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WHERE IS IT AND WHEN IS IT COMING BACK: A STUDY OF TRACKING AND HIDING WITH DEAF AND HEARING INFANTS

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WHERE IS IT AND WHEN IS IT COMING BACK
A STUDY OF TRACKING AND HIDING WITH DEAF AND HEARING INFANTS

BY

CAROL F. REICH

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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Abstract

WHERE IS IT AND WHEN IS IT COMING BACK

by

Carol F. Reich

Adviser: Professor Katherine Nelson

What are some of the early consequences of genetic deafness? How is information gathered; and does it matter which way it is gathered? These questions were examined by comparing the behavior of deaf and hearing infants on tracking and hiding tasks using an accepted standard as a test vehicle: the Uzgiris-Hunt scales. Observations began when the infants were six months of age and continued for a total of six sessions. There were deaf and hearing infants who were either in no-sound or full-sound conditions. A variety of measures were devised in addition to those dictated by the standard scale. Using the standard scale, the performances of the deaf infants were often similar on average to those of the hearing infants. When using the devised measures, differences in performance were observed between the deaf and hearing infants. On the standard scale, most of the deaf infants were scored as 'searching the point of disappearance' on a tracking task, unlike the hearing infants who had a variety of strategies. The deaf infants were the fastest to orient to the presence of a toy in their visual field, and were fixed at the end of the track. In addition, both oral and manual/visual exploration remained at a high level for the deaf infants. Thus, some of the observed early consequences of genetic deafness appear to be related to depriva-

tion of auditory information. The lack of information can lead to fixed strategies which may interfere with the deaf infants' ability to detect the arrival of new objects and events. Further, lack of clear auditory information is related to a higher level of exploratory behaviors that may not add critical event information.

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INTRODUCTION

How do children take in and utilize information when a sensory system which is designed to gather that information is damaged? The auditory system is a primary receptor of distal information, of both linguistic and non-linguistic types. This thesis addresses some of the consequences of an early permanent lack of consistent non-linguistic information in the auditory channel.

It is suggested that this information deficit could result in problems with localization of objects and anticipation of events. Behaviorally this might show itself in tasks involving appearance and disappearance, such as tracking and hiding. The specific question addressed in the present study is: are deaf infants at risk with regard to these tasks? For the deaf, the world is initially divided along a single dimension: deaf/hearing. The early experience of the world on either side of the dividing line is the focus of this study.

1. Consequences of Early Deafness

The observable consequences of early childhood deafness are varied and pervasive in the life of an individual. Most workers dealing with the developmental effects of deafness concentrate on the linguistic effects of the deprivation of sound (e.g., Schlesinger & Meadow, 1972, Bellugi and Klima, 1975). Problems with spoken and written language can, and often do, place severe restrictions on world functioning for hearing impaired children. For example, in 1966, Furth analyzed reading scores of 5,300 deaf students between the ages of 10.5 and 16.5 years. He found that only one percent of the children aged 10.5-11.5 had reading scores of grade 4.9

or better; only twelve percent of those aged 15.5 to 16.5 scored at 4.9 or better. To put this in perspective, a functional level of literacy in the United States is defined at the fifth grade level.

Some researchers believe that the basic deprivation of deafness is really a deprivation of language (e.g., Meadow 1975). While the present work does not deny the profound consequences in the area of language and communication, the work here is concentrated on a less explored consequence that may be due to the early deprivation of meaningful non-linguistic sound. The present study was designed to look at adaptation on a sensorimotor level when one of the systems that serves to organize early experience is nearly absent or severely limited. The concern here is: how does a child locate and anticipate objects when auditory cues are degraded, and how is the notion of a referent developed and maintained? More simply stated: What are some of the psycho-physical components of the subject/object relationship used to arrive at an 'understanding' by the child of objects in three dimensional space, and what connects the short successive intervals of an event? The latter is not only a problem of sequence and duration, but also one of anticipation and prediction. The point to be stressed is that there is more information available in sounds than simply linguistic information.

Howarth and Wood (1977) make a distinction between incidental noises and intentional noises of a non-linguistic nature. Incidental noises (e.g. footsteps) can give both advanced warning and signal the end of a sequence. Intentional but non-linguistic sounds (e.g. changes in intensity) can indicate which objects or events are important. Neither of these sounds may be regularly perceived by a deaf infant. For example, the connection between a baby's hunger or distress cry and the arrival of a caregiver may be very unclear to a deaf infant. The baby may not hear the gradually approaching footsteps of the adult, or the opening of a door or the sound of the mother's voice as she approaches. For a deaf infant the mother's voice cannot serve as an organizer to focus attention on the world or draw the baby's attention back to her (see White, 1985, in press).

Consider the constraints in the experiential world of a young deaf child who has a hearing loss of 80dB: this child cannot hear breathing (10dB), whispering (30dB), or normally spoken human speech (60dB). The child will also not hear footsteps, water running, or the closing of a door. How does this child take in and use information that must come in through other senses to locate herself and objects in the physical world? It has been generally assumed that the deaf develop exactly the same concepts as the hearing, albeit with scattered time lags (Furth, 1971). However, it is possible that some concepts develop differently in deaf children. Although deaf children have an object concept, the way in which it is achieved and maintained may be different. For deaf children, it is unlikely that, at present, auditory training can fully restore to them a system similar to one that develops using early normal auditory discrimination. Since a primary receptor is inconsistently available to them, it is conceivable that deaf infants learn to predict or anticipate the arrival of social or physical objects in ways that are different from the ways in which hearing infants learn to predict or anticipate.

Do deaf and hearing babies experience the world equivalently? Both have fairly good visual acuity and control over their visual systems at an early age, but deaf babies lack auditory acuity. If one of the systems that serves the organization of experience is seriously damaged, then the same stimulus presented to deaf and hearing babies will be differently perceived and may not be equivalent for the infants at all. A hearing child sees and hears a rattle shaken on his or her right side and then dropped to the floor. When the event is repeated a consistent sequence of information is available. A deaf baby sees a rattle shaken on the right side and may or may not hear something when the rattle is dropped. There is a wide range of environmental sounds available to a child and how a baby's auditory loss affects perception of this range is not known. A sound can be heard partially, clearly, distorted, or intermittently. For the hearing baby there are several parallel or contingent sources of information available; the components of the experience available to and used by the deaf baby are at present unknown.

The conception of the auditory system as a receptor of information from the world for non-linguistic events is important. In a study of the role of modalities, Goodnow (1962) posed two questions relevant to the concerns of the present study. First, which way does an individual gather information? Second, does it matter which way? The present study investigates the degree to which the quality of information is effected by the way in which a child gathers it.

2. Some Effects of Early Loss of Information Coming From Auditory Sources.

The auditory system is generally thought of as being "better than" the visual system in its capacity to discriminate temporal relationships (Nickerson, 1978, Blank & Bridger, 1966) and it may also be used as a gauge of distance and location. Although there is no absolute information about distance given by sound (Bower 1977), sound can be used to predict the appearance, reappearance, presence and location of an object, including a social object such as the primary caregiver. These sounds are single elements that can be seen as signs which predict the larger whole (Kagan, 1979), and, for a hearing infant, some noisy components of an event come to represent the entire event. For example, a bark serves as a representation of a dog, a closing door can signal departure, or the direction of the footsteps can signal an arrival or a departure.

The present work proposes that if information about environmental events comes in primarily through the visual channel, the child's understanding about those events may be different than when both auditory and visual channels are available. This will be seen in differential performance on tasks concerning appearance and reappearance. For a deaf child, an object has 'seeableness' and 'touchableness' (Gratch, 1976), but no 'hearableness' to signal its arrival or location. With imperfect audition, a child's effective environment is different from the beginning.

Having considered the first of Goodnow's (1962) questions concerning the way in which the deaf child gathers information, we now turn to her second question: does it matter which way? A controversy exists as to the independence of the perceptual systems in newborns. For example, it has been reported that hearing neonates will show auditory localization - they turn to the right when the sound is on the right and to the left when the sound is on the left (Wertheimer, 1961). A newborn infant turning toward a sound has not had the chance to "acquire" this response. Thus, the response was taken by Wertheimer as an indicator not only of auditory localization, but also of the infant's expectation that there would be something to see. As Aronson and Rosenbloom (1971) stated, auditory events are expected to have visual consequences. Wertheimer's interpretation rests on the assumption that the senses are initially integrated and that the infant's developmental burden is to differentiate and then to articulate the individual perceptual modalities. The implication of this position for the deaf is that poor auditory information may have little effect or make no difference to the quality of the information as all the systems are integrated initially.

McGurk, Turnure and Creighton (1977) failed to replicate Wertheimer's results. In their study, 80% of their infant subjects made no eye movements in response to single, lateral auditory stimulation. They interpret their results in support of the notion that... "during the neonatal period, the auditory and visual modalities are relatively independent systems. Thus, the developmental problem is to account for synthesis between perceptual modalities." For the deaf, this means that the developmental problem is to account for a synthesis in the remaining modalities with the absence of one major modality.

Piaget (1954) and Bower (1982) both take an interactionist position which falls between these two extremes. For Piaget, the earliest motor schemata (grasping and sucking) are present at birth, but the coordination between these schemata is achieved through continuing adaptations resulting from encounters with the world. For Bower, early perception is amodal: a sound elicits a total orientation of all receptors. The developing infant eventually refines 'something is happening on my right' into 'I hear a sound', leading to the anticipation of a visible object event. "Informal memories and expectations control the baby's behavior, and he uses his perceptual system to realize these expectations" (Bower, 1977, p. 50). A deaf baby, according to this position, will build his world from whatever is available. Sound, as Altschuler (1974) says, "...gives us eyes in the back of our heads so that without conscious effort or direction we monitor our surroundings flexibly...that allows for the necessary distance from the raw percepts for the conceptual manipulations and rearrangements of high level abstract thought. All these cognitive attributes afforded by the qualities of sound the deaf child does without" (p. 372).

Almost all children learn that objects exist, disappear, and recur: in Piaget's terms this is the concept of object permanence. Object permanence is generally taken to mean the attainment of a unitary cognitive concept - "...symbolic evocation of absent realities" (Piaget, 1954, 1962). For Piaget, a fully developed concept of the object includes the knowledge that objects are independent of the perceiver. The object exists and moves in a space common to it and to the observer. Further, the object continues to exist when the child is not actively involved with it.

To construct knowledge about objects, young deaf children may use a non-auditory based "organizing activity" (Sinclair, 1970); that is, they may use different basic action patterns during the sensorimotor period. This idea relies on an interactive model of the construction of knowledge where the child, the object, and the 'context' are actively related in the process of knowing. This position allows for the possibility of reaching the same end through different routes or of reaching a qualitatively different end through similar or different routes.

3. Possible Models to Explain the Performance Differences of Deaf and Hearing Children.

Historically, when the deaf have been compared to the hearing on conceptual tasks requiring abstract thinking, the deaf were found to lag behind the hearing in numbers of correct responses. This "inferior" or deficient performance was often attributed to their lack of language experience (Myklebust, 1964, Oleron, 1953). The deficit model in its extreme form views deafness as a profound impairment that prohibits the attainment and mastery of certain cognitive skills. In opposition to this position Furth, Youniss and other investigators (e.g., Furth, 1971), attempted to demonstrate that 'linguistic deficiency' does not mean that the deaf are lacking in general symbolic activity, and that thinking can develop without the benefit of the structure of a spoken language. Tasks involving rule learning, the use of logical symbols, and conservation, memory, and perception problems were given to deaf and hearing children over 6 years of age. Furth found that despite not having been provided with "a conventional symbol structure, deaf children construct their own symbols as they are needed for the development of thinking" (p. 70). They just do so more slowly and, thus, are seen as merely delayed.

In addition to the deficit and delay models, another model can be proposed: a difference model. A difference model proposes that a deaf child functions and processes differently in a world which does not provide clear or consistent auditory cues. From this point of view the "deficiency" resides in the kind of information that is afforded to the deaf infant, and not in the infant's ability to think or gain knowledge.

Consider again a very young deaf baby in a crib - if the infant cannot hear the sounds that precede the appearance of the caregiver in the visual field, how does the child come to know about and interpret disappearance and return? And is the interpretation qualitatively different from that of a hearing child? If most information is processed primarily in the visual modality, or at least without clear auditory support, a deaf child may use different channels and methods to learn about things. Without clear audition, and with the visual channel used to maintain contact and receive communication, it may be more difficult to construct a reference field and to move flexibly within that field. Objects and people may disappear suddenly from the visual field of a young, deaf, relatively immobile infant - they are there and then they are not there. The return of people and objects is unheralded. If this is approximately the way these events appear to a deaf child, then what do they use to anticipate and predict reappearance if they learn it at all?

In line with this question, Kelly and Tomlinson-Keasey (1976) suggest that preschool hearing-impaired children may not develop or use their cognitive abilities in the same way as their hearing peers. They suggest that this difference is not due to a language deficit, but to different sensory input. Information which is acquired visually may lead to the development of cognitive structures and ways of processing information that are qualitatively different from those of the hearing child. A deaf child may develop different patterns of action due to a different sort of supportive environment: an environment deficient in the information bearing properties of sound. For example, Gregory and Mogford (1980) note a study on play in which they detected differences in the organization of the play of deaf mothers and their babies. The differences were that the deaf mothers did not play anticipation games such as 'peek-a-boo' and 'this little piggy' with their children. A reason for the difference may simply be that one cannot participate in these games when the hands needed for communicating the rules are involved in the game itself. A further problem is that baby games often rely on the voice to modulate sequences and terminate behavior (Stern, 1977). These are examples in which the constraints on a semiotic system by its mode of expression are clear.

When the visual channel is relied on to receive many different types of information, it may be difficult for a child to shift attention to the next event when no other distal system pulls attention away. This could lead to missed information and problems in recognizing the regularities in events. If so, this lack of attentional shifting might lead to a prediction that a reduction of varied sources of information would lead to less flexible solutions to problems.

It is thus possible that the deaf child's relationship to objects and events may be different from that of hearing children and serve different purposes for the child. It may also be that the deaf child's links to social and inanimate objects are not very flexible (Nelson, 1978) and may be related to limits on information about the construction of the physical world.

In line with this, Kelly and Tomlinson-Keasey (1977) found that young deaf children have trouble giving an object multiple labels, or translating labels into multiple objects. They conclude that the transformation problem could be due to a cognitive system that is structurally different from a system that processes both sight and sound. They are careful to state that this does not imply an inferior or superior system, but a system that is different.

4. Observed Differences in Performances of Deaf Children.

Myklebust (1964) theorized that when one sensory modality is missing, the integration and the function of the others may be altered. In some of the earlier literature, (Furth, 1964; Oleron, 1953; Templin, 1950), deaf children were compared to hearing children and were found to be retarded in their mastery of specific cognitive concepts. In contrast, Blank and Bridger, 1966, found that deaf children showed greater facility than hearing children in handling tactual material. In these two studies, deaf and hearing children were compared on their ability to transfer concepts across sensory modalities. In both of these studies older deaf students were "more proficient in using tactual cues, suggesting that the tactile modality may not be equivalent to deaf and hearing children." Blank and Bridger could not determine whether the younger deaf children's solution to the problems was based "upon the use of a concept or repeating a successful strategy." In addition, Blank and Bridger noted that "The poor performance of these younger subjects was due not only to their failure to use language, but also to their adopting fixed patterns which were not altered even in the face of failure" (p. 33).

In another study Blank, Altman and Bridger (1968) gave a tactual discrimination problem to deaf and hearing three-year-olds. Twenty pre-school-age deaf children inserted their hands into a box where the experimental objects were located and were told by the experimenter to pick up two objects and then to "drop the right one." Ninety percent of the hearing children solved the problem ("drop the right one") within three or four trials. None of the deaf children performed the task correctly. The deaf children sat there either holding the objects or they dropped both objects. Blank et al. could, however, train the deaf children to reach a level of performance that equalled that of the hearing children by a four-step non-verbal training procedure which took about five minutes. Blank suggests that this study illustrates the limitation of the gestural system with reference to non-present objects.

In a previous study with deaf adolescents (Reich & Glick, note 1), it became apparent that they used objects in unusual ways. To illustrate: when communicating about an object which was the topic of the conversation, a deaf adolescent held that object out of the visual field of both himself and his listener, but maintained contact with it. When finished with his "turn," the deaf speaker did not release the object, but lowered it against the side of his body. Why was this tactile contact maintained when the object was out of the visual field? An answer may be that when the visual channel is occupied with communication, keeping contact tactually is a way of keeping the 'object at the border' (Winnecott, 1971) in a literal sense. Winnecott was speaking of infants' actions in an intermediate realm of experience, that is, at the border between subjective experience and what is objectively perceived. Perhaps deaf children hold the object being discussed outside the visual field and at the borders of their bodies as an aid to themselves. With the object out of sight, tactile contact could serve as some form of reference.

Writing on the kinesthetic sense in the deaf, Bell (1970) noted "...in the deaf child's desire to handle and feel...he seeks unconsciously to establish an impression beyond his sense of vision." The deaf child may maintain physical contact with an object for a longer period of time than a hearing child as was observed in older deaf children (see above). If so, this could be for at least two reasons; first, different types of information are used about an object, and secondly the degree of connection to that object is different. Once the object is "captured," physical links to it may be maintained because it is difficult for the child to predict the object's reappearance once he lets it go. If he lets it go, he cannot follow the object's path or maintain contact with an out-of-sight surface. It is not only that sound alone confers independence on an object, but that the attainment of "permanence" is both a perceptual and a conceptual problem. For the deaf child, the solutions must be established primarily within the non-auditory modalities.

Other studies comparing deaf and hearing children propose that there is a "mismatch" (Gormley & Franzen, 1978) between the child's typical pattern of response and a 'correct' response to the task. These studies suggest that deaf children may both take in information about things in the world differently and may also process that information in different ways. In a study of short term memory, Liben (1977) noted that deaf children might approach memory tasks more physically than hearing children, perhaps using different strategies as well. For example, one deaf child in the Liben study rocked to indicate a nonsense figure with a curved bottom. Finally, Hoemann (1972), in a study of 8- to 17-year-old deaf signing children, found that the children could teach the rules of a game to their peers when the objects were present. However, they "uniformly produced deficient explanations" when the objects were absent. These results may be due only in part to the constraints imposed by a gestural language system. However, these results could also be evidence of a cognitive difference in the relationship of deaf children to present and absent objects. In the present thesis, these issues are studied in relation to tracking and hiding tasks, which have both present and absent components.

5. Specific Aims of this Study

Audition is a system that handles distal environmental sound as well as linguistic information. Infants with genetic deafness experience degraded auditory information probably from birth. Investigating the possible effects of this loss of information on their development in relation to problems involving appearance and disappearance is the aim of the present study. The approach was to compare deaf infants and hearing infants under conditions in which the auditory components of the tasks are modified. The grouping of the infants was designed to illustrate a possible range of auditory experience from full sound to no sound. A group of normal hearing infants was tested in a "sound free" environment.

It is possible to look at the ways in which infants solve tracking and hiding problems by using a recognized ordinal scale of psychological development such as the one constructed by Uzgiris and Hunt (1976). However, it was expected that standardized measures might not be sufficiently sensitive to all of the differences between the groups. Thus, additional measures were devised for use in the present study. A further reason for devising these measures was to look at additional responses of both deaf and hearing infants. These measures may reflect on the applicability of a scale which was developed using an intact population for use with deaf infants.

The design of the study was longitudinal, in order to follow the course of cognitive development of very young deaf children about whose early development little is known. Cognitive studies of deaf infants are few in number (e.g., Escalona 1963) and those that exist have not produced clear conclusions. There is as yet no clear correspondence between measured hearing loss and any of the behavioral consequences of deafness.

Further, there are particular difficulties encountered in research with the deaf, not the least of which is the difficulty in finding infants in their first year of life. Many studies do not carefully control etiology, age of onset, degree of loss and the educational setting of the observed children. (See for example the comments of White, 1984.) Thus, comparisons between groups that are not controlled in these areas confound important factors which may partially account for the inconsistent results found in the literature.

In the present study, there were three groups of infants. Two groups were hearing infants, differentiated by the toys they received. One group was given toys with sound components; the other toys with the sound components removed. The third group was composed of hereditarily deaf infants who were given toys with sound components. It was expected that the largest difference would be between the hearing group with sound and the deaf group; and that the hearing group without sound would fall between these two for all measures.

A second prediction was that children deprived of simultaneous sources of information might settle on a successful strategy and continue to use it because they fail to attend to changes in the situation which would encourage them to respond differently.

A third prediction was that because of the limitations of incoming information, the deaf children might use other sensory means to gain information in a way which differed from the hearing children.

II. METHODS

A. Subjects

The subjects for this study were four deaf and seventeen hearing infants aged 6 months ($\pm$ 1 week) at the time of initial testing. All of the infants were full term babies whose birth and current pediatric records revealed no sensory abnormalities, other than deafness. They were recruited through a birthing center and a school for the deaf. Parents of potential participants were mailed a letter describing the study. Interested hearing parents telephoned and deaf parents responded by letter. All parents were subsequently interviewed in person.

Hearing Babies All of the children came from intact families. The education level of the parents ranged from completion of high school to the attainment of professional degrees. Seven hearing mothers were employed, two in full time jobs and five on a part-time basis. The jobs ranged from white collar to professional. None of the children were in a day-care program; their parents or a grandparent shared the responsibility for their care and two were taken to work with their mothers.

Most of the hearing babies were born in a birthing center in Manhattan and all were well within the normal range in weight and APGAR scores. After the initial interview, 20 hearing babies were randomly assigned to one of two experimental groups based on stimulus properties.

There had been 10 babies in each hearing group initially. One family moved away, one child developed a prolonged illness and missed two sessions. One child completed the study and then the mother telephoned to say that testing was being done to 'investigate a relative's suspicion of retardation.' Therefore this child's data were not included in the analysis, although they were in no way different from those of the other babies. Thus the final sample consisted of 17 hearing infants and 4 deaf infants.

Deaf Babies The four deaf children in this study lived in intact middle class homes. None of the deaf mothers were employed outside the home. The employment status of all of the fathers was white collar, or in a small business. The families of the deaf children included grandparents and relatives, all of whom live in close proximity, and many of these relatives were deaf. These babies were consistently exposed to adults other than their parents. These ranged from family members to the diagnostician and therapists in the school for the deaf. Some of the known early social experiences of all of the deaf infants were relatively similar to one another and different from those of the hearing babies. All of these infants were audiologically tested, aided, and enrolled in an infant program in a school for the deaf prior to their entry into the present study.

All of the deaf infants were hereditarily deaf. That is, both parents were deaf and there was a history of hereditary deafness in the family. The criterion of hereditary deafness was chosen primarily because hereditary deafness is significantly less associated with other disorders (Jensema & Mullins, 1974) than non-hereditary deafness. A further reason for choosing hereditary deafness as a criterion lay in wishing to approximate the experience of the deaf group (DS) with the hearing groups (HS, HNS) with regard to early language stimulation. Deaf children of deaf parents are exposed to a clear symbol system (American Sign Language) that provides labeling for objects in comparable ways to the labeling language surrounding hearing babies. (If the three groups of children differed along a dimension as critical as an opportunity to understand and learn a home language, then the use in the present study of objects that can be named would be confounded.)

A limitation imposed by the decision to choose hereditarily deaf infants was that deaf children of deaf parents represent only about 10% of deaf children (Northern & Downs, 1974) and this factor contributed to the small size of the sample. Since deafness is often an invisible handicap early in life (Altschuler, 1974), it is frequently not diagnosed until the child is three years old when that child comes from a hearing home (Meadow, 1975).

Hearing Loss The New York State Education Department definitions of degrees of deafness were used in this study. All of the babies in the Deaf Group (DS) have congenital, irreversible, bilateral sensorineural losses. These children were diagnosed and entered into an infant program in a school for the deaf. The degree of decibel (dB) in the New York State Education Department definitions loss figure is derived from an average of averaging frequencies in the speech range with reference to the better ear. The levels are as follows:

Moderate loss:	50-65 dB
Severe loss:	70-85 dB
Profound loss:	90 dB or greater

The hearing levels of infants in the study were:

Baby Albert - boy - severe to profound

Baby Winifred - girl - severe to profound

Baby Xenia - girl - profound

Baby Yves - boy - severe

The numerical range of the losses in the babies in the present study was from 75 to 90+ dB loss in the better ear. That is auditory perception was, at its best level, at a 75 dB loss across the speech range, and, at its worst at a 90 dB loss. Baby Yves was the 'least deaf' and Baby Xenia, the 'most deaf.' (See the audiograms of these children in Appendix.)

Although all of these children received hearing aids when they were between 3- and-4-months-old and before starting to participate in the present study, their mothers reported inconsistent use of aids at home. Further, the use of the aids was not consistent across sessions. There were times when the babies arrived without aids; at other times their mothers removed the baby's aids during a session. It is to be noted that the matter of providing hearing aids can lead to problems between young deaf children and their parents (Blum, 1984, in press). The best that can be said for the children in this sample is that they received more auditory experience than most deaf children who are diagnosed later in life, despite the inconsistencies noted above. In this sense, the babies in this study can be considered 'advantaged' in a deaf child population. Deaf children who enter into remediation at an early age 'do better' than those who enter later (White & White, 1984, in press). 'Doing better' refers to school related activities, both socially and academically.

It is important to note that aiding does not bestow normal hearing. In fact, it is impossible to know what a deaf infant experiences with or without aids. What we know at present is that both background and foreground sounds are amplified, and that amplified sound is a distortion of the normal hearing experience (Northern & Downs, 1974). Nonetheless, early aiding is considered an important part of early remediation because it exposes the child to sound stimulation.

B. Design of the Study:

A longitudinal design was chosen for several reasons. The first was that there is very little known about the normal development of deaf infants. That reason alone could lead to longitudinal design. Secondly, the effects of a major sensory deficit may increase as the demands of a child's world become more complex. Some of the possible effects of early deafness may then be apparent in a six month study of individual infants.

Experimental Groups Three experimental groups were formed to illustrate a possible range of auditory experience. The deaf babies (DS) and the hearing babies with sound (HS) represented two extremes of auditory stimulation from very little to augmented environmental sounds. The hearing group without sound (HNS) was chosen to represent a 'middle ground' in the study. Due to an experimentally-imposed disturbance of their normal auditory experience, this group (HNS) was expected to more closely resemble the deaf infants in performance than the HS babies. In other words, the prediction was that the HNS babies would 'do worse' than the HS babies through the six months of testing, especially in the hiding tasks. The increased use of peripheral vision by deaf infants (DS) is known to audiologists (Downs, 1974) and it was expected that this would help to compensate for lack of auditory cues in some of the tasks. That is, the deaf infants' use of the full range of their peripheral vision would enable them to rapidly orient to an object's arrival at the edge of their visual field without the aid of a clear sound cue. The increased use of peripheral vision would help to compensate for the lack of clear auditory cues. Overall, it was anticipated that the HS would do better than the other two groups. The experimental groups were as follows:

Group I (DS) - Deaf infants, (2 boys and 2 girls). Stimuli presented to these infants had added sound properties (bells and/or rattles) and the surface in front of these infants was hard plastic.

Group II (HS) - Nine normally hearing infants (5 boys, 4 girls). The test stimuli for this group all had added sound properties - bells or rattles that were shaken each time the toy was presented to the infant; e.g., the string of three pop-beads had bells inside. The surface of the table in front of these babies was hard plastic.

Group III (HNS) - Eight normally hearing infants (3 boys, 5 girls). The test stimuli were the same as for Group II, but all of the added sound properties were removed, e.g., 'Miss Piggy' - a finger puppet, had no bell around her neck. In addition, the surface of the table in front of these infants was thickly padded with layers of terry cloth.

Except for their sound properties, identical stimuli (toys) were presented to all three groups. The toys are fully described below.

<u>The test instrument: The Uzgiris-Hunt Scales</u>

An underlying assumption in the Uzgiris-Hunt scales is their ordinality. Uzgiris and Hunt (1975) selected and ordered behavioral responses to tasks involving disappearance and reappearance of objects based theoretically on Piaget's description of sensorimotor development.

They state (p. 19) that "...one can also use these scales, as they are, to assess the degree to which development along any given branch is a function of encounters with particular kinds of circumstances...". This rationale made this scale appropriate as an initial frame with which to look at the present data. The present study was concerned with repeated, controlled perceptual encounters that were varied in terms of the stimulus properties in order to look at the implications of a major sensory loss on the way a child gathers information.

There were a number of other reasons for using these scales. These were: first, that they represent the most comprehensive attempt to construct ordinal scales based on properties of sensorimotor development (Bloom, 1979). Second, they use objective measures to examine early experience. The scales are described by the authors as an empirically derived ordering in which the issue of order rather than that of stages is central to the study (Uzgiris-Hunt, p. 15). Third, since they are widely used by other workers, their use in the present study can help to relate the present results to the results of other studies (e.g., Corrigan, 1977; Bates, E., Beningi, L., Bretherton, I., Camaroni, L., and Volterra, V., 1979; Bloom, L., Lifter, K., and Broughton, J., 1979). Finally, within the scales there are a variety of tasks that can vary in amount of auditory dependence.

Scale I of the Uzgiris-Hunt Scales was used. This scale, The Development of Visual Pursuit and the Permanence of Pbjects, contains 14 "eliciting situations" (test items, tasks) arranged in sequence. The authors state that this series focuses on what Piaget (1937) termed the construction of the object, and that "it concerns the development of the concept of objects of independent existence" (p. 103). Only the first four tasks in Scale I are used in the present work, as these tasks generated the largest amount of continuous scoreable data throughout the six sessions for each of the experimental groups. All of the infants were given these tasks in each session.

Materials used in testing:

1. Three plastic pop-it beads, approximately 6 inches in overall length. This toy was used in the tracking tasks. The beads were red, yellow and blue. The red bead was always the top bead. For the groups using sound, this bead contained a bell.
2. A hard rubber finger puppet, "Miss Piggy" from the Puppet Series of puppets. This toy was used in the hiding tasks. It was 3 $^{1}/_{2}$ inches long, pink, with yellow molded hair and a purple dress. A bell was attached to the puppet used in the sound conditions.
3. Two opaque cotton cloths, one beige and one white, approximately 6 inches x 8 inches.

The bells used had properties similar to the toys used to test for hearing impairment. Audiologists have found that toys with noisemakers are useful for testing because of the sudden, rapid onset of noise, and because the noises produced are complex sounds (Downs, 1974). The same sounds and toys were used for both the deaf babies (DS) and the hearing babies (HS). Other hearing babies (HNS) received the same toys with the bells removed.

Procedure

The tasks described below are the first four tasks in the Uzgiris-Hunt Scale I Test of Object Permanence, and were administered as suggested in the protocols (see Appendix). In the following task descriptions, passing is defined by achieving the critical action specified in the Uzgiris-Hunt protocols for each task.

An infant was given a test item, for the number of trials recommended in the Uzgiris-Hunt protocols (see Appendix). The level of performance was recorded on the protocol sheets. Even if the infants refused to perform the task three times, the next task was given. Uzgiris-Hunt state that "...it is always wise to attempt to elicit actions critical for some two or three successive steps beyond the one for which the infant fails to show the critical actions..." (p. 139).

Task 1. Following a slowly moving object through 180 degree arc. Before the task began, the beads were placed on the table in front of the infant and jingled. The string of three pop-it beads was held at the infant's left approximately level with the baby's eyes, approximately 6 inches-8 inches from the ear. The beads were shaken causing the bell in the top red bead to jingle. When the baby's eyes turned to the left, the arc began. The beads were approximately 10" in front of the infant, and the arc stopped in front of the baby's right shoulder. The rate of movement was such that it took approximately five seconds to complete the arc. The presentation of tracking items was always from the examiner's right to the examiner's left. Task time was computed from the time the baby oriented visually to the object until the baby's eyes returned to the midline.

If the baby did not achieve the passing level as specified in the Uzgiris-Hunt test protocols (see Appendix A) for this item or did not track after three trials, the examiner proceeded to the next items.

Task 2. Noticing the disappearance of a slowly moving object. The procedure was the same as above, but the beads disappeared below the opposite edge of the table in front of the infant's seat. If the baby did not achieve level C - lingers with glance on the point of disappearance - after three trials, the examiner went on to the next item. The task time was computed from the time the baby visually oriented to the object until the baby's eyes returned to the midline.

Task 3. Finding an object which is partially covered. The 'Miss Piggy' finger-puppet was used for this task and for the following task. The puppet was presented to the child before the task started. It was placed on the surface of the table at the midline, to see if the baby would reach for it, and pick it up. The babies all picked it up, and played with it for about one minute. The examiner took the puppet, dropped it out of sight, then the puppet was brought back, shaken, and put on the table. As the baby reached, the puppet was partially covered with a white cloth. The top of the head or the bottom of the puppet was left uncovered on alternate trials. If either the first or second trial took longer than 15 seconds, the examiner removed both cover and puppet and started a new trial. During pilot work, it was found that the youngest babies could easily accomplish the removal of the screen and retrieval of the object within 15 seconds. The problem became one of the examiner moving fast enough to place the screen on the object before the baby's reach was completed.

Task 4. Finding an object which is completely covered. The procedure was exactly the same as in the previous task with one exception. As the baby reached for the puppet, the puppet was covered completely.

The task time was computed from the time of covering the object, to capture of the object by the infant (Gratch, 1976).

Scheduling and recording of sessions Each infant was seen six times for sessions which were approximately four weeks apart. This interval varied occasionally (7-10 days) due to an illness of either the baby or the mother. On arrival, the hearing dyads were seen in a playroom before entering a smaller room in which the testing was done; deaf infants were seen in a nearly identical setting in the school for the deaf. A videotape recording of each session was made with full knowledge and consent of the mothers. The infant was seated in a feeding table; that is, a table-height chair with a wide flat surface in front. The infant's mother was seated on the floor to the front and right of the baby during each session. The experimenter was seated on the floor directly in front of the baby. A stationary Panasonic video camera (WV341-P) with a Sony TV zoom lens (#788299) was mounted approximately 6 feet behind the experimenter. Elapsed time was automatically recorded on the videotape in each session.

After being seated, each infant was given a set of plastic keys on a shoe lace. All of the babies reached for and took this toy from the experimenter at the beginning of each test session. They played with the toy for approximately one minute. When the infants were 6 to 7 months old it was usually necessary for the experimenter to repossess the keys. As the babies grew older, they would drop the keys into the experimenter's open, extended hand.

C. The measures used

Eight measures were devised for the present study. Two of these relate directly to levels on the original scales (the pass/fail items). The other six measures were added to more fully describe the infants' performance and to help to discriminate differences between the groups. Of the six 'new' measures, two time measures were included (latency and time on task) to differentiate between the initial effects of sound availability on detecting the toy, and then the possible effects sound had on task performance. The remaining measures were chosen to look at some of the possible effects of a sensory deprivation both within and between tasks.

In both the tracking and hiding tasks, attention is a within-task problem. The baby must initially orient to the stimulus, and then complete the task. Thus, "anticipation" is a measure that applies only to the tracking tasks, and is measured after the track's completion. Howarth and Wood (1977) differentiate between incidental noises and intentional sounds. Incidental noises can give advance warning about the arrival of things outside of the visual field, and thus indicate movement, and the end of a sequence (p.4). Both incidental and intentional sound convey information about an event in a non-visual form. These indicate other things happening which may require a switch of attention. The jingle of bells at the beginning of a track is intentional and incidental, and it too requires a child to shift visual attention. For the deaf child, there are changing demands on the distribution of visual attention within the tasks in the present study. The efficiency and anticipation measures focus on possible differences in task solutions between deaf and hearing infants. The compensatory use of alternate modalities, oral and manual-visual are examined in the remaining two measures.

The specific measures used were as follows:

1. Pass or fail - The passing criterion given by Uzgiris-Hunt was used to score each session simply as a pass or a failure. That is, on each trial an infant's score was either pass or fail, in relation to the critical action for that particular eliciting situation. The scoring criterion used here was 2 clear passes out of the three trials. The scoring criteria for this test have varied widely among researchers (Corrigan, 1979) and it was decided that in the present study one pass out of 3 trials could be a matter of random behavior, and 3 passes out of three would be an extremely stringent criterion. Therefore, two clear passes qualified as a pass in the present study.

2. Pass/fail weighted score - These were weighted values assigned to the ordinal test criteria given by Uzgiris-Hunt for each ordinal test item. The weighted values ranged as follows: a=0, b=1, c=2, d=3, e=4 (see Appendix).

3. Latency - the length of time in seconds from presentation of the stimulus until the baby oriented visually to the stimulus in tracking tasks. This measure is included in time on task.

4. Time on task - the length of time in seconds from presentation of the stimulus to completion of the tracking tasks. For the hiding tasks, the elapsed time was counted from the covering of the object to retrieval.

5. Oral exploration - a measure of whether or not the baby mouthed the experimental object after the experimental task in both tracking and hiding tasks.

6. Visual/manual exploration - As noted above, the babies were allowed to handle the experimental toys after each presentation. Whether or not the baby also explored the object visually after the hiding or tracking tasks by holding the object slightly below eye level and slowly rotated was noted. Any other visual exploration was not included in this measure, due to the inability to reliably detect eye movement in the present study.

7. Anticipation - A frequency tabulation was computed for the variable labeled anticipation. This variable coded four possible responses at the completion of both tracking tasks. These responses approximate the ordered actions in the Uzgiris-Hunt Scale I, Task 2, and were scored using the videotapes as follows:

0 - doesn't look - returns gaze to the midline.

1 - looks at endpoint - looks at the end of the track. This response includes a turn of the infant's eyes to the right.

2 - looks at beginning - infant looks to the left. The beginning of the track always began on the infant's left.

3 - looks at both ends

8. Efficiency - a criterion used on the hiding tasks to calculate the number of moves the infant made from the time of the covering of the test object to its retrieval. The experimental criterion 'efficiency' was used only in these two hiding tasks. The number of moves a child made in capturing or trying to capture the test object (Miss Piggy), was computed for each testing session. They were arranged as follows: from

the least number of observed behaviors necessary to complete the task to the number of behaviors involved in not completing the task.

0 - removes the cover and retrieves the toy

1 - does this with no more than 2 intervening behaviors (i.e., transfers cover, touches object)

2 - removes cover and retrieves the toy with no more than 5 intervening behaviors

3 - attempts to but does not retrieve the object using fewer than 4 behaviors

4 - does not retrieve the object using more than 4 behaviors.

D. Data Analysis

All of the variables, with the exception of the two pass/fail measures, were scored from videotapes. Two independent coders coded the data for one child and reached an inter-rater reliability of .96 for all measures.

To simplify the reading of these data, the following schematic is presented showing which measures were used in each of the experimental tasks. The numbers refer to the order in which the measures were presented in the previous section. Please note that not all measures are applicable to each task.

Tracking Tasks

Task 1 - object remains in view:
1. pass/fail
2. pass/fail score (weighted)
3. latency
4. time on task
5. oral exploration
6. visual/manual exploration
7. anticipation
8. (not applicable)

Task 2 - object disappears:
1. pass/fail
2. pass/fail score (weighted)
3. latency
4. time on task
5. oral exploration
6. visual/manual exploration
7. anticipation
8. (not applicable)

Hiding Tasks

Task 3 - partially covered:
1. pass/fail
2. pass/fail score (weighted)
3. (not applicable)
4. time on task
5. oral exploration
6. visual/manual exploration
7. (not applicable)
8. efficiency

Task 4 - completely covered:
1. pass/fail
2. pass/fail score (weighted)
3. (not applicable)
4. time on task
5. oral exploration
6. visual/manual exploration
7. (not applicable)
8. efficiency

For the hearing infants only, all of the analyses of the experimental variables employed a series of analyses of variance which compared the HS (hearing with sound) group to the HNS (hearing no sound) group. In addition a Wilks Lambda multiple F was utilized to test and identify statistically significant effects within each variable: session, group, and task. Session referred to each of six monthly visits per child. Task refers to each of four tasks; two tracking tasks and two hiding tasks. Thus, the design was a group X session X task for each of 8 variables. (Time [trial] was not entered as a factor since responses were averaged across trials within sessions.)

Deaf infants (DS) will be presented and labeled individually in comparison to the HS (hearing sound) and HNS (hearing no sound) groups. This study lies at the edge between experimental control and preservation of individual data; the deaf babies are members of an 'at-risk' population for which the developmental progress on tasks of this type is not documented. The small number of subjects dictated the decision to preserve and present each deaf infant's data individually. The hearing children served as two baselines against which the individual performance of the deaf children was compared.

III. RESULTS

The results will be presented separately for the tracking and hiding tasks and in the order in which the measures were described in the Methods section. An overall analysis of all the tasks (tracking and hiding) revealed no main effect for task, which indicates that no one task was consistently easier or harder across sessions. It is to be noted that the data for the deaf children (DS group) are presented individually, while the data for the hearing children (HS and HNS) are presented by group. Where there is a spread in the deaf children's data, the individuals are noted on the graphs. The figures reflect this organization as well. Unless otherwise noted, the trend analysis results refer to a linear trend.

A. Tracking Tasks (Tasks 1 and 2)

The two tracking tasks were: following an object through a 180° arc (task 1) and following a slowly disappearing object (task 2).

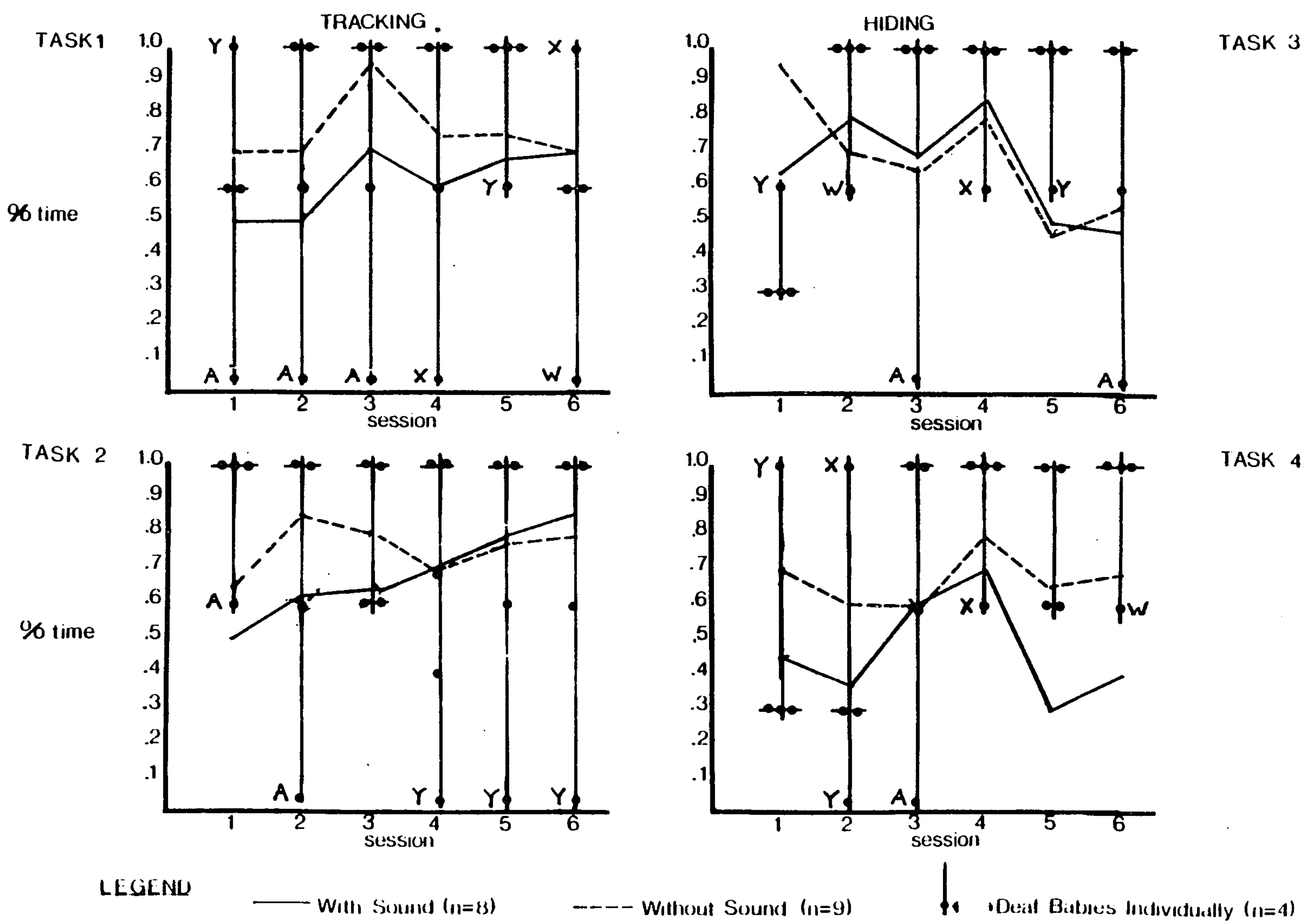
1. Pass or fail scores. These scores, as given on the Uzgiris-Hunt Scales, were assigned a value of 0 or 1 and computed by session for each baby (See Fig. 1). For the hearing groups (HS and HNS) there was a significant session effect ($F(1, 15) = 2.93$, $p < .05$) and a significant task effect ($F(1, 15) = 3.68$, $p < .05$). There was also a significant interaction (session x task) ($F(1, 15) = 11.00$, $p < .001$). (See Table 1 - task x session means.) Task 2 was on average easier than task 1 as indicated by the scores being closer to 1.0. In other words, when an object disappears completely, it is a task in which the infants 'do better.' The trend analysis reached significance as a second order

Table 1. Pass/Fail (0,1) Task x Session Means (Hearing Subjects - Tracking Tasks)

	Task 1	Task 2
Session 1 - 6 mo.	.63	.73
Session 2 - 7 mo.	.61	.75
Session 3 - 8 mo.	.80	.88
Session 4 - 9 mo.	.61	.75
Session 5 - 10 mo.	.57	.71
Session 6 - 11 mo.	.61	.63

Figure 1. **PASS/FAIL SCORE - UZGIRIS-HUNT SCALE**

0 = fail 1 = pass



polynomial ($F(1, 15) = 8.78$, $p < .01$). The hearing babies did 'best' between eight and nine months, and then their performance declined. That is, there was no clear linear developmental trend for this measure on the tracking tasks.

The data for the deaf group are also shown in Figure 1. For the deaf group, there is little clustering of their data. It is only in the fifth session of task 1, and the third session in task 2 that the range of scores of the deaf infants (DS) is not extreme. In task 1, the three low scores in the first three sessions belong to one infant. In task 2, the three low scores in the final three sessions belong to a different infant.

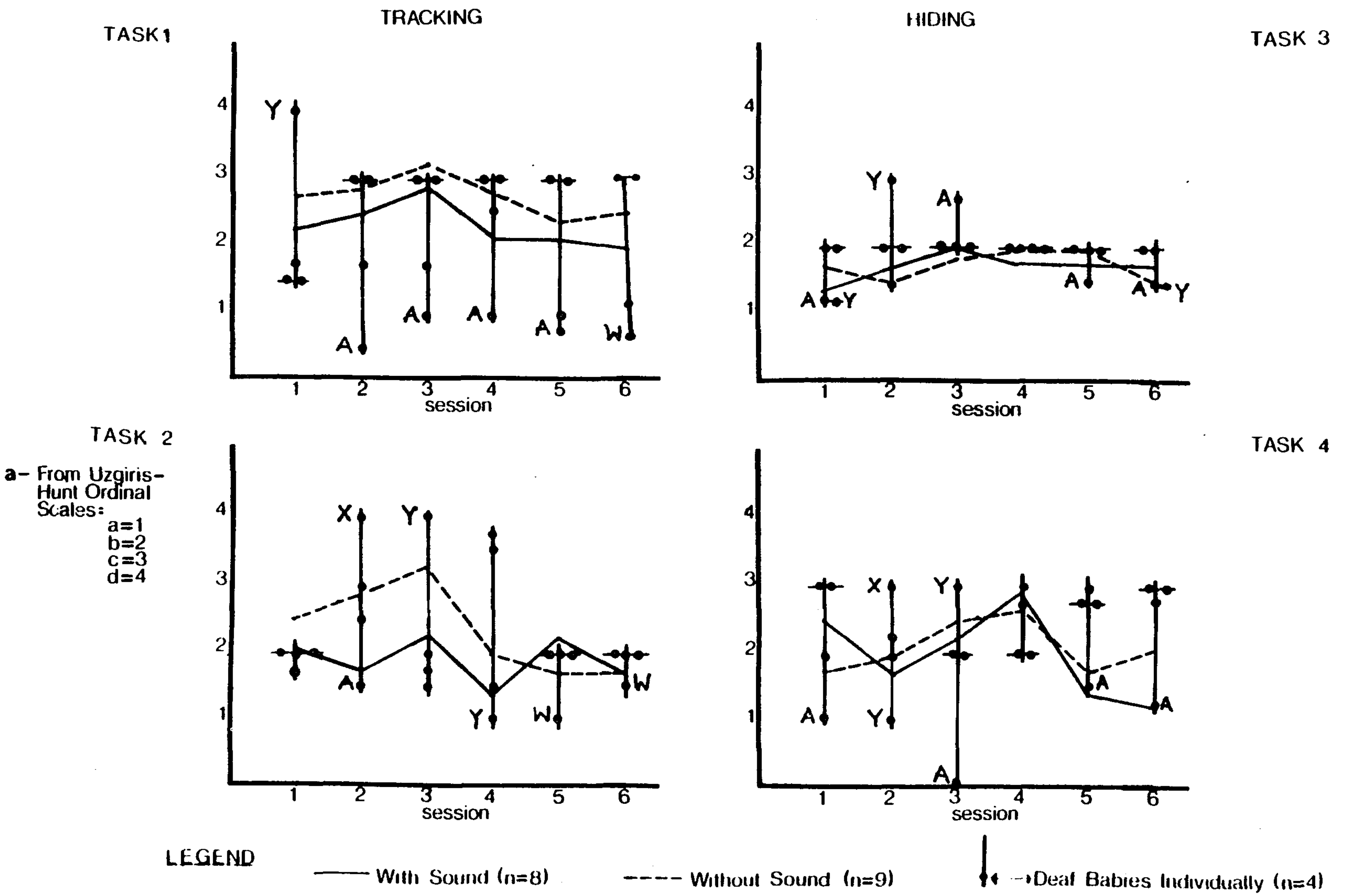
2. Pass/fail weighted scores. Figure 2 shows weighted pass/fail scores. Here the criterion level achieved within each task on the test protocol was weighted and scored. For the hearing groups (HS and HNS) the only significant effect was for session ($F(1, 15) = 6.07$, $p < .001$). Trend analysis reached significance as a second order polymonial ($F(1, 15) = 21.92$, $p < .001$), indicating no linear developmental trend for this measure. Table 2 shows that the means for task 1 are slightly higher than those for task 2, though the difference was not significant on this measure. That is, the hearing infants were not significantly more successful on either tracking task by the Uzgiris-Hunt criteria. There was significant change over time for the pass/fail weighted measure, but the change was non-linear. There were no group differences for the hearing infants on this measure.

The performances of the deaf babies (DS) are scattered around the nearly identical curves for both hearing groups in task 1. In task 2, the performances of the deaf infants cluster at session 1, 5, and 6. The performance of the deaf infants is also non-linear using this measure (see

Table 2. (Scores Weighted) Task x Session Means (Hearing Subjects - Tracking Tasks)

	Task 1	Task 2
Session 1 - 6 mo.	2.47	2.31
Session 2 - 7 mo.	2.53	2.39
Session 3 - 8 mo.	2.80	2.73
Session 4 - 9 mo.	2.47	2.31
Session 5 - 10 mo.	2.39	2.00
Session 6 - 11 mo.	2.37	1.82

Figure 2. **PASS/FAIL SCORE - WEIGHTED**[a]



Appendix for deaf infants' individual scores).

It is of interest to compare the percentage of babies who passed each task at specific ages. Appendix Table 1 gives this information and includes the age at which 100% of the babies in the Uzgiris-Hunt sample showed the critical actions in these tasks. (Please note that no infants in the present study appear in the 0-3 month age range, as testing began at 6 months of age.) What is striking here is that using the original scale criteria, all of the deaf babies passed at the same time as (for task 2) or earlier than (for task 1) the Uzgiris-Hunt normative sample. Some of the hearing babies in the present study passed both of these tasks later. This will be discussed later.

3. Latency. The single main effect for groups for the hearing children (HS v. HNS) was in latency ($F(2, 5) = 4.61$, $p < .05$). The babies in the HNS group oriented to the presentation of toys more quickly than the babies in the HS (with sound) did (see Figure 3). This effect was unexpected because it was anticipated that additional sound cues would aid in orienting hearing infants to the object. There are large standard deviations shown in Table 3 for this experimental measure. Analyses revealed that the extreme scores were not attributable to one individual infant. There were no significant interactions and no significant trend analysis. This means that the variability was not due to any differences between sessions, but, rather, to differences between the subjects.

The latency for the deaf infants (DS) in task 1 bracket the means of the HNS group, as shown in Figure 3. The outlying points reflect the scores of one deaf child. Without these scores, the time taken to orient to the stimulus is always faster for the DS than most of the HS (with sound) group. In task 2, the latencies of the deaf infants fall

Figure 3. **LATENCY**

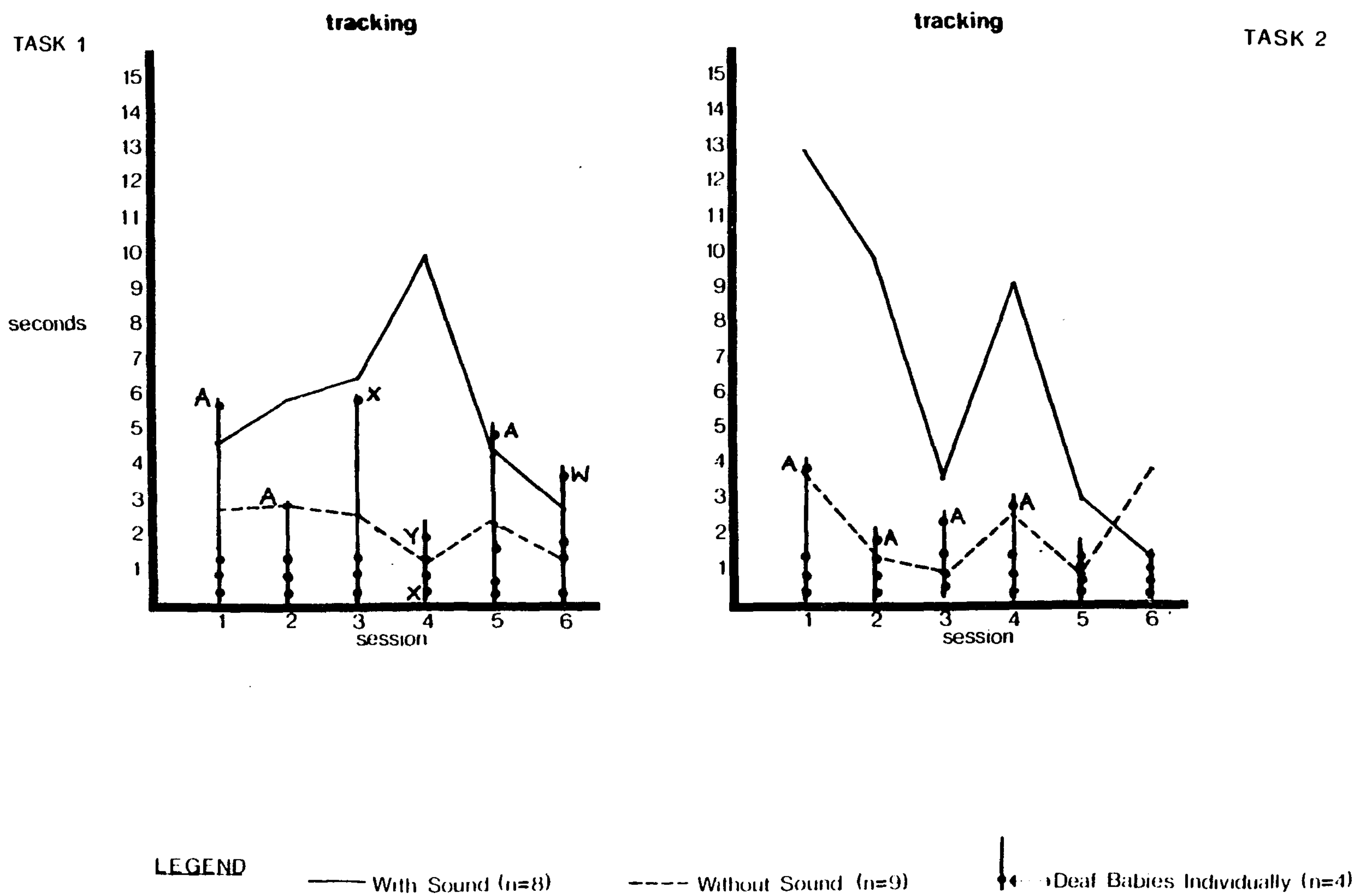


Table 3. Latency - Means and Standard Deviation x Session in the Tracking Tasks (Hearing Subjects)

		Session 1		Session 2		Session 3		Session 4		Session 5		Session 6	
		HS	HNS	HS	HNS	HS	HNS	HS	HNS	HS	HNS	HS	HNS
TASK 1	$\bar{X}$	4.8	2.7	5.8	3.0	6.6	2.8	10.1	1.3	4.5	2.4	2.8	1.5
	SD	4.7	2.7	5.0	5.6	9.7	8.4	30.0	.7	10.2	3.1	3.6	1.5
TASK 2	$\bar{X}$	13.0	5.8	9.9	1.4	3.8	1.4	9.4	2.7	3.3	1.0	1.4	4.0
	SD	27.3	3.9	16.7	1.0	4.3	1.0	19.3	5.6	7.4	.9	1.6	9.1

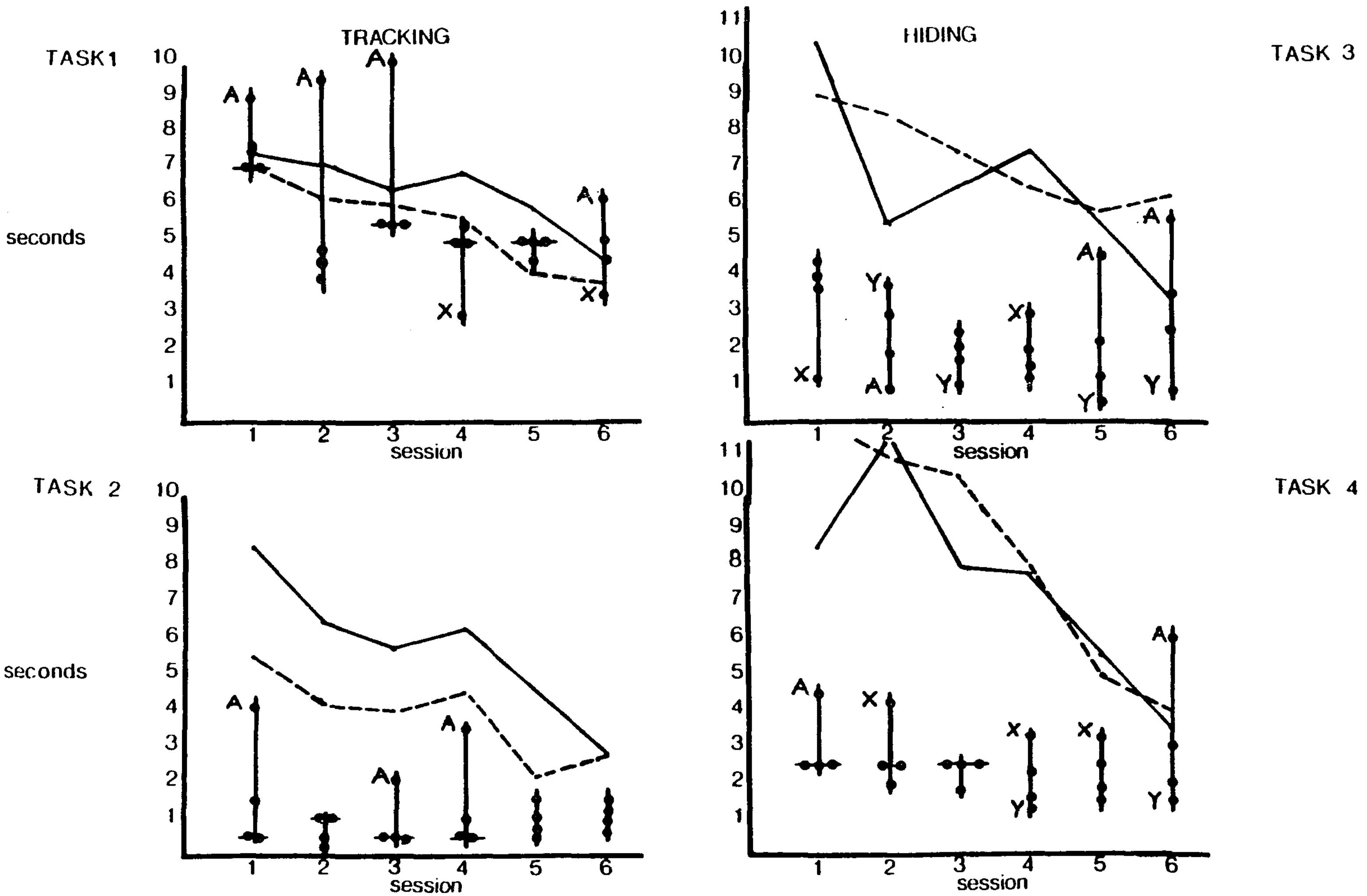
consistently below the mean latencies for the HS group and are in accord with or lower than the means of the HNS group. This indicates that the deaf babies' (DS) orienting responses to the arrival of the toy are basically faster than either hearing group.

4. Time on task. This measure was of the total time taken from visual orientation to completion of the task. There was no significant difference between the hearing (HS and HNS) groups on this measure although there was a tendency for the HNS babies to take less time. It took less time for the HNS (without sound) group to complete task 2, but there was no consistent superiority of one task over the other throughout the sessions. There was a session effect for both groups, ($F(1, 15) = 34.95$, $p < .001$), in that the hearing babies took less time to complete the task in session 6, than in the first session (see Figure 4). There were also two significant interactions for this measure : session x task ($F(1, 15) = 4.1$, $p < .01$) and group x task ($F(3, 15) = 2.24$, $p < .05$). The linear declining trend analysis was also significant ($F(1, 15) = 101.13$, $p < .001$) indicating that it took both hearing groups less time to complete the tasks as they got older.

As shown in Figure 4, in task 2 (object disappearing from view), all of the scores of the deaf infants fall below those of both hearing groups (i.e., they are faster). There is also a tendency for the deaf babies to be faster on task 1 (the 180° moving arc), but this is not consistent. Again, the extreme outlying scores belong to one infant.

5. Oral exploration. Oral exploration of the toys by both hearing groups (HS and HNS) is shown in Figure 5. There is both a session effect ($F(1, 15) = 7.07$, $p < .001$) and a task effect ($F(1, 15) = 5.15$, $p < .001$) for this variable in the tracking tasks. The mouthing behavior for both

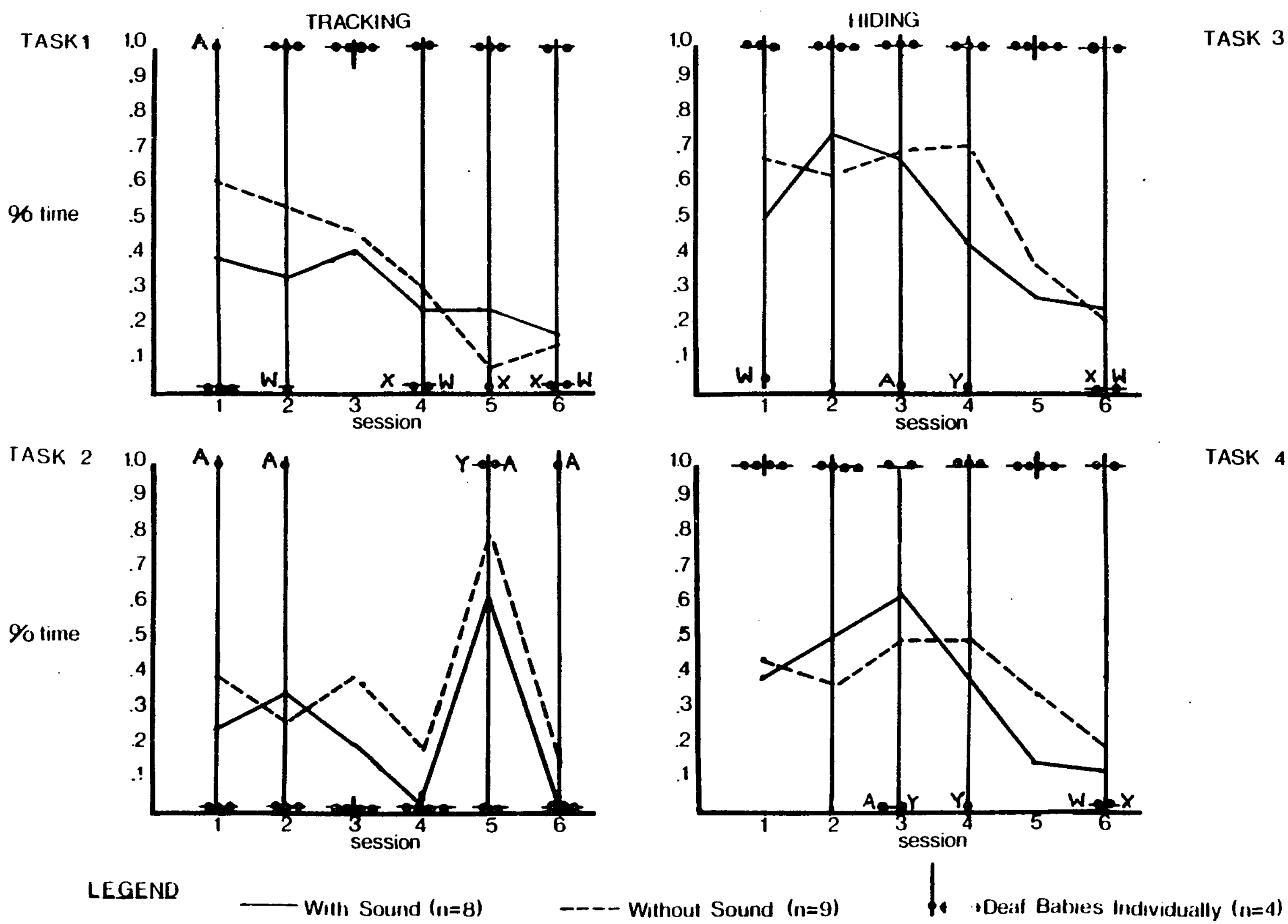
Figure 4. **TIME ON TASK**



LEGEND

—— With Sound (n=8) ---- Without Sound (n=9) Deaf Babies Individually (n=4)

Figure 5. **ORAL EXPLORATION**



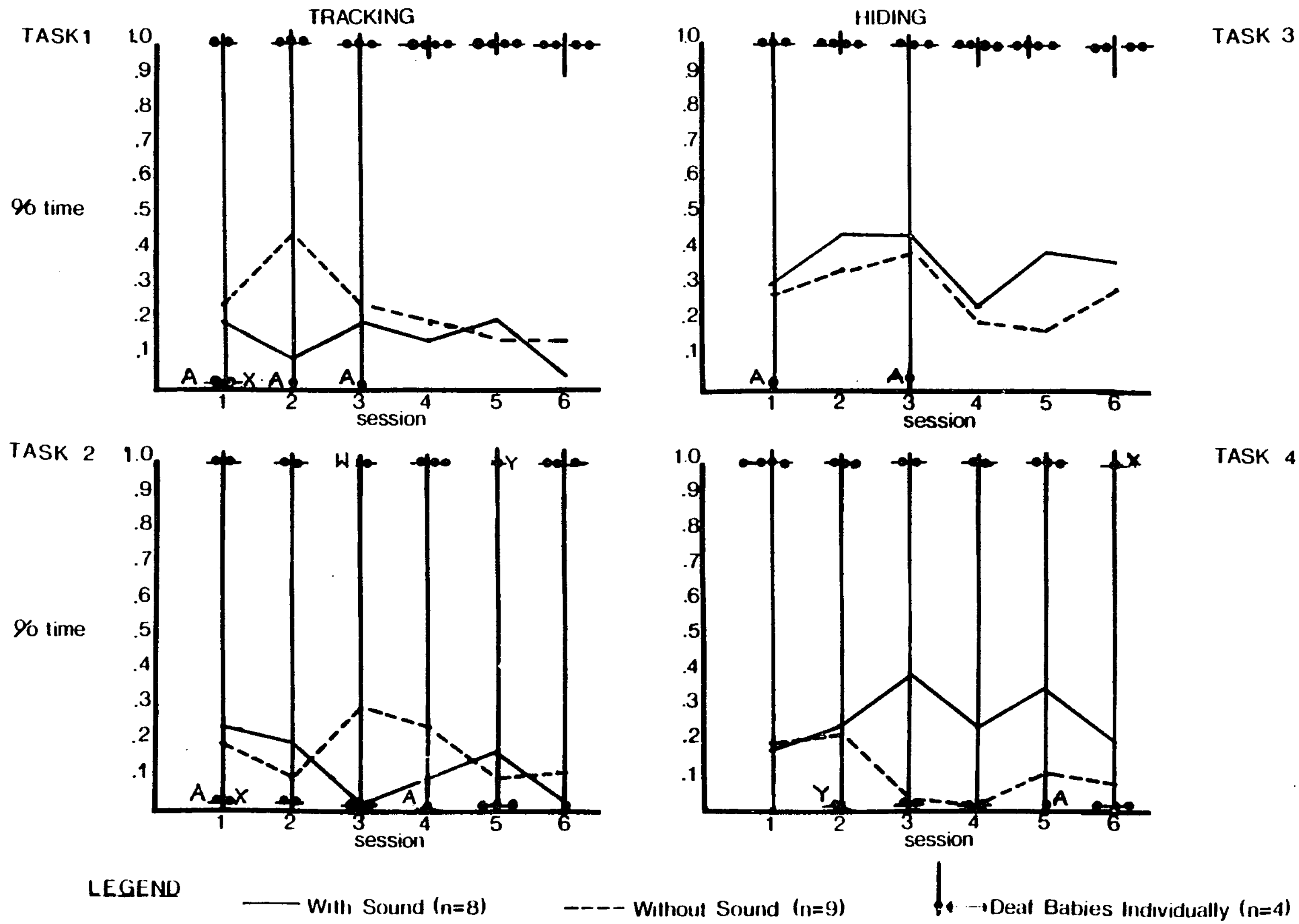
groups is significantly different in task 2 from their mouthing behavior in the first tracking task. There were no significant interactions for this measure. Significance was found in the trend analysis for this measure ($F(1, 15) = 21.09$, $p < .001$), which indicates a negative developmental decline in oral exploration for both hearing groups (HS and HNS). That is, oral exploration decreased with age in all of the tasks.

For the deaf group, even though individual babies' scores are shown in relation to averaged hearing babies' scores, the amount of oral exploration for the deaf babies is higher in task 1 than that found in both hearing groups. Further, there is no decline across the six sessions such as is seen in the hearing groups (see App. B for deaf infants' individual scores on this measure). Mouthing reached its highest level in session 3 and then in the remaining 3 sessions half of the deaf babies used this form of exploration and half did not. In task 2 there was very little oral exploration of the beads by three of the four deaf infants. Task 1 always precedes task 2 during any session. Thus, some deaf children may not want or need additional oral exploration during a second exposure to this toy.

6. Visual-manual exploration. Visual exploration of the test toys while they were held by both hearing groups (HS and HNS) are shown in Figure 6. There was a significant session effect in this measure indicating more exploration in some sessions than in others ($F(1, 15) = 2.45$, $p < .04$). There was also a significant session x task interaction ($F(3, 15) = 9.93$, $p < .001$) for this measure. Finally, the linear trend analysis was significant ($F(1, 15) = 9.93$, $p < .001$) for this measure, indicating a decrease in visual-manual exploration of the toys for the hearing groups as they grew older.

For the deaf infants (DS) there is a difference in the amount of

Figure 6. **MANUAL-VISUAL EXPLORATION**



visual-manual exploration in the two tracking tasks. Visual exploration occurred in 50% of the infants in the first session of task 1, and increased across sessions reaching a maximum for all four babies in the last three sessions. In task 2 visual exploration occurred about half the time across sessions. In other words, there was more visual exploration after task 1 (when the object remained in view) for the deaf infants. As with oral exploration this may have been because the first tasks satisfied the need to explore the toy.

7. Anticipation. By anticipation is meant that the infant's gaze returns to the beginning of the track. In task 1 (following a slowly moving object through a 180° arc), most babies' gaze immediately returned to the midline at the completion of the track. In the third session, 3 of the babies in the group without sound (HNS) looked at the beginning of the track. The remaining 6 babies returned to the midline, as did all of the HS babies.

In task 2 (noticing the disappearance of a slowly moving object), there was a reduction in returning to the midline in both (HS and HNS) groups. For the group without sound (HNS), the second most frequently used response was to look toward the beginning of the track through the six test sessions. For the group with sound (HS), the second most frequent responses were to either glance at the end of the track or return to the beginning of the track. Through the remaining three sessions, there were six instances of looking at the end of the track and 18 instances of looking at the beginning of the track at the completion of the task for the HNS group. That is, there was a decrease in returning to the midline in the HNS group. This difference is reflected in a significant task effect for this measure ($F(1, 15) = 27.8$, $p < .001$) based on an analysis of variance. This finding is not surprising since there may be no reason for a child to search for an object whose trajectory is always in the same direction, and which remains in view.

For the deaf group, a frequency tabulation of the measure labeled anticipation yielded the information that the primary response used by 3 out of the 4 deaf infants in both tracking tasks was the 'non-criterion' response of searching the endpoint of disappearance. One deaf infant returned her attention to the beginning of the track each time. Each of the deaf infants used their preferred strategy most of the time in both tracking tasks.

B. Hiding Tasks

The data for the two hiding tasks referred to here as tasks 3 and 4 will be presented in the same order as for the tracking tasks, with the exception of the latency measures which pertains only to tracking. Task 3 involves a partially hidden object, and task 4 involves a completely hidden object.

1. Pass or fail scores. Pass or fail was based on whether or not the child achieved the critical behavior indicated in the Uzgiris-Hunt scales. There was a significant task effect ($F(1, 15) = 12.2, p < .001$) in both hearing groups. This means that task 3 was consistently 'easier' than task 4 in all but one session (see Table 5). There was also a significant session effect ($F(1, 15) = 26.7, p < .001$) and a significant session x task interaction ($F(1, 15) = 11.00, p < .001$), indicating that in some sessions some tasks were easier than in other sessions. The trend analysis was significant as a second order polynomial, indicating a non-linear developmental trend (see Fig. 1 p. 34).

Table 4. Anticipation in Tracking Tasks. Frequency tabulation of the gaze of hearing infants at the conclusion of each tracking task.

	Task 1		Task 2	
	With Sound	Without Sound	With Sound	Without Sound
0 (RM)	135	116	85	89
1 (LE)	3	26	27	11
2 (LB)	6	18	22	45
3 (LAB)	0	2	10	17

0 = returns to midline (RM)
1 = looks at end of track (LE)
2 = looks at beginning of track (LB)
3 = looks at both (LAB)

Table 5. Pass Fail (0,1) Task x Session Means
(Hearing Subjects - Hiding Tasks)

	Task 3	Task 4
Session 1 - 6 mo.	.73	.49
Session 2 - 7 mo.	.75	.49
Session 3 - 8 mo.	.86	.67
Session 4 - 9 mo.	.80	.82
Session 5 - 10 mo.	.77	.53
Session 6 - 11 mo.	.82	.57

Though the scores of the DS group (deaf infants) were below those of both hearing groups in the first session of task 3, in later sessions the deaf infants did as well or better than the hearing infants. In task 4 (completely hidden object) 3 out of 4 of the DS group did as well as or better than the hearing groups in the later sessions. (See Fig. 1 p. 34.)

2. Pass/fail score (weighted) is shown in Figure 2 (p. 37) for both hearing and deaf babies. For the hearing babies, there was a significant session effect for both hearing groups ($F(1, 15) = 26.7$, $p < .001$). However, the trend analysis did not indicate a significant linear trend over sessions, indicating that a second order polynomial described the data better.

Concerning the ordinality of the scales, one would expect task 3 (partially hidden object) to be 'passed' before task 4 (completely hidden object). Table 6 indicates that, with one exception (at the 10 month session), task 4 was apparently easier than task 3 for the hearing babies.

The scores of the individual deaf children are nearly identical to those of the hearing groups on task 3 (partially hidden object). If averaged, the scores of the deaf babies would approximate those of the hearing groups on task 4. All of the deaf infants 'passed' both tasks at a slightly younger age than all of the hearing babies (HS and HNS) 'passed' both hiding tasks.

Appendix Table 1 shows the percent of subjects passing each task using the 2/3 trials passed criterion for each behavior. (This was the same criterion used by Uzgiris-Hunt (1975) and Corrigan (1979).) In the hiding tasks, 80% of the hearing groups passed task 3 at 6 months of age; 90% passed at 8 months of age; and 100% passed at 11 months of age. In task 4, 85% passed at 8 months of age, and 95% passed at 9 months of age. One

Table 6. Pass/Fail (Weighted) Task x Session Means (Hearing Subjects - Hiding Tasks)

	Task 3	Task 4
Session 1 - 6 mo.	1.61	2.16
Session 2 - 7 mo.	1.73	1.92
Session 3 - 8 mo.	1.88	2.49
Session 4 - 9 mo.	1.82	2.77
Session 5 - 10 mo.	1.77	1.73
Session 6 - 11 mo.	1.71	1.82

hearing baby did not meet the criterion by 11 months of age.

By contrast, all of the deaf infants (DS) 'passed' task 3 at 6-7 months of age, and they 'passed' task 4 at 9 months of age. That is, all of the deaf infants 'passed' both tasks at a younger age than many of the hearing infants did, using this criterion for passing.

3. Time on task (see Fig. 4 on p. 42). Both groups (HS and HNS) showed a marked developmental effect in both of these tasks. That is, all of the babies took less time to complete the tasks as they grew older. This session effect was significant ($F(1, 15) = 34.95$, $p < .001$). There were no group, task, or interaction effects for this measure. Trend analysis showed a significant linear developmental trend ($F(1, 15) = 101.13$, $p < .001$), confirming the sharp session effect.

The DS (deaf infants) did better (i.e., were faster) than both hearing groups on both hiding tasks for all sessions until the last session, when all the groups were similar.

4. Oral exploration. The amount of oral exploration in the hiding task is shown in Figure 5 on page 43. There was a significant session effect ($F(1, 15) = 7.07$, $p < .001$) for the hearing groups. The trend analysis ($F(1, 15) = 21.09$, $p < .001$) was significant as a linear trend. In other words, for the hearing infants, oral exploration of the toy in the hiding tasks decreased over time. There were no significant interactions.

For the deaf infants, three of the four infants orally explored consistently more on both hiding tasks than did both hearing groups, for all but the last session.

5. Visual-manual exploration. The amount of visual-manual exploration of the toy in the hiding task is shown in Figure 6 on page 45. For

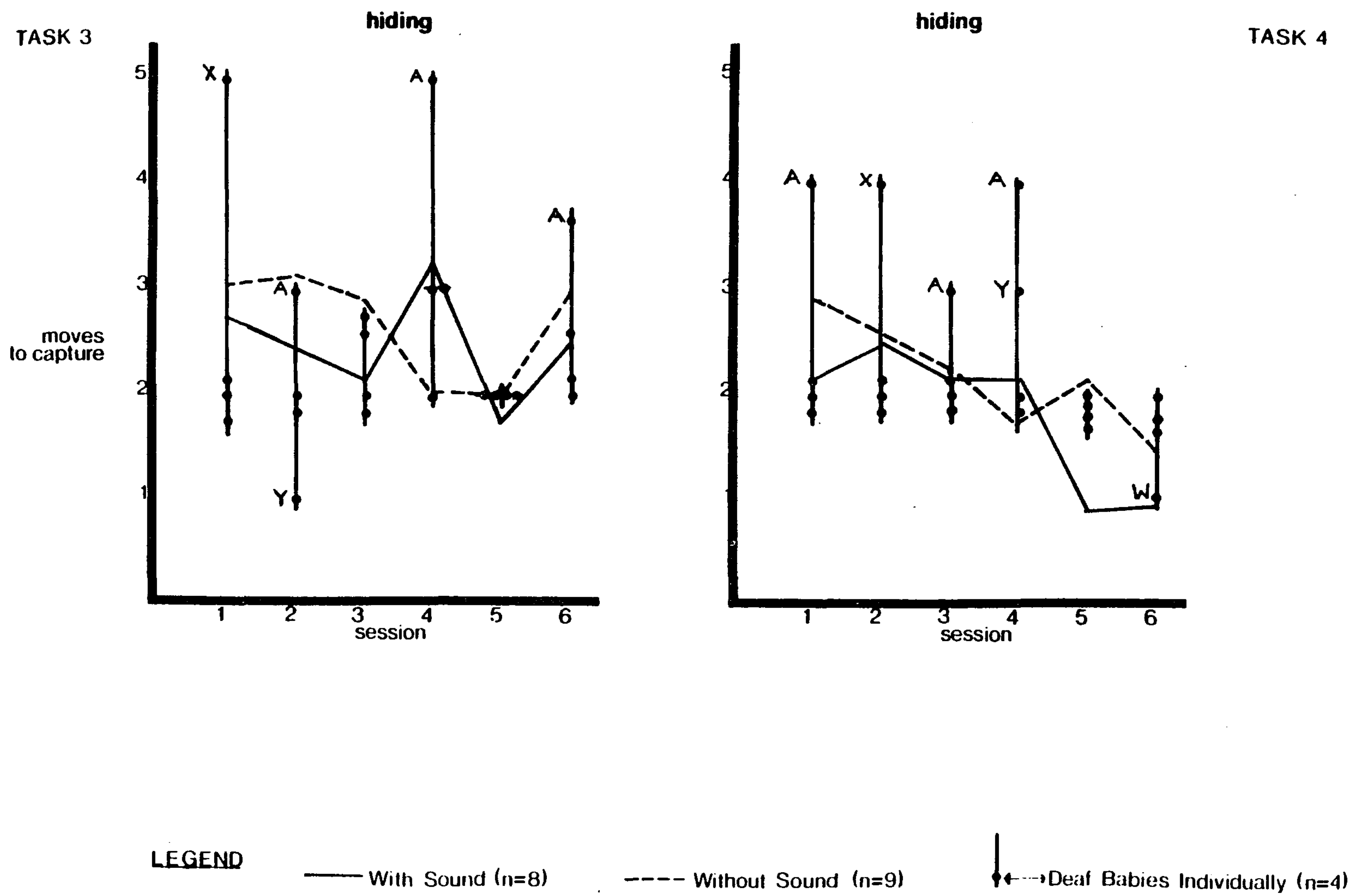
the hearing infants there was a significant effect of task ($F(1, 15) = 13.7$, $p < .001$) which was apparently due to more visual exploration of the partially hidden object in task 3. This was true for both hearing groups (HS and HNS). There was also a significant task x session interaction ($F(1, 15) = 2.4$, $p < .05$). The trend analysis was significant, indicating a rectilinear trend. In other words, there was very little change over time in the amount of visual-manual exploration of the toy by the hearing babies (HS and HNS) in the hiding tasks.

Deaf infants explored the partially hidden object in task 3 at consistently high levels. Visual-manual exploration was less frequent for two of the infants in task 4 (completely hidden object), though on average still at a higher level than for the hearing groups. Although the amount of visual exploration was greater for the deaf infants, it was related to the task in the same way as for the hearing groups - more in task 3 than in task 4.

<u>6. Efficiency</u> is a measure used only in the hiding tasks and indicates the number of moves made by a baby prior to capturing the object. (See Fig. 7 on p. 54.) For the hearing groups (HS and HNS) there is both a significant session effect ($F(1, 15) = 6.5$, $p < .001$) and a task effect ($F(1, 15) = 48.1$, $p < .001$). There is also a significant session x task interaction ($F(1, 15) = 3.54$, $p < .01$). In other words, in some sessions, the number of moves used to capture the toy by the hearing infants was affected by both the task and the session. The trend analysis reached significance, indicating a linear trend ($F(1, 15) = 10.75$, $p < .01$). That is, the babies got more efficient as they got older.

In general, the scores of the deaf babies (DS) are more variable than those of the hearing groups on the partially hidden task 3. For the

Figure 7. **EFFICIENCY - NUMBER OF MOVES TO CAPTURE**



completely hidden task 4, their scores would approximate those of the hearing groups if they were averaged. Additionally, there is less variability in the DS group on task 4.

C. Developmental Aspects

Because these data were collected longitudinally, there are interesting developmental aspects which can be addressed.

Wherever there were session effects, trend analyses were done. These analyses found linear developmental trends in the following measures for the hearing groups: time on task, visual and oral exploration, and efficiency in the hiding tasks. Taken together, the time on task and efficiency measures showed the children improving with age, while they used oral and visual-manual exploration less as they grew older. The latency of the deaf children did not improve in task 1, although the latency shortened through the sessions in task 2. The same relationship exists between task 1 and task 2 in efficiency for the deaf infants. That is, the infants grew more efficient in task 2, but not in task 1. Visual-manual exploration was high and remained so in task 3 for the DS (deaf infants). Oral exploration decreased markedly only in sessions 3 and 4 in task 2 (see p. 43). There was no orderly decrease over time in these two exploratory modes for the deaf infants.

There is one descriptive result to note for both hearing groups (HS and HNS). There was a suggestion in the data that there was a seven- to nine-month shift in performance on the seven variables. That is, at or between the second and fourth sessions there was a change in performance in either a positive or negative direction. This shift has been seen by several researchers in infant development (Sameroff and Cavanagh, 1979, Emde et al., 1976, Kagan, 1979).

On only two measures did more than half of the deaf infants (three out of four) shift in the same (the 8th) month (See Table 7). These measures were latency, and pass/fail (Uzgiris-Hunt Scale). However, some evidence of a shift was shown on all measures in the 7th or 8th month by the deaf infants (see Table 7, p. 57, and deaf infants' individual data, pp. 95-106). Much more investigation needs to be done with deaf infants to elucidate their developmental patterns.

In contrast, the hearing infants show some evidence of the 7- to 9-month shift on six of the seven measures. In Figure 4 (Time on Task) the shift occurs in the 7th month. Finally, as shown in Figure 1 (Pass/Fail Score) and Figure 6 (Manual-Visual Exploration), there is a shift in tasks 1 and 2 in the 7th month. In task 3 on this measure the shift occurs in the 8th month for the HS group, and in the 7th month for the HNS group. In other words, the task and the stimulus may contribute to the apparent differences in timing of the shift, in addition to the infant's own development and growth processes. This generalized shift on a number of measures in the three experimental groups suggests some form of developmental reorganization. This reorganization may be a matter of distribution of attention, increasing motor abilities, increased experience and skill, or a combination of changes in all of these areas. The present data do not allow an interpretation of the observed shift.

Table 7. Tasks on Which the 7- to 9-Month Shift Occurred for the Deaf Infants

Experimental Variables	Task	DS (N=4)	Session	Age in Months
P/F (U-H Scale)	1	2	3	8
	2	3	2	7
	3	3	3	8
	4	2	2	7
P/F Score Weighted	1	1	2	7
		1	3	8
	2	2	2	7
		1	3	8
	3	1	2	7
		1	3	8
	4	2	2	7
Latency	1	3	3	8
	2	1	2	7
Time on Task	1	2	3	8
		2	2	7
	2	2	2	7
	3	1	2	7
		1	3	8
	4	1	2	7
Oral Exploration	2	1	2	7
	3	1	3	8
	4	1	2	7
		1	3	8
Visual Exploration	1	1	3	8
	2	1	2	7
		2	3	8
	4	1	3	8
Efficiency	3	1	2	7
		1	3	8
	4	2	2	7

IV. DISCUSSION

Both groups of hearing infants (HS and HNS) look the same on all measures, with the exception of latency. The deaf infants' performance basically resembles that of the hearing infants, with some important exceptions in fine-grained measures. These measures were anticipation and latency, and oral and manual-visual exploration of the object.

What do these results suggest about the importance of the presence or absence of the auditory modality for infant development? To summarize the results:

First, on "gross criteria" of performance, there was an overall similarity between hearing and non-hearing babies. They all seemed to reach "pass/fail" criteria at approximately the same levels at the same time. However, an examination of more fine grained measures reveals differences between the manner of "passing" or "failing" that indicate that there are some differences between hearing and non-hearing children. Finally, on a measure such as "latency" (time to get "on task") there were differences between all three groups tested. Deaf babies are fastest in "picking up" an object moving in from the periphery; hearing babies tested under "no-sound" conditions were next fastest, and hearing babies tested with objects that make noise were slowest in visual orientation to an object approaching from the periphery.

In some ways, the on task performances of deaf and hearing babies look similar (passing/failing items); in some ways they look different (fine grained analysis). On the "pre-task" measures of latency, the deaf babies look even better than both groups of hearing babies in visually locating an object.

This set of results is complex. It raises a number of questions about the nature of development; the methodology to study it, and the role of sensory modalities in interaction.

The following topics are included in the discussion:

A. Can information be too much, too soon?

B. Retaining a strategy

C. Some alternate ways of getting information

D. Tracking and hiding reconsidered

E. Using a standard test on a non-standard sample

F. Developmental issues

These topics will be considered with reference to the deaf and hearing infants.

A. Can Information Be Too Much, Too Soon?

An apparently counter-intuitive finding of the present study had to do with the pre-task latency measure. The hearing children given a stimulus with both auditory and visual features were slowest to visually orient to the stimulus entering the visual field. One might have expected that the arrival of a sounding object might have alerted attention and led to visual search. Such was not the case. This is shown clearly when the results of the normal hearing babies are compared with those who are also auditorily intact but are not given a "sounding" stimulus. These babies were faster to locate an incoming object. Finally, the deaf babies were fastest at visually picking up on an approaching object. These results suggest several alternate explanations: one is that an overload of the central processing mechanism could account for the delay in the initial responses of the hearing group with sound (HS). A second explanation is that competitive systems might be operating. This might account for why the search for salience could slow down the HS group's response time. A third possible explanation is that sensory modalities might be "functionally equivalent" in the task domain used here and for infants in the age group tested here. It could be that the hearing child can best be described as being modally unbiased in detecting the arrival of an object. Several sensory modalities could provide information about the arrival of an object. The arrival of a "sounding object" might be sufficient for the HS group. The sound confirms the object's arrival, the head and eyes need not follow with speed. This is particularly the case since there were no functional consequences for the infant's not immediately responding to the object's entrance. The experimenter would raise the object 3 to 5 inches away from the babies' ears, wait, then "sound" the object and in all cases, wait for orientation toward the object before beginning the task.

The significant difference between the HS (with sound) and HNS (no sound) groups for latency was not expected. The increased reaction time found here might indicate that early in life less information at the time of stimulus presentation might be better than too much information. In an article on auditory localization, Muir, Abraham & Harris (1979) mention the importance of optimizing testing conditions. In the present study, the experimenter waited for the infants to turn their heads toward the stimulus, before starting the tracking task. It is possible that the infants in the group with sound (HS) did not need to turn their heads. The presence of sound enabled them to infer an object's presence in space. They expected that something would appear in their visual field, and turned only when that expectation was not met.

Even for infants with intact sensory systems, the present study indicated that in an experimental setting, additional information may hamper initial responses to test stimuli. Seemingly, then, the additional information is not ignored by the infant, but may actually interfere with the task demands. In the tracking tasks, the child was relatively immobile in the presence of something moving through the visual field. With the absence of, or with diminished sound cues, perhaps the young infant's attention is less distracted and is therefore more clearly directed toward the relevant properties of the task.

The deaf infants had a shorter latency in the tracking tasks than the HS (with sound) group and, in task 2, performed very much like the HNS (without sound) group. Here, the deaf infants exhibited great skill in using their peripheral vision to detect the presence of an object. One of the problems in using behavioral measures for testing hearing in the very young deaf is "false positives" that result from the children's ability to use their peripheral vision. In fact, during testing, these babies really 'attended to' the experimenter and were therefore almost always looking straight ahead, enabling detection of movement on the periphery.

Although there was a range of hearing loss in the deaf infants, similarity in pattern and amount of loss did not appear to relate to similarity of performance. There is a similar precipitous pattern of loss in Baby A and Baby X (see audiograms in Appendix). However, they sometimes each represent the extreme scores in individual sessions even though their measured auditory loss appears to be the same. In addition, Baby X was the only infant whose gaze did not remain fixed on the point of disappearance; she returned her gaze to the beginning of the track.

That the HNS group and the DS group appear to behave similarly on this measure may only mean that something happened at the time of testing to the HNS (without sound) group's use of the auditory modality, as the hearing groups are alike on all other measures.

The finding that very young hearing infants respond to the stimulus more quickly when it doesn't have added sound properties is important because of our current concern with enriching early childhood. For example, there are music boxes in mobiles, added sounds in many infant toys, and one major company has made a subscription available to parents which provides appropriate educational toys monthly. It is almost as if the formula that prevails is that it is never too early to provide as much stimulation as possible. In a recent newspaper article (1984), Dr. T. Berry Brazelton was quoted as saying that "...if the child receives suitable sensory stimulation...this can influence its total developmental pattern." The important word is "suitable." Suitable may be taken to mean appropriate to the child's abilities at a particular time. According to the present findings it appears that for hearing infants, adding a great deal of sensory information may not be helpful, and that increasing the information load may contribute to erratic and lengthy initial responding.

B. Retaining a Strategy

In general, it took less time for the deaf infants (DS) to complete the tasks. With the exception of tracking an object that remains in view, their time on task did not improve as they got older. By contrast, the hearing infants were initially slower than the DS to complete the tasks, and they became better over time. As a single piece of evidence, this result is puzzling. However, combined with the data taken from the anticipation measures, a picture begins to emerge of a difference between the deaf and hearing babies.

There is a suggestion that deaf babies may fixate on a single strategy and continue to use it. The hearing babies were more varied in their response patterns. This difference showed up very clearly in the second tracking task when the toy disappeared from view. For both groups of hearing infants, the most preferred direction of gaze at the end of both tracking tasks was to return their eyes to the midline. There is an additional response given in the Uzgiris-Hunt protocols: "searches around the point of disappearance." Hearing babies in both groups used this response in addition to using all of the other listed responses. What is of interest is that this latter response was the only response given by three out of four deaf infants.

In this case it does matter how one gathers information. The deaf infants, who are the fastest to orient visually to the stimulus at the beginning of the track, are the most 'fixed' at the end of the task, and their strategies do not change. The hearing groups exhibit flexible strategies, and their searching around the point of disappearance is not their only strategy. One may infer some of the consequences of early deafness in the relationship between the latency and anticipation measures. The deaf infants do not demonstrate flexible perceptual strategies in the disappearance tasks. They attend very quickly when their attention is not engaged, and stay at the end of the track when their attention is engaged. In contrast to the hearing infants, this can be seen as a problem relating to the distribution of attention for the deaf infants. The apparently fixed strategy used by the deaf infants in the tracking tasks plus their rapid detection of new objects in their visual field when their attention is not engaged elsewhere, are taken as evidence that the deaf infants may be information-deprived as a result of their being sound deprived. If a baby responds to the disappearance of an object by fixing attention on the point of disappearance while simultaneously having to rely on her visual system for new information, then many new cues will be missed. Regularities will not be easily recognized by the infant across situations, and a new strategy may only emerge when there is enough evidence that she has 'missed again' while waiting at the object's last position. Is there any other environmental source of evidence for the baby that she missed something? What would equivalent information be in this instance, and what could lead to the baby's distributing attention differently? Lack of sound cues may leave the infant in the position of searching for relevant information.

C. Some Alternate Ways of Getting Information

When one sensory system fails to consistently supply accurate information, then perhaps a child might come to rely heavily on those systems which are more consistent (intact). This may lead to a reliance on obtaining information from other sources. Two measures in the present study (oral exploration and manual-visual exploration) relate to alternate means of obtaining information. Between presentations, the children were allowed to play with toys. Oral exploration and manual-visual exploration were between-task measures, and they provide supplementary information about some of the different ways in which these children (DS) explore their world.

For the hearing groups, both oral and visual exploration of the object decreased over time within a session. For these babies, apparently, enough is learned about the object during the task, so that no further exploration of the object is required between tasks. The decrease in oral exploration of the toys in the tasks as the hearing babies grew older is not an unexpected result. Mouthing, or non-nutritive oral behavior, has been referred to as restricted and as relatively rare in active infants (Escalona, 1965). With intact receptors, it would be unlikely that this early form of activity would continue at a high level. It is not clear whether the high level in three of the four tasks in the amount of oral exploration by the deaf infants is a regression to an earlier mode, or an attempt to add more needed information. As Bower stated (1969), "Exploratory behavior is...best conceived as mediated by a set of behavioural systems evolved for the special function of extracting information from the environment."

In addition to measuring the amount of oral manipulation, the occurrence of looking at the toy while holding it (manual-visual exploration) was measured. Deaf children generally explored more visually than the HS and HNS infants, which is not surprising if these infants are considered as information deprived. What was unexpected, however, was that this type of exploration was most consistent and high on those tasks where toys were presented for the first time after at least a 'break' of one month (tasks 1 and 3). Perhaps it was important to re-know the objects in each session. Not only did the hearing groups start off exploring less in this manner overall, but they also lessened significantly over time according to the trend analysis. Further work in this area is warranted because of the importance of the visual modality as a prime source of information for deaf children.

D. Tracking and Hiding Reconsidered

The four tasks analyzed in the present study involved many types of disappearance and reappearance. The tasks used in the present study have been taken to indicate the development of the concept of object permanence. Object permanence in a current definition (Corrigan, 1979) includes having a notion of the continued existence of objects which have disappeared and of the pre-existence of objects which have just appeared. However, the relationship between the behaviors elicited by these tasks and having the idea of the pre-existence and continued existence of an object is not a simple one. There is a difference between the perceptual task of finding and detecting an object and of knowing about the existence of objects. The tracking tasks can both be viewed as being able to be solved by visually detecting the presence of an object: a process in which deaf infants seem to excel.

Some of the particularities of the tracking and hiding tasks are discussed below.

Tracking Tasks

The first tracking task involved visually following a slowly moving object that remained in view. In the second task, the object disappeared over an edge but remained potentially in view on the floor. The "disappearance" in these tasks may be experienced as the slow disappearance of an object in which there are long intermediary moments between appearance and disappearance. The stimulus to be tracked can have a relatively invariant path; and the repetitive motions are done by the experimenter. Part of the baby's task is to synchronize her movements to those of the stimulus. The <u>way in which an object disappears</u> may be an important factor even when the actions that bring it about are roughly equivalent until the final action. The successive positions in the tracking tasks are temporally related and visible. The infant must empirically "rediscover" the links between disappearance and reappearance (K.E. Nelson, 1971).

The second task objectively differs from the first only at the end of the track, but this may not be true from an infant's point of view. Several studies, notably those done by T.G.R. Bower, et al. (Bower, Broughton and Moore 1971, Bower 1972, and Bower 1979), have indicated the problems associated with various types of disappearances. The differences between the two types of disappearance brings into question the ordinality of the four tasks used in the present study. Successful tracking in the two tasks involved at least 'expectations' about the future position of an object based on visible local changes. Harris (1983, p. 721) suggests that "Piaget offers little insight into such phenomena because he talks globally about the infant's difficulty with disappearance rather than particular kinds of disappearance."

With regard to the deaf infants in the present study, these babies 'searching' the end of the track could be taken to clearly illustrate Piaget's observation that children must come to override their perceptions in matters of permanence in order to correctly predict or anticipate the re-arrival of an object. Here, the infants are waiting for the object where they last saw it. It could re-emerge there, but in the present study, it never did. In this case, the infants will always miss the reappearance of the object at the beginning of the track until they learn to return their gaze to the beginning of the track. K.E. Nelson (1971), in a group of studies on the development of visual tracking, found that even by 9 months of age, infants do not actually anticipate the train's re-emergence at the end of a tunnel. Therefore, hearing infants apparently track a moving invisible object on an empirical basis on the bases of very local rules. The infant has to discover and re-discover the connections between appearance and disappearance. This empirical re-discovery is more of a possibility when several channels are available to receive new information. For the hearing infants there could be enough parallel or simultaneous information in the environment to solve the problem. The deaf children may need more help to reach a solution, due to their use of vision as a primary receptor for information.

Hiding Tasks

In this study, there were two variations of the hiding task: one in which the object was partly covered (task 3), and the other in which the object was completely covered (task 4). In both tasks, the type of disappearance is abrupt. That is, there are no detectable intermediaries between appearance and disappearance as there are in a tracking task (see Bower, 1964). The disappearance occurs on a flat surface in front of the infant, with the object's gestalt changed by the cover. Here, the infants must connect their own observations of the experimenter's actions to a complex series of their own actions to solve the problem.

Both Tasks

The tracking and hiding tasks involve different disappearances and solutions. A tracking task is based on a continued perception of the object, and a hiding task involves the occlusion of the object. Tracking and hiding tasks in this study involve different motor coordinations, different immediate perceptual information, and different types of disappearance. How can a hierarchical link be established between these two types of task for deaf infants until more is known about their active experience of discrete events? In the present study, for the hearing infants, ordinality doesn't hold at all on the pass/fail measure for the tracking tasks, and doesn't hold completely on the hiding tasks. Perhaps these results would be different if the children were actively involved in the disappearance. In fact, the child is virtually immobile in the presence of something which is moved. Thus, the total disappearance is defined by an adult in a testing situation for all of these tasks.

In all of the tasks in the present study, the active role of transformation was not performed by the infant, but by an adult. The infant's active involvement with the stimulus varied from a relatively passive observer in the tracking task, to active manual search in the hiding task. The observance of a passing object is not entirely passive as several modalities are being both exercised and coordinated. Further, the activity involved in searching for a hidden object may or may not involve the infant's understanding that 'not-visible' is not the same as 'not there.' It is assumed that regularity of experience for the hearing infants enabled them to detect and use more information about the world as they developed. Very little is known about the experience of deaf infants. For example, what parts of an event are experienced as regularities when a major sensory system is damaged?

Piaget (1952) acknowledged that there are constraints placed on behavioral plasticity by the anatomical and physiological structures of the particular organism. If the elaboration of certain schemata depend on specific repeated encounters with the world, then the restricted auditory systems of the deaf infant are going to constrain their encounters and they may need to experience very specific situations to gain accurate information about particular transformations in the world. In arguing for a major role of experience, it is recommended that future research examine which experiences are critical in producing major cognitive changes in deaf infants.

E. Using a Standard Test on a Non-Standard Sample

There were at least three problems in using the Uzgiris-Hunt protocols in the present study. The first concerned the level of achievement of a critical action as defined in the original scales. The second problem was one of the testing situation itself. The third problem concerns the use of a scale which claims to be longitudinal, but was developed using a cross-sectional sample.

1. Problems of scoring. The Uzgiris-Hunt protocols utilize the idea of critical actions, that is, those behaviors that must be present to consider that the infant has attained a particular level (see pp. 85-87).

The trend analysis of these measures was significant as a second order polynomial for both pass/fail distributions. This means that the distributions were not linear, and that this way of looking at task performance may not be the most sensitive indicator of linear change over time either for the deaf or for the hearing infants. That this may be so is indicated by the fact that the deaf infants do as well if not better than the hearing babies in many of the qualitative performance measures designed for this study. However, when evaluating their performance using the Uzgiris-Hunt pass/fail criteria, their performance is also variable both across sessions and across tasks. Perhaps this result is an artifact of the system of measurement or of the administration of the test items, or perhaps children with perceptual handicaps do not follow a "normal" developmental curve in their cognitive development.

2. Concerns about the testing situation. While the topography of each test session was the same for the deaf and hearing babies, the choreography varied between the two groups. Hearing babies, after being seated in the chair, would often turn to their mothers. The tester would then make sounds ('baby talk'), use their names or use a toy that squeaked or rattled. The babies would then turn to face the tester. By contrast, it took longer to make initial contact with the deaf babies. They did not respond to baby talk, the rattling, squeaking of a toy, or to their names. In order to gain their attention, the tester put her hand on the table in front of them while one of their hands was touching the same surface. They felt the vibration and turned to her. After a few sessions, they would also touch the tester's hand.

When the hearing mothers spoke to me during the testing session, it was possible to maintain visual contact with the baby, and simultaneously speak with the mother. When the deaf mothers wanted to communicate at the end of a task, they would either speak or touch the tester's arm. In order to respond, it was necessary for the tester to turn her head away from the baby. The social contact with the baby was thus disrupted. This happened often enough that the tester learned to literally "place-hold" by touching the baby's hand as she turned to the mother.

Early attempts at contact with the deaf babies were conscious and even self-conscious. Theirs was a system initially unknown to the tester, and it was necessary to watch for cues. In contrast, the hearing babies presented no problems along these lines. We shared a sound system that carried a great amount of information and could be used in parallel with the tasks. It was easy to say 'good' or 'hooray for you' and then to smile simultaneously at the end of a task. The smile was there for the deaf babies to see too, but was meaningful only if they saw it. Thus, although the tasks were the same for all babies, the sound and social systems in which they were embedded were often very different. This brings up the issue of whether the use of tests standardized on a "normal" population are appropriate for "special" populations.

3. Problems of using a cross-sectional scale on a longitudinal sample. As indicated in a previous section, the Uzgiris-Hunt test items used in this study are the first four items in a standardized, recognized scale which measures "object permanence." The items are described as ordinal and are presumed to reflect what Brainerd (1978) called a measurement sequence that occurs when each item in a sequence consists of the previous item plus something new. However, these items may be ordered more in terms of logic rather than in terms of psychological reality (Harris, 1984, p. 717). It is important to understand that Uzgiris-Hunt developed these scales from data that were derived from a cross-sectional sample of a minimum of 4 infants representing each month up to one year of age. A further problem is that the reported mean scale scores included scores from children of different ages. This mixture of ages and differing individuals could account for some of the variability in their scores. For example, the mean scale score for object permanence was 1.77 and the mean deviation was .74. If this variation occurred in a so-called "normal" population, it may not be reasonable to apply the scales to a population in which there is great perceptual variability and little knowledge concerning their early development. Uzgiris and Hunt in fact

state: "Whether these sequences appear in repeated examinations of the same infants followed longitudinally when the infants encounter differing programs of circumstances remains to be determined" (p. 131).

The present study consisted of repeated examinations of the same infants followed longitudinally for six months, and found some deviations from the expected developmental course. The study offers some small evidence that true longitudinal testing of these scales should be done with both intact and special children. For example, considerable variability in the present sample of hearing children was found on the latency measure. The differences between individual subjects within a session were larger than the variation between an individual subject's performance across sessions. That is, the variation is due to differences between individual children within sessions. This alone is reason enough to suggest that the test be standardized in a truly longitudinal manner.

There are other reasons for encouraging the use of a longitudinal design when dealing with handicapped children. We do not know whether children who are deprived of a sensory system function differently from those who are not deprived. Nor do we know whether and how differences in function appear behaviorally. In these groups, particularly, there should be a concern that the differences found be identified as delays, deviations, or differences. Certain delays may constitute important divergences in cognitive development and would be addressed differently during remediation. Other researchers have found that though a group of infants pass through a sequence of items in a fixed order, the repeated testing of individual infants will sometimes reveal "backsliding" (Harris, p. 753) from one test to another. These regressions have been noted by Uzgiris (1973) and Kopp, Sigman and Parmelee (1974).

F. Developmental Aspects

The data in this study were collected longitudinally. That is, each infant was seen once a month from age six months through the eleventh month. Therefore, it is possible to make inferences about developmental trends. Wherever there were significant session effects for the hearing groups, trend analyses were calculated (using SPSS-X). These analyses indicated significant first order linear trends in the following measures for the hearing groups: time on task, oral and manual-visual exploration, and efficiency in the hiding tasks. That is, it took the hearing babies less time to complete the tasks as they got older and they did so more efficiently. The deaf babies, on the other hand, were fast and remained so throughout. While being faster than the hearing babies, the deaf babies used as many or more moves.

Oral exploration decreased for the hearing babies, but not the deaf babies. Manual-visual exploration decreased overall for the hearing babies, but remained at a higher level for the deaf infants in tasks involving novel presentations of the toy. This indicates that the deaf babies continue to use alternate means of exploring their environment.

For both hearing groups (HS and HNS) there was a suggestion that there was a seven- to nine-month shift in performance on each of the seven measures. This was shown by a change in either a positive or negative direction which took place at or between the second and fourth sessions (see Figs. 1-7). This "shift" has been seen by several researchers of infant development (Sameroff & Cavanagh, 1979, Emde et al., 1976, Kagan, 1979). The deaf infants show some evidence of this shift (see pp. 95-106). However, it is less pronounced, and less consistent across measures.

The absence of this shift in some of the deaf infants may indicate the unsuitability of the test measures (already mentioned in section E earlier), or it may imply a problem in the general reception of information such that there is less of a base to reorganize and coordinate with new information. This in turn could lead to a restricted range of strategies in the deaf infants (as mentioned in section B). As Liben (1978) has suggested, "...the absence of an auditory channel might be expected to limit the motivation for exploration and, hence, retard cognitive growth (p. 200)." The absence of a clear auditory channel may also lead to an increase of exploration in the other senses. This may in turn lead to a different experience of the object, both quantitatively and qualitatively (as suggested in section C). Perhaps the 7- to 8-month shift in some of the deaf infants did not occur because there is less opportunity for external stimuli to disturb the existing cognitive organization.

There may be a suggestion of a processing problem for the two hearing groups as well. Here, at an early age (6- to 7-months of age) it was apparently easier to orient to and track a toy from which added auditory stimuli had been removed. For these very young hearing babies, too much information appeared to delay their responses. Additional information may increase the demands on a limited processing capacity and thereby disrupt responding.

No major theory of development can explain the results of the present study for the deaf. However, there are two views of how a child is able to attain mastery of his environment that point to the problems of deaf infants. The first view states that just by using one's senses one can gather sufficient information since there is enough redundancy in the information "out there" that interpretation or supplemention is not needed (see Gibson, 1966, 1979). If this were the case, then simply missing a single sense as deaf children do, should not affect their performance in any way. The second position states that perceptual information alone is insufficient and may even be misleading. In order to gain mastery of the environment, one has to construct and test hypotheses (see Piaget, 1954). If this were the case, then one would expect that a deaf child might override misleading perceptual cues and thus appear the same as a hearing child. However, the nature of the damage in deafness is such that the information which would lead to correcting the hypotheses may take longer to get into the system, if it gets in at all.

In the Gibsonian view, a child lacking one sensory modality should still be able to tune her intact systems to the information that _is_ available in the environment. Gibson argues that there is information about an object that is amodal. Therefore the deaf infant may not be information deprived. Piaget (1952, 1954), does not presume an early coordination between the various sensory modalities, especially not between vision and hearing. Thus, not having an intact auditory system may not have a direct or a pervasive effect on this particular cognitive problems relating to visual transformations. On the other hand, Piaget's theory includes the important notion of a developing coordination between _schemes_, thereby providing the possibility that a deaf infant constructs an accurate picture of the object world since there is no initial coordination between the senses.

Both of these theories are important to the present study which was primarily concerned with the relationship of the _information bearing properties of sound_ to the infant's understanding of the disappearance and reappearance of objects. However, neither theory can explain some of the particular results of the present study, although both are useful when noting that deaf children do come to have knowledge of objects in general.

V. SUMMARY AND CONCLUSIONS

Young deaf infants interact with an environment that is, for them, restricted in terms of clear auditory information. This restriction seems to have an effect both on the way they detect and monitor an object, and on the strategies they use to anticipate its reappearance.

Perhaps the two most important consequences of early pre-lingual deafness elucidated in the present study are: first, the tendency of the deaf infants to fix onto and to retain a strategy, and second, the deaf infant's ability to rapidly detect an object's arrival in the visual field. The first of these behaviors could have negative consequences for the infants; the second could serve the infants well.

To clarify the first point: while these infants have used their capacities in a seemingly adaptive way, this adaptation itself could lead to restricting incoming information. In the tracking tasks used in the present study, the deaf children fixated at the point of disappearance. A child who remains at the disappearance point may miss the arrival of that object elsewhere. Additionally, fixing onto and retaining a strategy may lead to missing other important information concerning the object or event. Thus, the loss of information to the deaf infant can be at least two-fold: no new specific information is detected, and general event information may also be lost.

Initially three hypotheses were proposed in the present study:

1. In general, it was predicted that the largest differences would be between the hearing group with sound (HS) and the deaf infants.

2. It was predicted that children deprived of simultaneous sources of information might settle on a successful strategy and continue to use it.

3. It was predicted that the deaf children might use other sensory means to gain information in a way that differed from the hearing children.

As described above, support for the second hypothesis was found in the present study. The first hypothesis was not proved. Generally, both groups of hearing infants performed the same on the tasks. However, the hypothesis was not confirmed specifically in the latency measure. The deaf infants were in general as fast, and often faster, than the hearing infants to detect the arrival of an object in their visual field at the beginning of a tracking task. It is important to note that this rapid detection occurred at the beginning of a task, before their attention was engaged. When their attention was engaged at the end of the tracking task, the deaf infants did not readily detect the new position of the toy as their gaze remained at the point of disappearance.

To summarize, the interaction of the deaf infants with their environment seems to lead to differences in performance at a very young age. The deaf infants rely on the visual modality while hearing infants can rely on the visual and auditory modalities. While the performance differences are immediately adaptive for the deaf infants, increasing complexities in the child's environment may decrease the efficiency of their adaptations, if alternate strategies are not developed which do not interfere with their ability to detect visual changes in their surroundings. Thus, the retaining of a strategy can actually lead to increasing the effects of auditory loss.

When the performance of the deaf infants is compared to that of the hearing infants on the standardized scale used in the present study, there are no observable differences. That is, there is no difference, deficit or deficiency in the performance of the deaf infants on the standard scale, or in the order in which the tasks were 'passed.'

Models which talk about deficiency or delay make assumptions about a standard that is not being met. A delay model assumes that there is a 'catch-up' some time later in the child's development. A deficit model assumes that the criterion will never be met or reached. This work sides with a difference model which is meant to express the possibility that similar end points can be reached, but that there may be different routes to them.

An alternative interpretation of a difference model is that there may be actual differences (neither deficiencies nor delays) in a population which processes information differently. The present work cannot state which interpretation is valid, as the children were not yet a year old when the study ended. However, during that first year the deaf infants were neither deficient nor delayed in their performance on the tasks given to them using standardized measures.

At a very young age, the deaf infants are as competent at solving the standard tasks as the hearing infants. However, when examining the ways in which the solutions to the task are accomplished by the deaf infants, differencese in performance begin to appear. These differences relate to the third hypothesis; that alternate modes would be used by the deaf infants to gain information.

When performance differences were observed between the deaf and the hearing infants, the differences were in the amounts of exploratory behavior and in the between-task strategies used to monitor the disappearance of an object. It is adaptive to increase visual/manual and oral exploration of an object when one important information channel isn't functioning efficiently. While this alternate type of information can add to knowledge about an object's identity, it probably doesn't add much direct information about its disappearance and recurrence.

The reasons for performance differences in the hearing infants on the latency measure are unclear. The scores for the hearing infants with sound are widely divergent. The response time of the deaf infants is almost always faster than that of this hearing group. Though the patterns of hearing loss of the deaf infants are not exactly the same, their ability to visually detect an object's arrival is rapid. Here, the deaf infants may be showing early evidence of the long term effects of deafness. The hearing infants may be showing, in part, the effects of violating their assumptions about sound and objects.

The test conditions were optimized for all of the infants in that the experimenter waited for the infants to turn their heads toward the object. However, while the test was developed using hearing infants, the deaf infants understood the task demands and performed at the level of the hearing infants. The standardized test did not prove to be sensitive to possible important performance differences between the deaf and hearing infants.

As the normal development of a deaf child is still unknown, it would be reasonable to suggest that their development be studied longitudinally. This would lead to assessment vehicles that might be sensitive to the deaf population's particular ways of processing information and ultimately make apparent their true competencies. Only by meeting the deaf on their own terms can any differences between them and a hearing population be explored. It is necessary to know which differences are of limited importance and which can preface later problems. It may also be important to understand in global terms which differences can be attributed to the auditory deficit itself.

Initially, this study was prompted by observing an older deaf child go get and hold onto an object that was under discussion. This led to considerations of how objects might be viewed by the deaf when their arrival and disappearance is not accompanied by meaningful sound cues.

Tracking and hiding tasks were used in the present study to look specifically at the way infants solve these tasks. The tasks were administered in an experimental setting and were seen only as a means to elicit search skills. It was noted in the present study that it was easier for most of the infants to find a completely hidden object than it was to find a partially hidden one.

This finding may result from repeated testing of individual infants with a test developed from a cross-sectional sample as noted above. However, a more serious problem may be indicated by this result. That is, the order and relationship of the tasks may be real both logically and psychologically to an adult, but not to an infant. For an infant it may be more complex to remove a cover from a partially hidden object than it is to uncover something that is totally occluded. When an object is partially covered, is the task to pull the object or the cover? This particular ambiguity does not exist wen the object is completely covered. In other words, we cannot know precisely what the infant has learned to do in the ambiguous situation. It must be noted that these tasks in the present study were only "stand-ins" for real world events which could not be monitored, such as a deaf infant lying in a crib waiting for someone to arrive.

The initial exploration in the present study has pointed to some of the varied subtle behavioral components both deaf and hearing infants use in locating objects. Looking at the skills these very young children master, I find an agreement with Harris' position (p. 724) that "...it might be claimed that (intact) adults never really resolve the philosophical question of object permanence. What we do attain is...a rich repertoire for finding objects."

As in many other great issues of childhood, A.A. Milne has described the problem of disappearance and reappearance and its solution much more succinctly than most philosophers or scientists:

> James James
> Morrison Morrison
> (Commonly known as Jim)
> Told his
> Other relations
> Not to go blaming <u>him</u>.
> James James
> <u>Said</u> to his Mother
> "Mother," he said, said he:
> "You must never go down to the end of the town
> Without consulting me."
>
> James James
> Morrison's mother
> Hasn't been heard of since.
> King John
> Said he was sorry
> So did the Queen and Prince.
> King John
> (Somebody told me)
> Said to a man he knew:
> "If people go down to the end of the town, well,
> What can <u>anyone</u> do?"

APPENDIX

Name______________________ Birthdate__________ Date of Exam__________ Group __________

Scale I

Situation	Presentation 1	2	3	4	5	6	7	Instructions
1. Following a slowly moving object through 180° arc (3-4)								hold object 10" in front of eyes-after inf focuses on it move slowly thru 180° arc
a. does not follow object	___	___	___	___	___	___	___	
b. follows jerkily thru part of arc	___	___	___	___	___	___	___	
c. follows smoothly thru part of arc	___	___	___	___	___	___	___	use ring w/or w/o bell or pop-it beads w/or w/out bell
* d. follows smoothly thru complete arc	___	___	___	___	___	___	___	
other								
2. Noticing the disappearance of a slowly moving object (3-4)								use same objects as in 1 move it slowly to one side away from the infant making it disappear below edge of inf. seat. Repeat always in the same directy and have disappear at the same point
a. does not follow to the point of disappearance	___	___	___	___	___	___	___	
b. loses interest as soon as object disappears	___	___	___	___	___	___	___	
* c. lingers w/glance on point of disappearance	___	___	___	___	___	___	___	
* d. returns glance to starting point after several presentaty	___	___	___	___	___	___	___	
e. searches around point of disappearance	___	___	___	___	___	___	___	
other								
3. Finding an object which is partially covered (3)								rubber dolls w/ & w/o sound. Place object on surface squeeze and wait until infant reaches for it. Take object and place it on the surface and cover it, leaving feet visible. Squeeze again.
a. loses interest	___	___	___	___	___	___	___	
b. reacts to loss but does not obtain object	___	___	___	___	___	___	___	
* c. obtains the object	___	___	___	___	___	___	___	
other								

Name________________ Birthdate________ Date of Exam________ Group ________

Scale I

Situation	Presentation 1	2	3	4	5	6	7	Instructions
4. Finding an object which is completely covered (3)								Object same as in 3. As inf. reaches for object, lay it on the surface and cover completely w/bunched up cloth. If inf succeeds on try, do all subsequent presentations to left or right side of inf.
a. loses interest	___	___	___	___	___	___	___	
b. reacts to loss but does not obtain object or search	___	___	___	___	___	___	___	
c. pulls screen but does not uncover or obtain object	___	___	___	___	___	___	___	
* d. pulls screen off and obtains object	___	___	___	___	___	___	___	
other								
6. Finding an object completely covered w/a screen in 2 places alternately (3-5)								Objects same as in 4. If inf. obtains object on 2 successive tries, place 2nd screen on opposite side of inf. during last covering of the object w/1st screen. Then hide object under 2nd screen. Repeat, hide under 2nd screen 2 more times, to switch to hiding under 1st screen. Use sound for 2 groups.
a. loses interest	___	___	___	___	___	___	___	
b. searches haphazardly under one or both screens	___	___	___	___	___	___	___	
* c. searches correctly under each of the screens	___	___	___	___	___	___	___	
other								

D. Search following invisible displacement

Situation	1	2	3	4	5	6	7	Instructions
10. Finding an object following on invisible displacement w/a single screen								While inf watches, place small object (car or soft toy) in box, hide box under screen, turn box over and leave toy under screen. inf. empty box. Use object that makes noise in box w/ 2 groups.
a. loses interest in the object	___	___	___	___	___	___	___	
b. reacts to loss-no search	___	___	___	___	___	___	___	
c. searches only in the box	___	___	___	___	___	___	___	
* d. checks box and finds object under screen	___	___	___	___	___	___	___	
* e. searches for object directly under screen	___	___	___	___	___	___	___	
other								

Name________________________ Birthdate__________ Date of Exam_________ Group __________

Scale I

Situation	Presentation 1	2	3	4	5	6	7	Instructions
12. Finding an object following one invisible displacement w/ 2 screens alternated								Same objects as in 10. Use box to place object under screen, alternate on each presentation. Place empty box in center with 2 covers.
a. loses interest in object	___	___	___	___	___	___	___	
b. searches haphazardly under both screens	___	___	___	___	___	___	___	
* c. searches under screen where box disappeared	___	___	___	___	___	___	___	
other								

E. Search following invisible displacements

Situation	Presentation 1	2	3	4	5	6	7	Instructions
14. Finding an object following a series of invisible displacements. (4-6)								Same objects as in 12. While inf. watches, hide object in palm of your hand. Close hand, and move hand in one direction under screen having hand reappear between screens. Leave object under last screen and show empty hand. Repeat always in same direction
a. searches in your hand or around the room	___	___	___	___	___	___	___	
b. searches under 1st two screens only	___	___	___	___	___	___	___	
* c. searches under screens in same order followed by E's hand & finds object	___	___	___	___	___	___	___	
* d. searches under last screen on 2 successive tries following success in finding object there	___	___	___	___	___	___	___	
other								

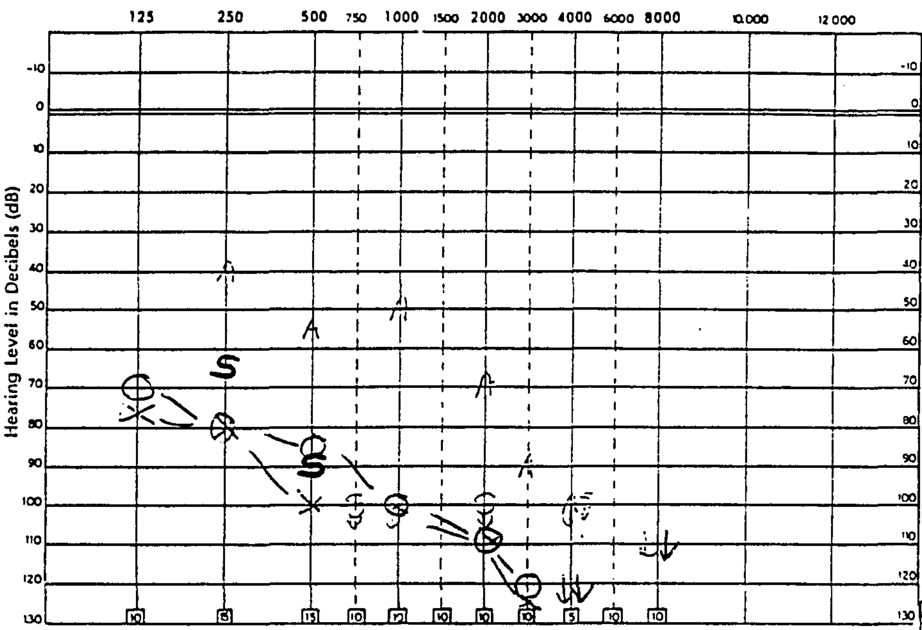
Audiogram

DATE — Baby A - boy NAME — 12/6/80 B.D. — EXAMINER

Maico Peters APG AUDIOMETER

PURE TONE AUDIOMETRY

Frequency in Hertz (Hz.)



Pure-tone Average (500, 1000, and 2000 Hz.)

Ear	Two-Frequency	Three-Frequency
Right	93	98
Left	100	103

Retest at 250 Hz.

Right	dB
Left	85 dB

TO CONVERT ISO 1964 THRESHOLDS TO ASA 1951 THRESHOLDS SUBTRACT VALUES ABOVE; TO CONVERT ASA '51 TO ISO '64 ADD THE CORRECTIONS.

THIS AUDIOGRAM OBTAINED AND PLOTTED ON THE BASIS OF CALIBRATION.
ISO 1964 ☐ ASA 1951 ☐ ANSI 1969 ☒

MASKING LEVELS		250	500	1000	2000	4000	8000	OTHER
Bone Conduction	NOISE IN RIGHT EAR							
	NOISE IN LEFT EAR							
Air Conduction	NOISE IN RIGHT EAR							
	NOISE IN LEFT EAR							

Type of noise:

Serial Play 1st time

COMMENTS:
Aided bin. Widex A12 + T Vol 6
gc
40 dB
70 dB SF unaided

Audiogram Key

	Right	Left
AC Unmasked	O	X
AC Masked	△	☐
BC Mastoid Unmasked	<	>
BC Mastoid Masked	[	]
BC Forehead Masked	˥	Γ

Both

BC Forehead Unmasked ↓

Sound Field S Aided A

Examples of No Response Symbols

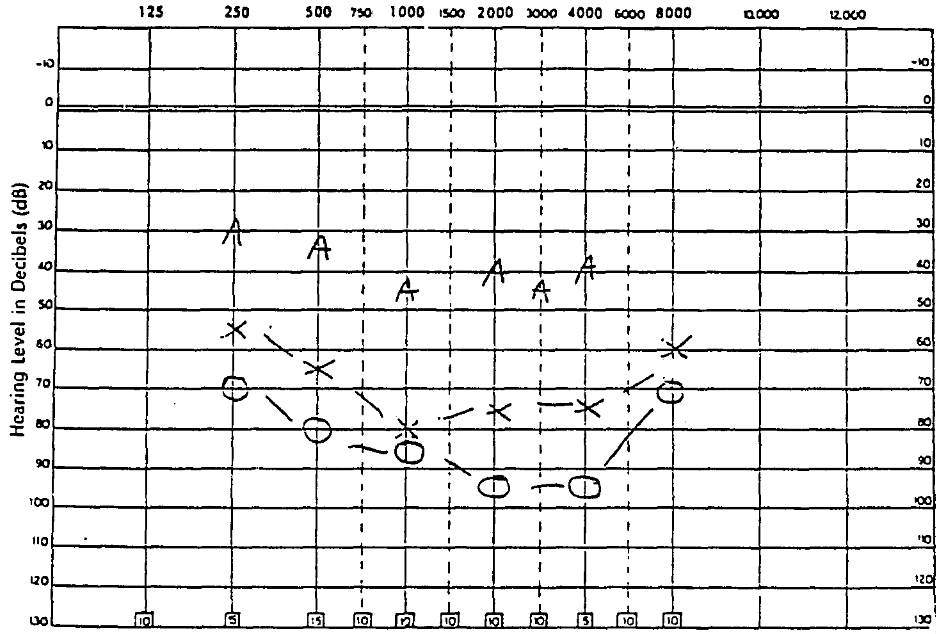
Audiogram

DATE ______ NAME Baby W - girl ______ B.D. 9/21/81 ______ EXAMINER ______

AUDIOMETER MA 34

PURE TONE AUDIOMETRY

Frequency in Hertz (Hz.)



Pure-tone Average (500, 1000, and 2000 Hz.)

Ear	Two-Frequency	Three-Frequen[cy]
Right	83	87
Left	70	73

Retest at ...... 1k Hz.

Right	
Left	80

TO CONVERT ISO 1964 THRESHOLDS TO ASA 1951 THRESHOLDS SUBTRACT VALUES ABOVE. TO CONVERT ASA '51 TO ISO '64 ADD THE CORRECTIONS.

THIS AUDIOGRAM OBTAINED AND PLOTTED ON THE BASIS OF ISO 1964 ☐ ASA 1951 ☐ CALIBRATION. ANSI 1969 ☒

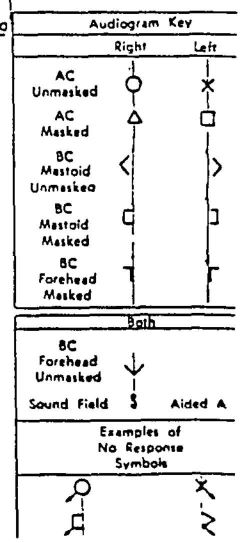
MASKING LEVELS		250	500	1000	2000	4000	8000	OTHER
Bone Conduction	NOISE IN RIGHT EAR							
	NOISE IN LEFT EAR							
Air Conduction	NOISE IN RIGHT EAR							
	NOISE IN LEFT EAR							

Serial Play
1st time

Type of noise:

COMMENTS:

go R 75
L 55
Aided 35



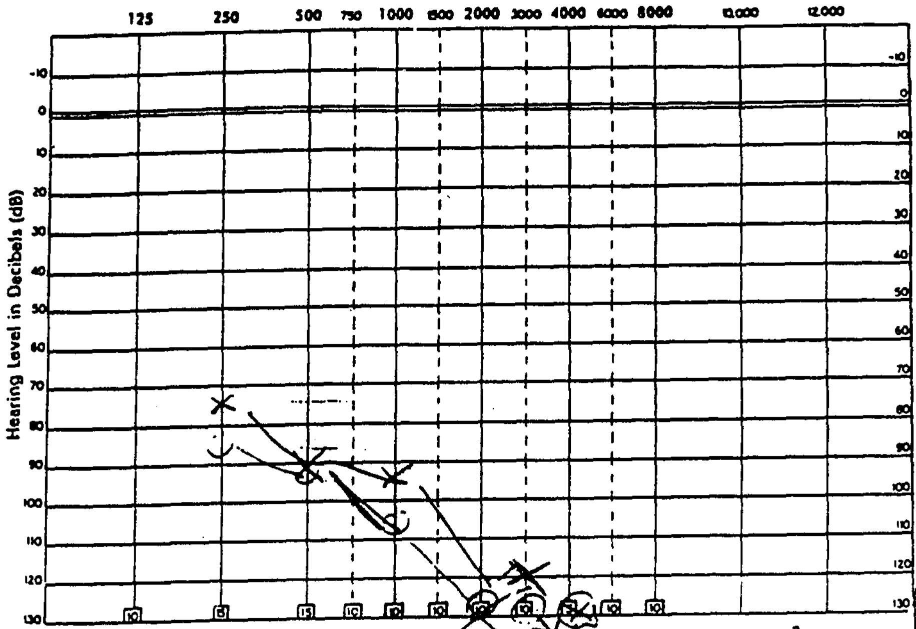
Audiogram

DATE	NAME Baby X - girl	B.O. 3/2/82	EXAMINER

AUDIOMETER Petris AP6 / MA24

PURE TONE AUDIOMETRY

Frequency in Hertz (Hz.)



Pure-tone Average (500, 1000, and 2000 Hz)

Ear	Two-Frequency	Three Frequency
Right	87	10[illegible]
Left	92	105

Retest at ....

Right	
Left	

TO CONVERT ISO 1964 THRESHOLDS TO ASA 1951 THRESHOLDS SUBTRACT VALUES ABOVE; TO CONVERT ASA '51 TO ISO '64 ADD THE CORRECTIONS.

THIS AUDIOGRAM OBTAINED AND PLOTTED ON THE BASIS OF ISO 1964 ☐ ASA 1951 ☐ CALIBRATION. ANSI 1969 ☒

MASKING LEVELS		250	500	1000	2000	4000	8000	OTHER
Bone Conduction	NOISE IN RIGHT EAR							
	NOISE IN LEFT EAR							
Air Conduction	NOISE IN RIGHT EAR							
	NOISE IN LEFT EAR							

Type of noise:

COMMENTS

Audiogram Key

	Right	Left
AC Unmasked	O	X
AC Masked	△	☐
BC Mastoid Unmasked	<	
BC Mastoid Masked	[	
BC Forehead Masked		

Both

BC Forehead Unmasked ∨

Sound Field S

Examples of No Response Symbols

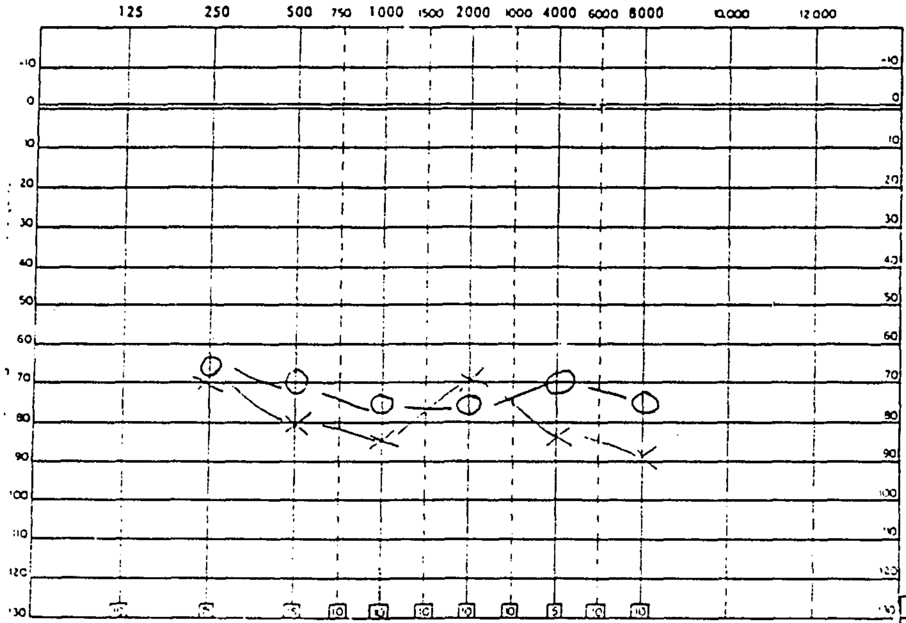
Audiogram

DATE	NAME	B.D.	EXAMINER
	Baby Y - boy	3/11/	

AUDIOMETER: MA 24

PURE TONE AUDIOMETRY

Frequency in Hertz (Hz.)



Pure-tone Average (500, 1000, and 2000 Hz)

Ear	Two-Frequency	Three-Frequency
Right	72	73
Left	75	78

Retest at Hz

Right		±3
Left		±5

ISO 1964 ASA 1951 ANSI 1969

MASKING LEVELS		250	500	1000	2000	4000	8000	OTHER
Bone Conduction	Noise in right ear							
	Noise in left ear							
Air Conduction	Noise in right ear							
	Noise in left ear							

Type of noise

COMMENTS

Audiogram Key

	Right	Left
AC Unmasked	O	X
AC Masked	△	□
BC Mastoid Unmasked	<	>
BC Mastoid Masked	[	]
BC Forehead Masked	⅂	Γ

Both

BC Forehead Unmasked

Sound Field S Aided A

Examples of No Response Symbols

TABLE A-1

Percent of Subjects Passing Each Task (i.e., $^2/_3$ of the trials)

Age in Months HN & HNS (N=17) DS (N=4)

	0-3 Months	4-7 Months	8-11 Months
Task 1 (Tracking)			
HS & HNS	-	65%	75%
DS	-	75%	100%
* U-H	100%	NA	NA
Task 2 (Tracking)			
HS & HNS	-	85%	95%
DS	-	100%	NA
U-H	-	100%	NA
Task 3 (Hiding)			
HS & HNS		80%	90-100%
DS		100%	NA
U-H		-	100%
Task 4 (Hiding)			
HS & HNS	-	-	85-95%
DS	-	-	100%
U-H	-	-	100%

* Uzgiris-Hunt subjects - not normative

NA = Not applicable
HS = Hearing with sound
HNS = Hearing without sound
DS = Deaf Infants

TABLE A-2

Pass/Fail Score - Session Means and Standard Deviations by Task for Sound (HS) and No-Sound (HNS) Groups

Session	1		2		3		4		5		6	
	HS	HNS	HS	HNS	HS	HNS	HS	HNS	HS	HNS	HS	HNS
Task 1												
$\bar{X}$	.54	.70	.50	.70	.67	.93	.50	.70	.54	.59	.54	.67
SD	.50	.39	.47	.42	.31	.22	.47	.31	.43	.40	.43	.44
Task 2												
$\bar{X}$	.66	.78	.62	.85	.79	.96	.66	.81	.70	.70	.62	.62
SD	.47	.44	.45	.24	.35	.11	.47	.18	.38	.45	.45	.45
Task 3												
$\bar{X}$	.62	.81	.79	.70	.88	.85	.79	.82	.75	.78	.83	.81
SD	.41	.18	.24	.26	.35	.24	.35	.29	.30	.37	.25	.33
Task 4												
$\bar{X}$	.50	.48	.38	.59	.63	.70	.79	.85	.50	.56	.46	.66
SD	.40	.29	.28	.49	.42	.35	.17	.34	.30	.23	.17	.33

TABLE A-3

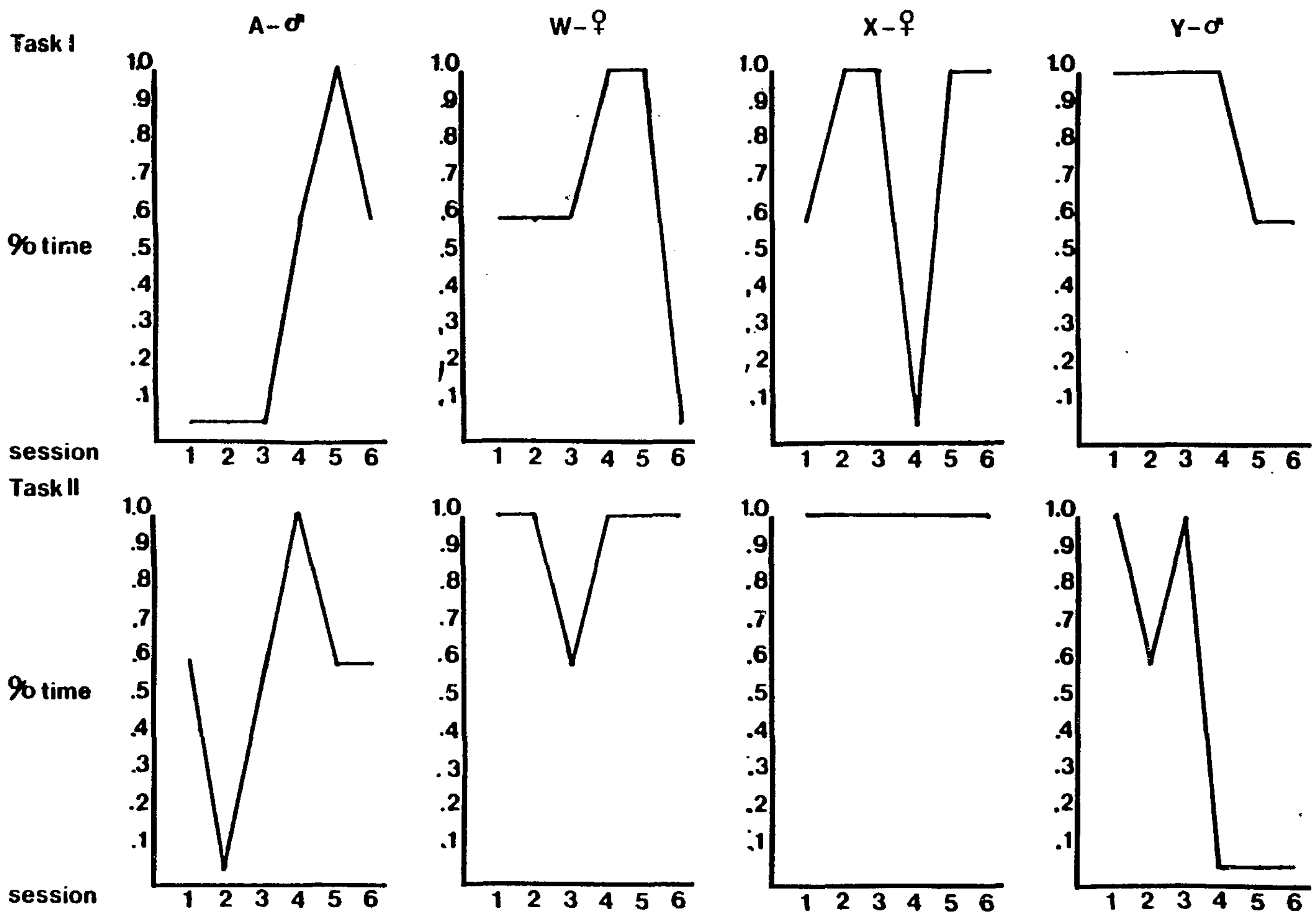
Pass/Fail Weighted - Session Means and Standard Deviations by Task for Sound (HS) and No-Sound (HNS) Groups

Session	1		2		3		4		5		6	
	HS	HNS	HS	HNS	HS	HNS	HS	HNS	HS	HNS	HS	HNS
Task 1												
$\bar{X}$	2.3	2.6	2.4	2.6	2.7	2.9	2.3	2.6	2.3	2.4	2.3	2.5
SD	.89	.48	.61	.58	.31	.22	.77	.45	.74	.66	.92	.78
Task 2												
$\bar{X}$	2.2	2.4	1.8	2.8	2.3	3.1	2.5	2.1	2.1	1.8	1.8	1.8
SD	1.4	.96	1.5	1.0	1.1	.76	1.7	.60	1.0	1.2	1.3	1.46
Task 3												
$\bar{X}$	1.5	1.7	1.8	1.7	1.9	1.8	1.8	1.8	1.7	1.8	1.7	1.6
SD	.64	.27	.29	.30	.35	.23	.35	.33	.54	.29	.34	.66
Task 4												
$\bar{X}$	2.6	1.7	1.8	2.0	2.5	2.5	2.9	2.6	1.6	1.8	1.4	2.2
SD	.45	.88	.87	1.2	1.0	.70	.17	.78	.73	.72	.51	.83

Figure A-1

DEAF INFANTS INDIVIDUALLY

Pass/Fail Score - Uzgiris-Hunt Scale[a]
Tracking

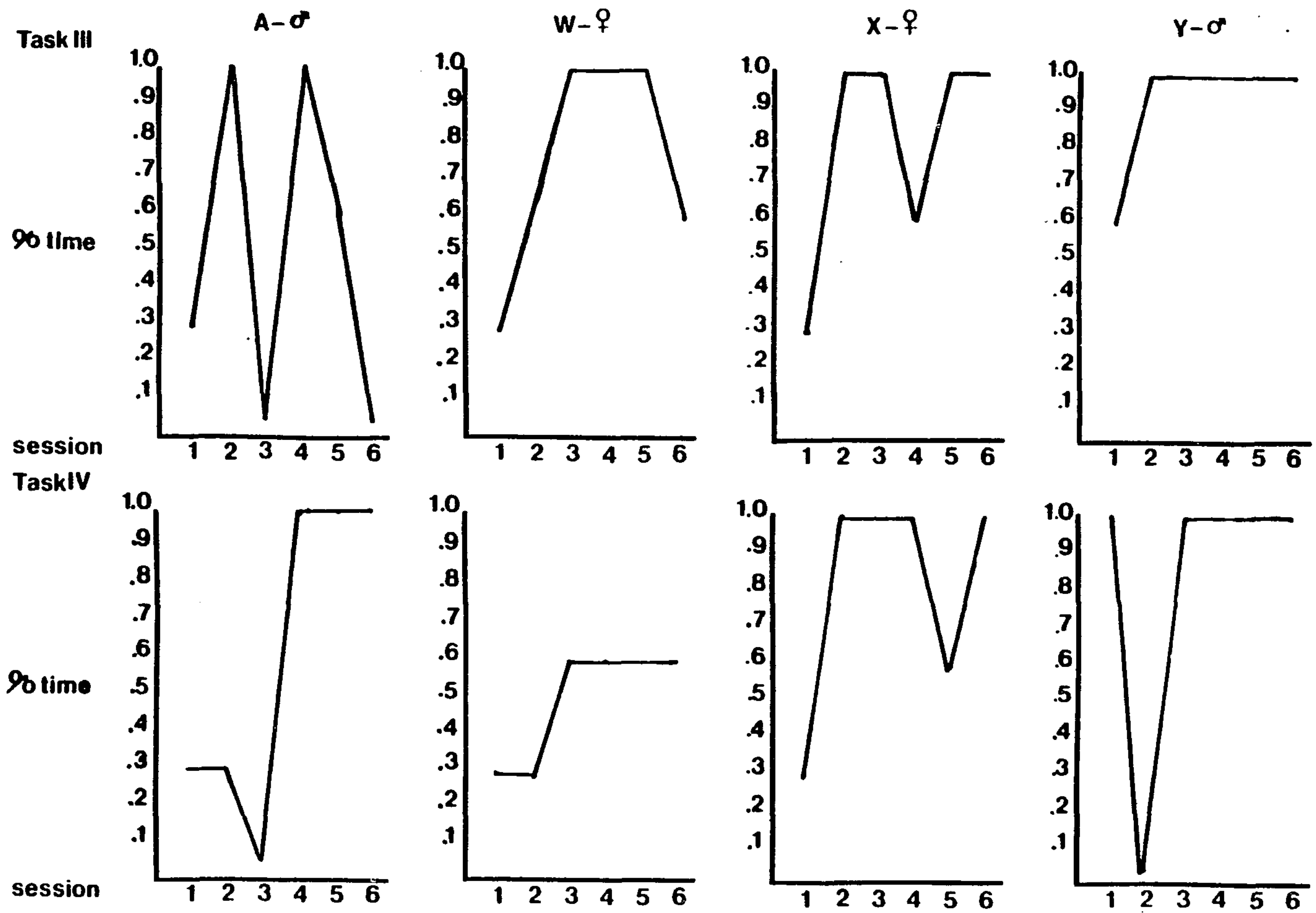


a— 0= Fail 1=Pass

Figure A-2

DEAF INFANTS INDIVIDUALLY

Pass/Fail Score – Uzgiris-Hunt Scale[a]
Hiding

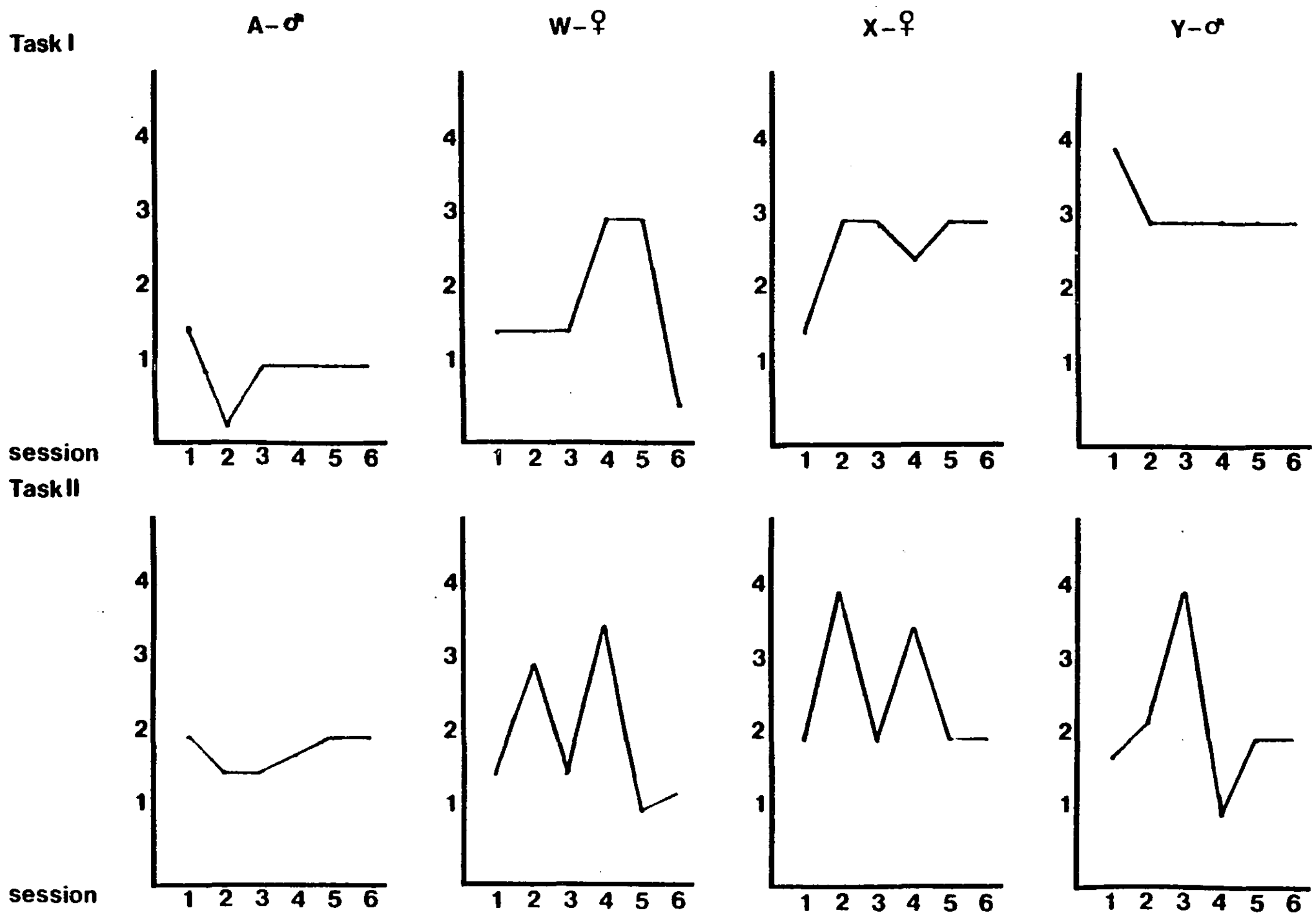


a – 0=Fail 1=Pass

Figure A-3

DEAF INFANTS INDIVIDUALLY

Pass/Fail Score – Weighted[a]
Tracking

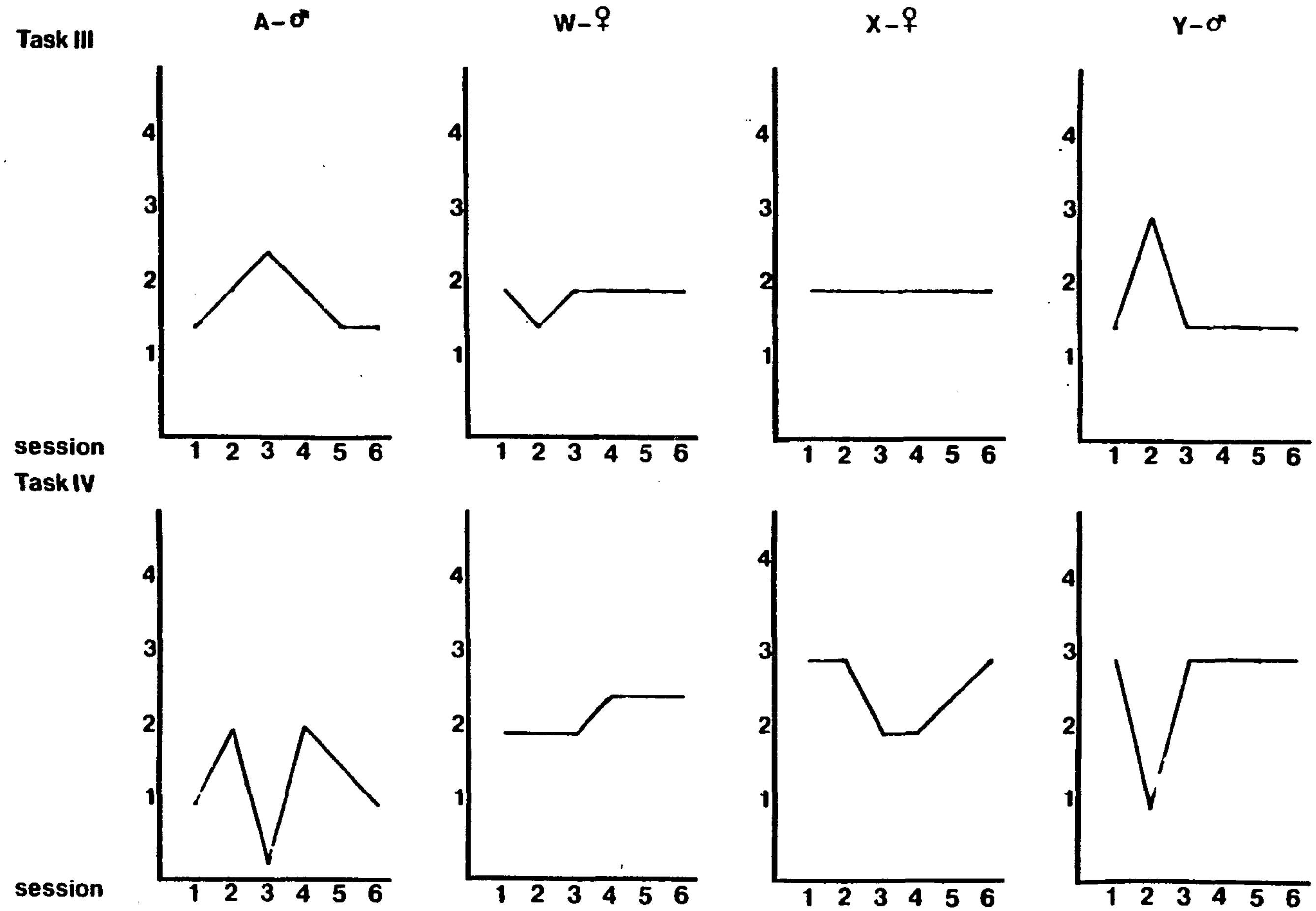


a – From Uzgiris-Hunt Ordinal Scales. a=1 b=2 c=3 d=4

Figure A-4

DEAF INFANTS INDIVIDUALLY

Pass Fail Score - Weighted[a]
Hiding

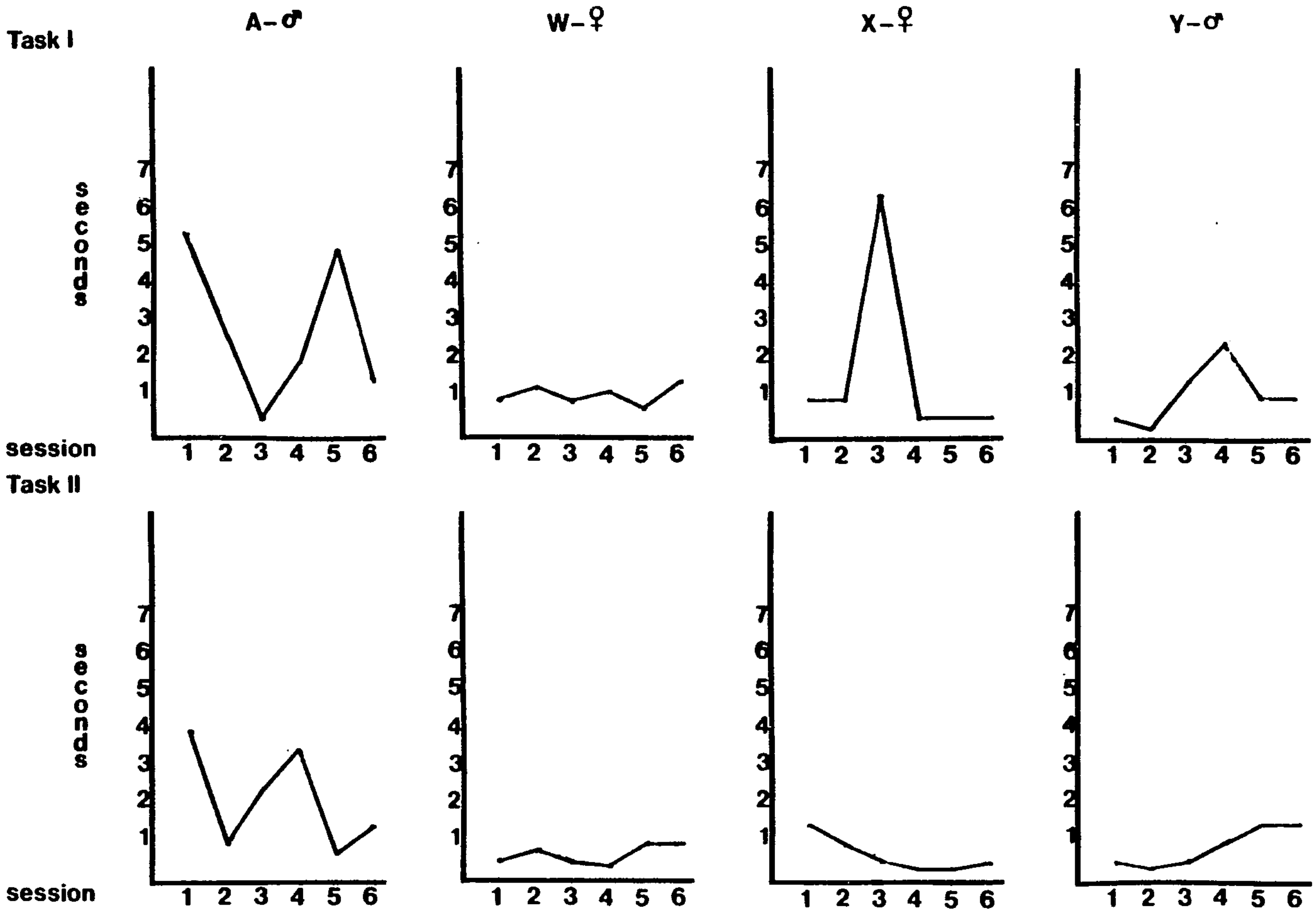


a - From Uzgiris-Hunt Ordinal Scales: a=1 b=2 c=3 d=4

DEAF INFANTS INDIVIDUALLY

Figure A-5

Latency-Tracking



DEAF INFANTS INDIVIDUALLY

Figure A-6

Time on Task–Tracking

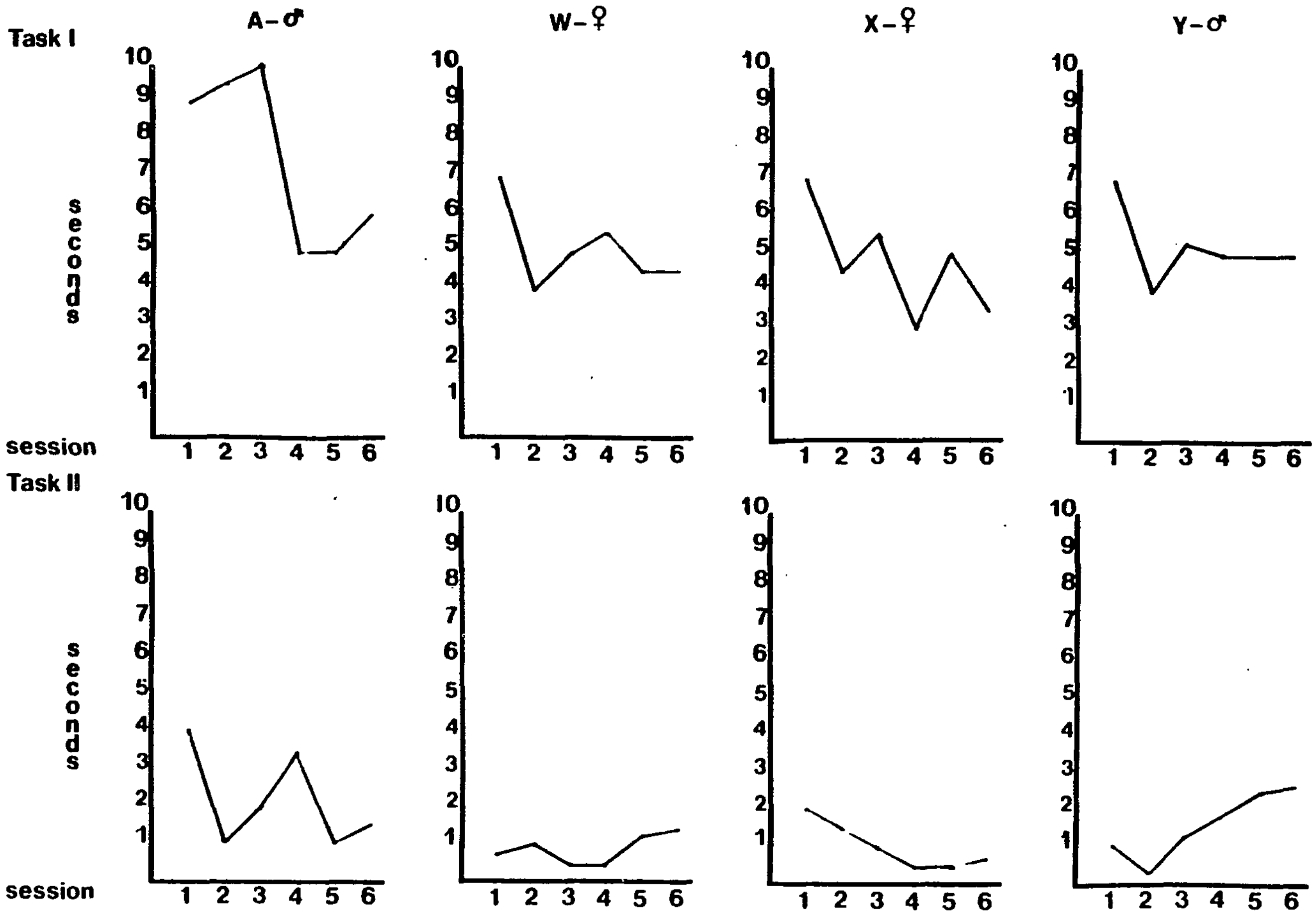


Figure A-7

DEAF INFANTS INDIVIDUALLY

Time on Task - Hiding

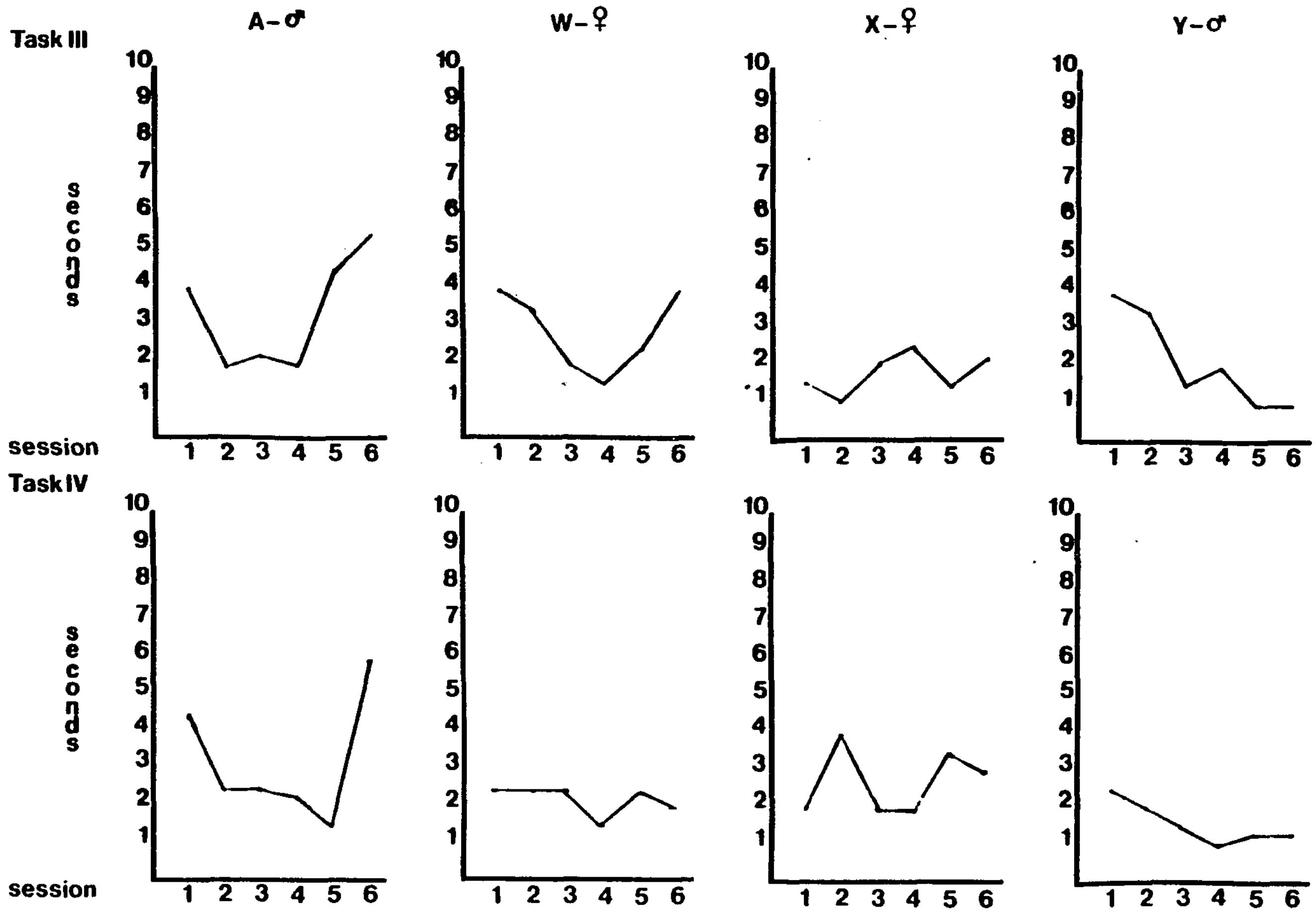
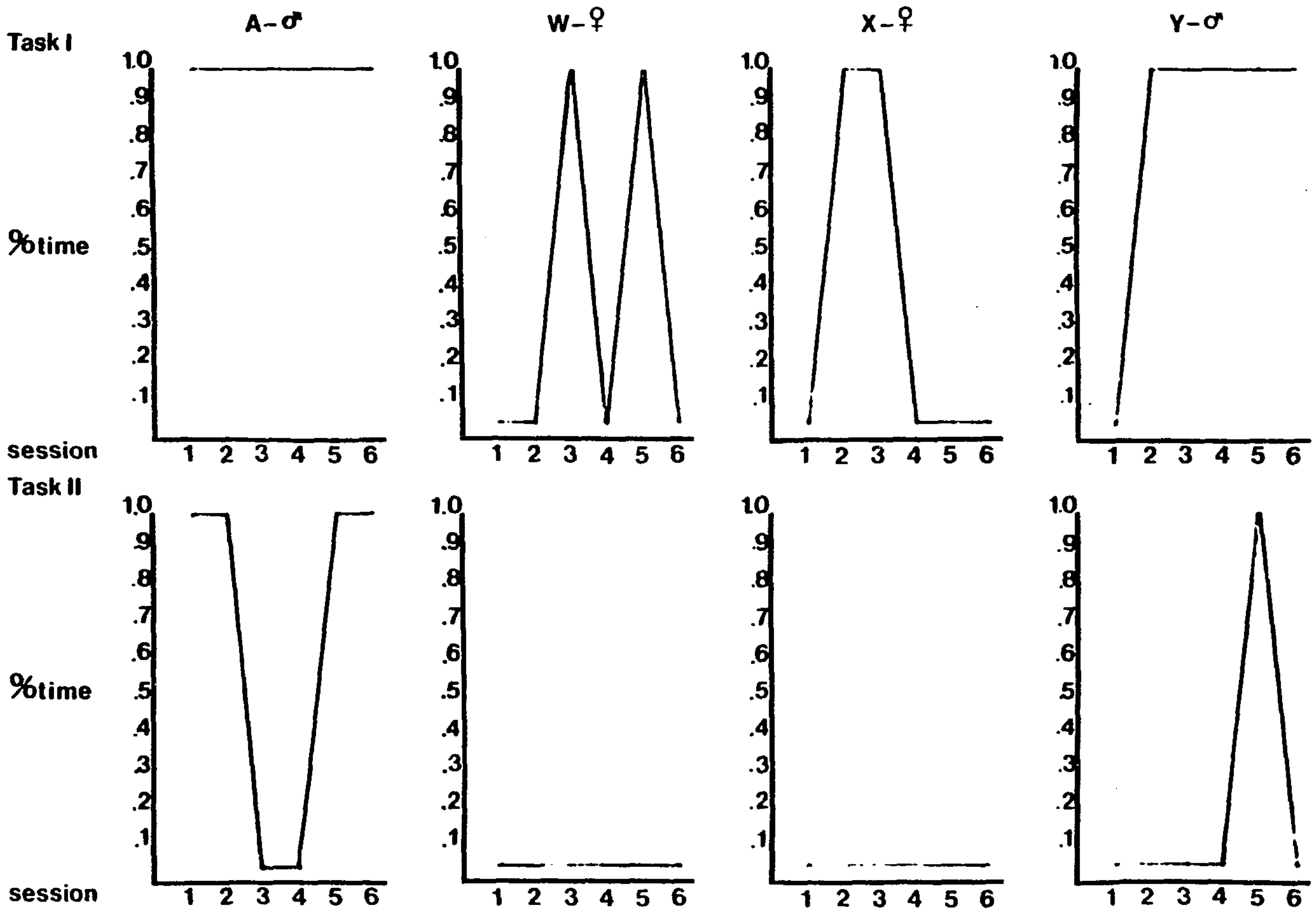


Figure A-8

DEAF INFANTS INDIVIDUALLY

Oral Exploration
Tracking



DEAF INFANTS INDIVIDUALLY

Oral Exploration

Hiding

Figure A-9

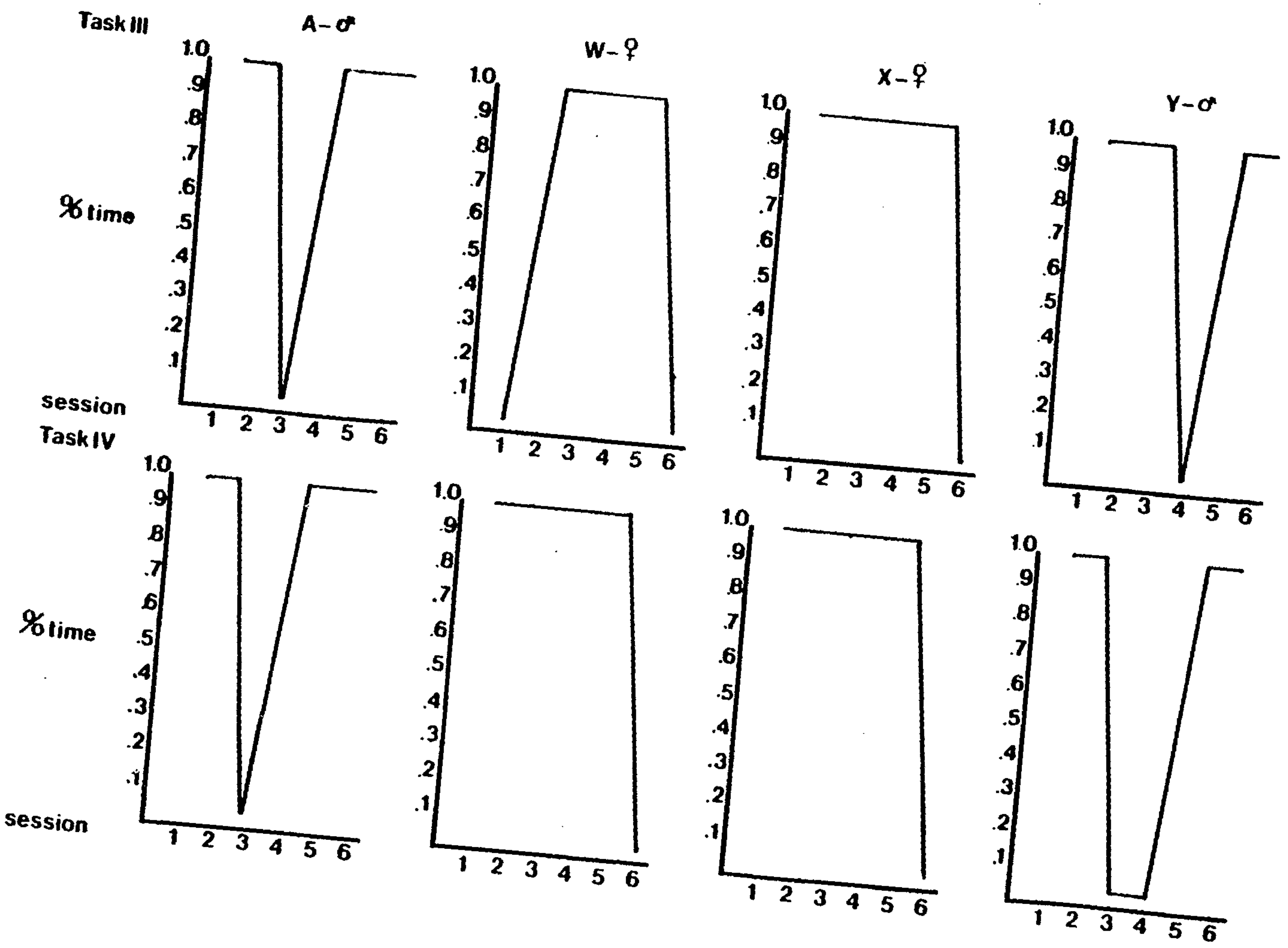
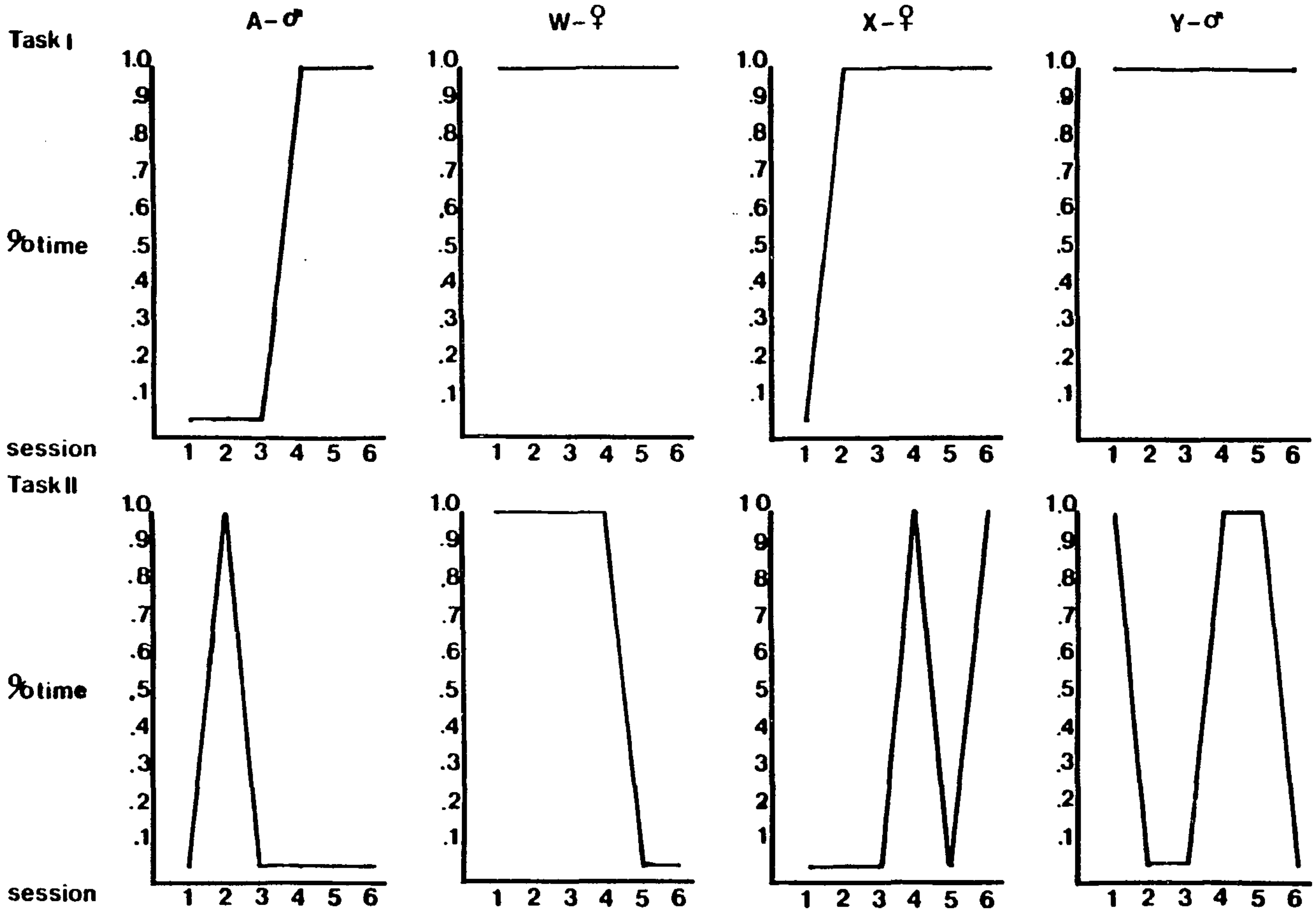


Figure A-10

DEAF INFANTS INDIVIDUALLY

Visual Exploration
Tracking



DEAF INFANTS INDIVIDUALLY

Visual Exploration

Hiding

Figure A-11

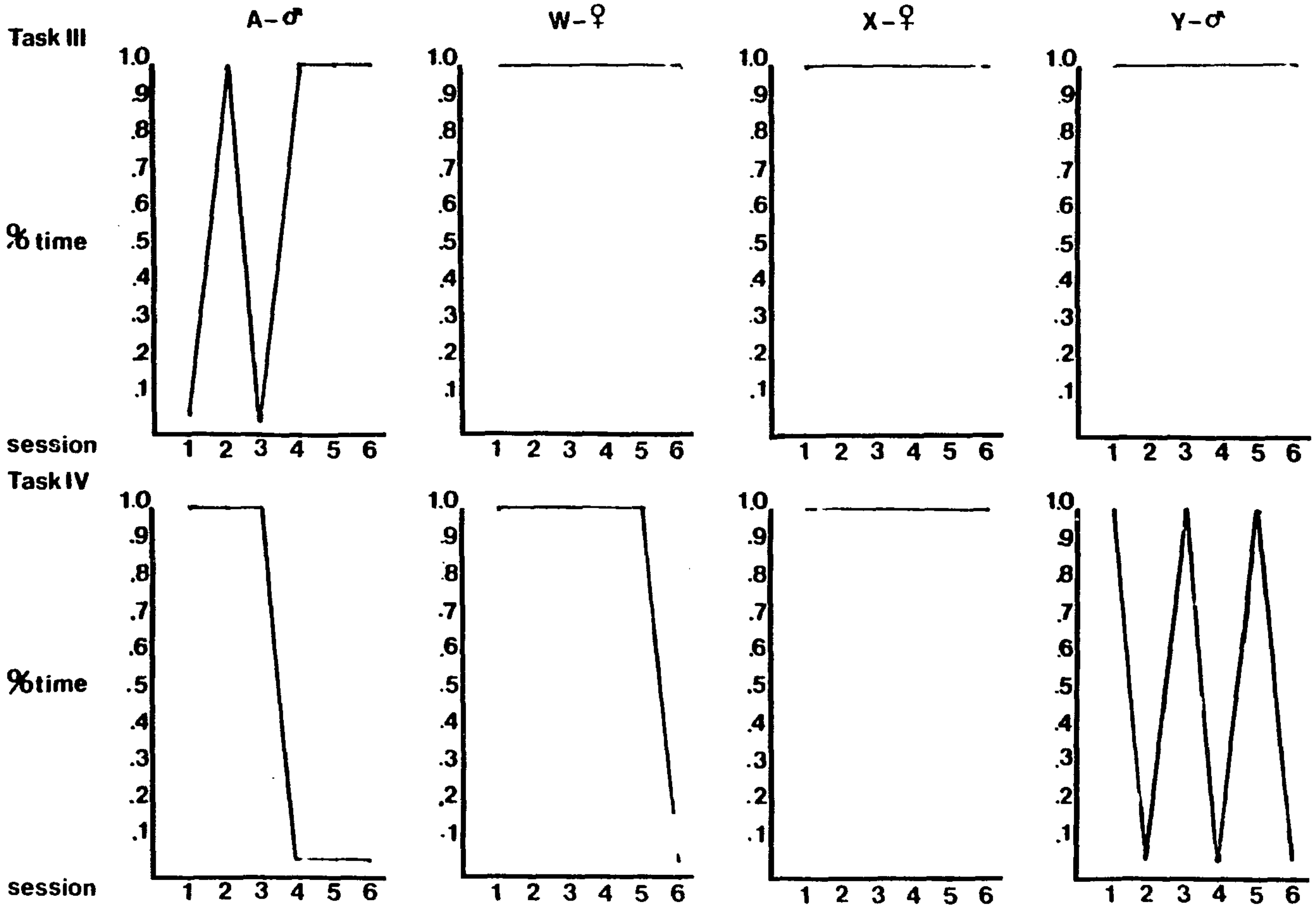
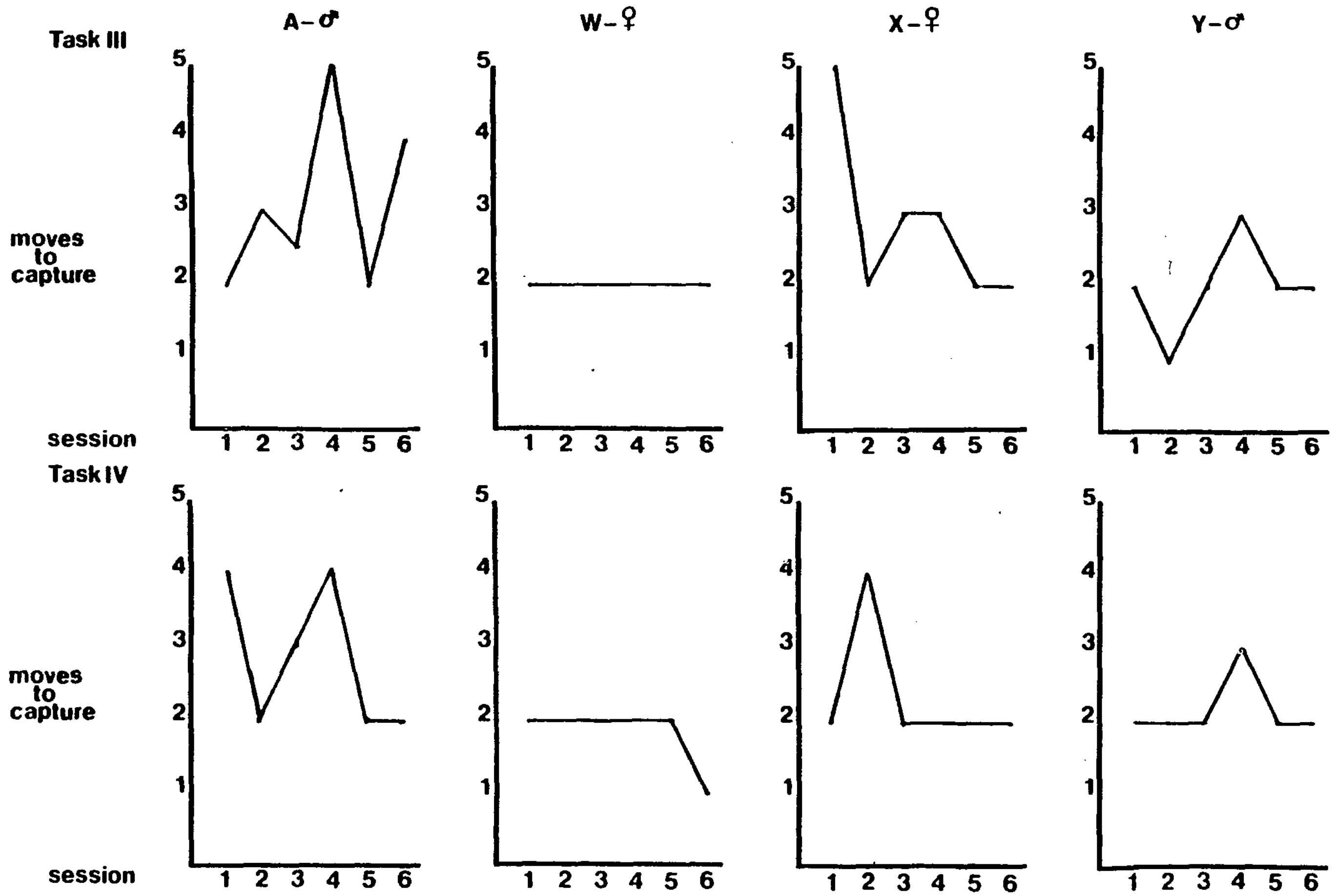


Figure A-12

DEAF INFANTS INDIVIDUALLY

Efficiency-Hiding



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