. Traditional notions of visual stimulation as used with older visually handicapped children do not apply to visually handicapped only and multi-handicapped infants 6 - 24 months old.

2. Visual efficiency training may be less a matter of specific procedures than of intervention and/or maturation in general.

3. Visual acuity changes over time regardless of type or frequency of intervention and can be measured in visually handicapped infants by visual preference techniques.

4. There is no evidence that mere exposure to binaural sensory aids are more effective than any other type of intervention in developing visual perceptual abilities in infants. For this purpose, the expense of binaural sensory aids does not seem justified unless accompanied by teacher - directed intervention.

This study does suggest areas for further research. First, investigation of intersensory coordination and auditory development in visually handicapped infants seems warranted. Visually handicapped infants may be better able to use auditory information than the literature suggests. Second, changes in visual acuity over time should be explored in a controlled study of visual stimulation techniques. While this study concluded that visual acuity improved regardless of the amount of attention given to visual development by the three educational programs, more definitive answers might be obtained where traditional visual stimulation techniques were applied to infants randomly assigned to a treatment group. And third, examination of binaural sensory aid efficacy in infancy should continue with regard to other factors, particularly spatial awareness and locomotion, but again within the context of a controlled study and with teacher intervention.

Parents of all subjects in this study received results of their child's performance on January 17, 1983. Copies were also sent to physicians and educational programs when requested by the parents.

Dissemination will be achieved through presentations at the 61st Annual Convention of the Council for Exceptional Children, April 4-8, 1983, in Detroit; the Second International Symposium on Visually Handicapped Infants and Young Children: Birth To 7, May 22-27, 1983, in Aruba, Netherlands Antilles; and through publication in the Journal of Visual Impairment and Blindness.

APPENDICES

APPENDIX A

Procedures for Forced-Choice Visual Preference Test (FCVPT)

The FCVPT was administered by the investigator and one or more graduate student assistants trained in the Infant Development Laboratory at the University of Pittsburgh. The apparatus used was the one designed by Strauss (1979) for use with severely handicapped children (see Figure 3). It consists of a three-sided portable chamber shaped like a learning carrel and made of plywood which has been painted black. If has a roof-like panel going three-quarters of the way across the top, on which a light can be mounted to illuminate the presentation stage, or back panel. The three sides and top panel served to isolate the child from the rest of the room and thus restricted visual attention to the infant's immediate environment. The legs of the apparatus are detachable and adjust to various heights. For the Dallas testing, the legs were not used, and the apparatus was supported on a table. Additionally, the Phase 2 posttest in Dallas used an apparatus constructed of heavy cardboard, but otherwise identical to the original Strauss plywood version.

Subjects were placed either in an adult's lap or in a booster chair facing the presentation stage, at a distance of 2 - 4 feet. The presentation stage folded down to allow the investigator to change stimuli and to insert a double screen for use with the FCVPT. The Infant Laboratory provided a series of slides that correspond to several different acuity gratings. One of each of these slides was projected to the back panel screen simultaneously with a homogeneous gray pattern of

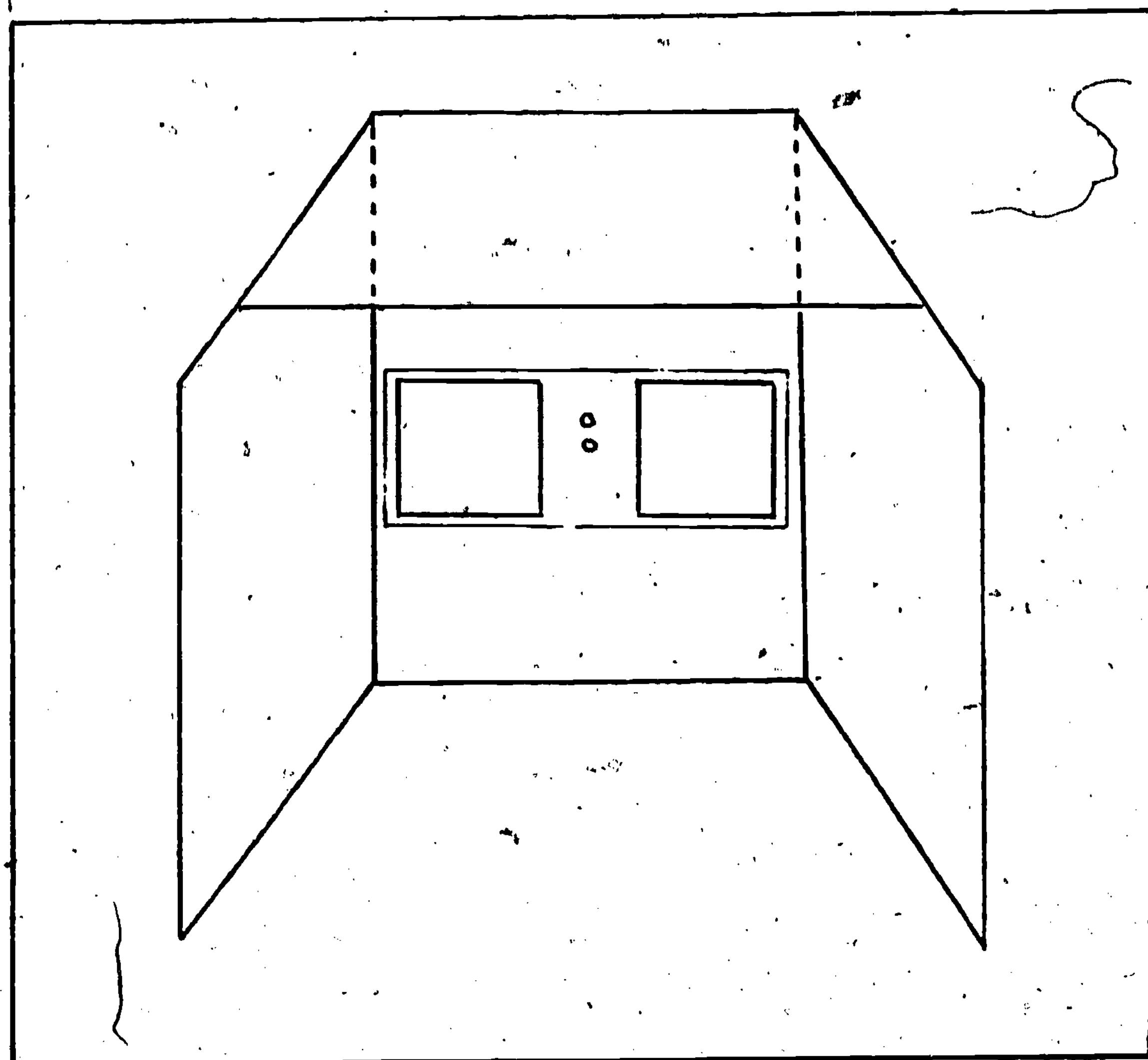

Figure 3. Testing apparatus.

the same overall brightness. The centers of the two stimuli were 30.5 cm apart when projected.

Testing required one person to act as an observer. This observer did not know the location of the striped slide when it was projected and was unable to see a corneal reflection of the stimulus in the infant's eyes. The observer was required to determine on which side the striped stimulus had been presented for each trial by observing the child's behavior through a .64 cm peephole in the center of the presentation stage.

The observer had to decide whether the striped pattern was on the right or on the left, based on any and all cues provided by the child--e.g., direction of first fixation, duration of fixation, facial expressions, head position, respiratory changes, etc. Each infant was tested with several acuity gratings corresponding to distance visual acuities of 20/100 to 20/1800 at a distance of 4 feet. The investigator recorded the observer's choice as the slides were presented and provided feedback on the observer's accuracy.

The results of the observer's judgments of which side the stripes were on, over trials, yielded a percent correct for each of several stripe widths. The observer's percent correct ranged from less than 50% on stripe widths for which the child gave no cues as to the location of the stimulus pattern, to 100% accuracy for stripe widths to which the child clearly responded. Acuity was then estimated for each infant when the number of corrent responses was 66% or greater for the best distance visual acuity. Best distance visual acuity was doubled if the subject was two feet from the presentation stage instead of four feet.

APPENDIX D

Coding Form for Experimental Protocol

Subject No. ______ Name ______________________ Date Tested ________ Observer ____________ Date Coded __________

	1	2	3	4	5	6	7	8
Fixation (total sec.)								
Brightening	yes no	yes no	yes no	yes no	yes no	yes no	yes no	yes no
Eye blinks (frequency)								

	9	10	11	12	13	14	15	16
Fixation (total sec.)								
Brightening	yes no	yes no	yes no	yes no	yes no	yes no	yes no	yes no
Eye blinks (frequency)								

$$\frac{\text{Total agreements } (\pm 1 \text{ sec.})}{\text{Total agreements } (\pm 1 \text{ sec.}) + \text{Total Disagreements } (>1 \text{ sec.})} = \_\_\_\_ \times 100 = \underline{\text{Interobserver Agmt.}}$$

APPENDIX E

Table 14

Individual Subjects' Distance Visual Acuity
on Forced-Choice Visual Preference Test

	Age Group	Handicap	BSA	Pretest	Posttest
	6 - 12 = 1 13 - 24 = 2	VH only = 1 MH = 2	yes = 1 no = 2		
S_1	1	1	1	20/1800	20/200
S_2	1	1	1	20/450	20/450
S_3	2	1	1	20/900	20/200
S_4	1	1	1	20/200	20/225
S_5	2	1	1	20/900	20/200
S_6	2	2	2	20/450	20/450
S_7	1	2	1	20/200	20/200
S_8[a]	1	1	2	20/450[a]	
S_9[a]	2	1	2	undet.[a]	20/100[a]
S_{10}[a]	1	1	1	20/1800[a]	
S_{11}	2	2	2	20/200	20/200
S_{12}[a]	2	2	2	undet.[a]	
S_{13}[a]	2	1	2	20/100[a]	
S_{14}[a]	2	2	2	20/1800[a]	
S_{15}[a]	2+	2	2	20/100[a]	20/900[a]
S_{16}	2	2	2	20/900	20/450
S_{17}[a]	2+	2	2	20/900[a]	20/450[a]
S_{18}	1	2	2	20/1800	20/450
S_{19}	2	1	2	20/200	20/200
S_{20}	2	1	2	20/900	20/200
S_{21}	1	2	2	20/450	20/200
S_{22}[a]	1	1	2	20/900[a]	
S_{23}	1	1	2	20/200	20/200
S_{24}	2	2	2	20/200	20/200
S_{25}	1	2	2	20/200	20/200
S_{26}	1	2	2	20/200	20/200

[a]Data for these subjects were not included in the analysis.

Table 15

Mean Responses in Study I -- Eye Orientations

	Stationary				Moving				
	Visual		Visual-Auditory		Visual		Visual-Auditory		Subject Mean
	BSA	No BSA	BSA	No BSA	BSA	No BSA	BSA	No BSA	
S_1	00.0	00.0	00.0	00.0	00.0	00.0	1.3	00.0	.16
S_2	00.0	15.0	2.6	00.0	15.0	00.0	4.4	4.4	5.18
S_3^a	n/a	n/a	00.0	n/a	n/a	n/a	n/a	n/a	n/a
S_4	5.8	7.0	9.9	13.6	15.0	15.0	15.0	15.0	12.04
S_5	00.0	10.0	.2	3.4	.9	2.3	00.0	00.0	2.10
S_6	00.0	00.0	2.9	00.0	00.0	00.0	00.0	00.0	.36
S_7	00.0	1.5	00.0	00.0	.4	00.0	1.6	6.3	1.23
S_8	11.1	4.4	5.2	2.0	1.5	13.7	15.0	14.8	8.46
S_9^a	00.0	1.5	n/a	n/a	n/a	n/a	n/a	.7	n/a
S_{10}	00.0	7.9	14.4	00.0	00.0	.6	00.0	5.6	3.56
S_{11}^a	4.8	3.1	00.0	.5	00.0	unc	unc	[illegible].0	unc
S_{12}^a	3.5	n/a	n/a	1.8	n/a	n/a	n/a	n/a	n/a
S_{13}	3.2	1.6	9.1	7.2	2.2	7.2	7.7	1.1	4.91
S_{14}	11.3	9.7	1.4	2.2	9.8	.7	12.6	15.0	7.84
S_{15}^a	.9	13.3	4.9	5.2	3.1	.3	1.4	15.0	6.51
S_{16}	7.1	2.0	12.9	3.6	2.2	.4	.3	.1	3.58
S_{17}^a	1.7	00.0	5.5	00.0	00.0	00.0	.3	2.6	1.26
S_{18}	2.5	3.3	.8	3.2	.4	2.7	2.6	.6	2.01
S_{19}^a	n/a	n/a	5.6	n/a	.5	.4	n/a	n/a	n/a
S_{20}	1.4	5.3	2.1	1.8	8.1	3.4	2.7	1.5	3.29
S_{21}^a	.5	8.9	1.2	3.6	unc	unc	5.5	unc	unc
S_{22}	11.8	3.0	12.5	15.0	12.9	9.4	15.0	1.1	10.09
S_{23}	10.3	10.7	10.5	9.6	11.7	14.7	8.4	11.8	10.96
S_{24}	.4	00.0	1.6	3.3	00.0	00.0	.4	3.8	1.19
S_{25}	3.8	2.0	.9	00.0	1.4	1.1	.2	00.0	1.18
S_{26}	2.4	3.6	5.3	5.2	1.5	1.5	3.4	2.9	3.29

[a] Subject not included in analysis.
unc = uncodable due to poor video quality.
n/a = protocol terminated prior to completion.

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