Language, Thought and Deafness: Conceptual and Methodological Issues, With Reference to Visuo-Spatial Processing, Control of Attention and Sign Language.

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ABSTRACT

A review of the literature indicated that a reappraisal of the conceptual and methodological approach to the study of deafness was necessary if research is to explain why deaf children fail to achieve the scholastic potential predicted by I.Q. tests.

This study aims to test the utility and validity of an approach, in which the psychological consequences of deafness are viewed as an alternative perspective on normal human information processing; the result of functional adaptation to the environment. Qualitative and quantitative methods of data analysis, are used to examine process and structure underlying outcome.

The approach is tested by examining control of attention and visuo-spatial processing and the relationship of these to language in severely and profoundly prelingually deaf children between the ages of 2 and 6 years, whose primary means of communication is British Sign language (BSL). These were examined using tests of problems solving, memory, intelligence and observational studies of play.

The results emphasise the importance of visual information gathering and processing for deaf children. Control of attention is seen to vary as a function of the visual complexity of the environment and of stimuli, ease of environmental monitoring, and social factors. An observational study indicated that the deaf child uses language to direct his/her behaviour and as an adjunct to play. It was also observed that the children spent time exploring and using mirror images, and that this activity was related to BSL structures and functions.

The use of these same mirror image like structures was also evident in visuo-spatial problem solving. In general visuo-spatial abilities were found to vary as a function of task and information characteristics, attentional demands of the stimuli and social factors; the presence of a deaf

experimenter improved problem solving performance for concrete problems. The results were discussed with reference to Sign language, and its ability to represent information, and also interference, both positive and negative, consequent on tasks requiring the processing of both a visuo-spatial language and visuo-spatial information.

It was concluded that the approach offered the potential to generate data which would lead to a richer, and ecologically more useful, description of the cognitive abilities of deaf children.

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CHAPTER 1: General Introduction and Definitions

Scope and Nature of the Thesis

The psychology of deafness is, by and large, a by product. Deafness does not merely entail a loss of hearing, but also, limited access to oral language and all which is consequent. Thus the deaf have been seen as a natural experimental population with which to test theories concerning the relationship between language and thought. The processes which have led to a psychology of deafness could be schematised thus;

Observation of hearing populations
↓
Theory/Model building to describe data
↓
Formulation of hypotheses → Testing of predictions using deaf populations as comparators
↓
Conformation of theory/model on basis of comparative data → Formulation of hypotheses
↓
Evaluation of deaf data qua original theory/model → psychology ofdeafness

Two things are immediately obvious from this scheme; 1) it is tautologous and 2) there are no direct observations of the deaf. This has led to a deficit model of deafness, which emphasises what the deaf cannot do compared to the hearing and which claims that similarities in performance are explained by the theory which the deficit was used to test.

Whilst this approach may have told us something about the hearing, it has told us little which is of practical use to the deaf and educators of the deaf. Despite nearly a hundred years of research, we are no nearer to answering the central question which the research has posed;

"Why do deaf children fail to achieve the scholastic potential

predicted by I.Q tests".

Where earlier research had addressed this question indirectly, by comparing the deaf to the theoretical yardsticks upon which successful hearing education was founded, more recent research has addressed the problem directly. This has been done by posing the same kinds of fundamental questions as were asked of hearing populations, directly to deaf populations. A second factor has also had to be taken into consideration; Sign language has been recognised as an independent and fully functional natural language. Social changes have also taken place with the deaf community demanding their right to have Sign language recognised as their preferred first language. These taken together have led to increasing acceptance of sign language, in research, if not in *educational* practice.

To summarise, there has been a recognition of the inadequacy, from the point of view of a useful psychology of deafness, of data derived from studies where the deaf are an experimental population with which to test theories about hearing populations. This has led to research where the deaf per se are the focus. The linguistic status of sign language, and of the deaf themselves, has changed, giving rise to a research climate which is different from that in which the earlier research was conducted. This then raises the question, what implications do these changes have for evaluating the previous research and for formulating future research?

This study raises and explores some of these implications. Previous research is examined with two questions in mind 1) what are the underlying assumptions, both explicit and implicit, and 2) how would different assumptions, derived from an alternative perspective, affect the interpretation of results or choice of study. This train of thought is carried through to the empirical work, by the choice of test materials and methods of data analysis.

It was felt that earlier cognitive research did not provide a secure empirical base on which construct testable hypotheses. Neither was it felt that a purely theoretically derived alternative could provide such a base without it first being demonstrated that an approach based on such a system was empirically viable and would lead to data which was ecologically valid and practically useful. As this project, by its nature, is of limited scope, its aim is to construct and test the feasibility of, an alternative approach to the psychology of deafness, within a limited domain. Two key constructs are common to all the studies; visuo-spatial processing and control of attention. These are the two areas, which an examination of past and present research, and my own observations, suggest as being of central importance.

The project takes as its focus the relationship between Sign language and thought and, therefore, children whose primary means of communication is Sign language. The extent to which any conclusions drawn apply to orally educated children is an empirical question which is not addressed here. Bohm (1984) said "...science has been affected by a point of view which tries to be value free. This is of course mere prejudice.". Anyone beginning to research into issues surrounding deafness and language, immediately finds themselves in a political maelstrom, where polemic tends to be the main currency. In such a situation it is virtually impossible to hold an unbiased view. I do not claim any privileged exemption from this, nor do I claim to be "nothing but an unbiased observer". I have endeavoured to specify my bias in the form of explicitly stated assumptions.

Definitions

The following is not intended to be an exhaustive set of definitions for all terms used, rather they represent the minimum necessary to set the tone and context of what will follow. For this reason, any justifications for the choice of definition are kept to a minimum, as these will emerge during the course of the discussions to follow. Some terms are only defined in the course of the discussion. For example, in Chapter 3 the term verbal is discussed and defined.

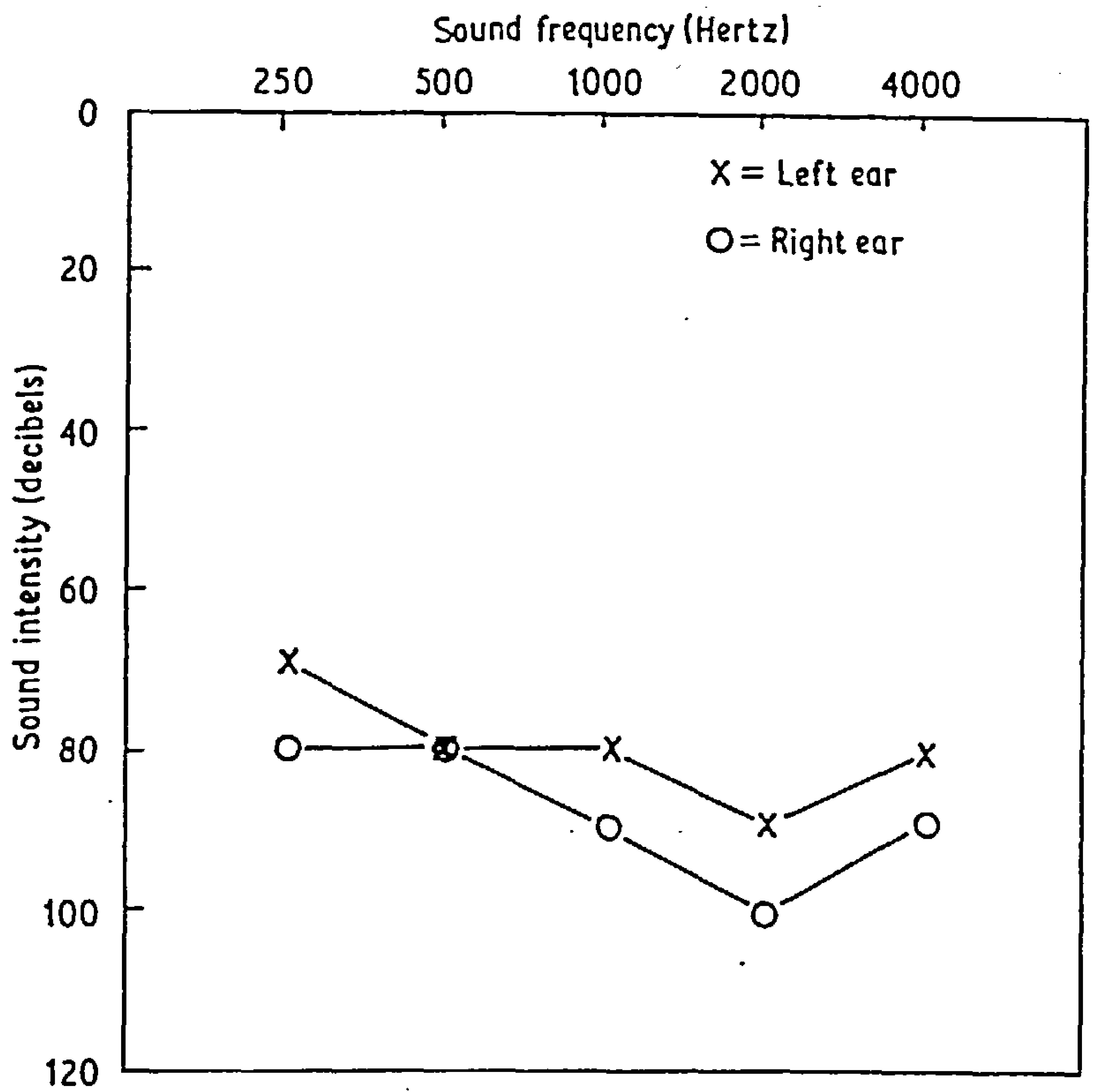
Deafness

Deafness is a complex term, referring to loss of the sense of hearing, which is applied to a heterogeneous group of people. The implications of deafness extend beyond hearing loss to include linguistic and cultural considerations. Webster (1986) suggested that deafness be more accurately characterised as a lack of language. In fact these tend to be related, but already we have acceded to an assumption about what constitutes language. In his definition Webster means spoken language. I will say more about this latter.

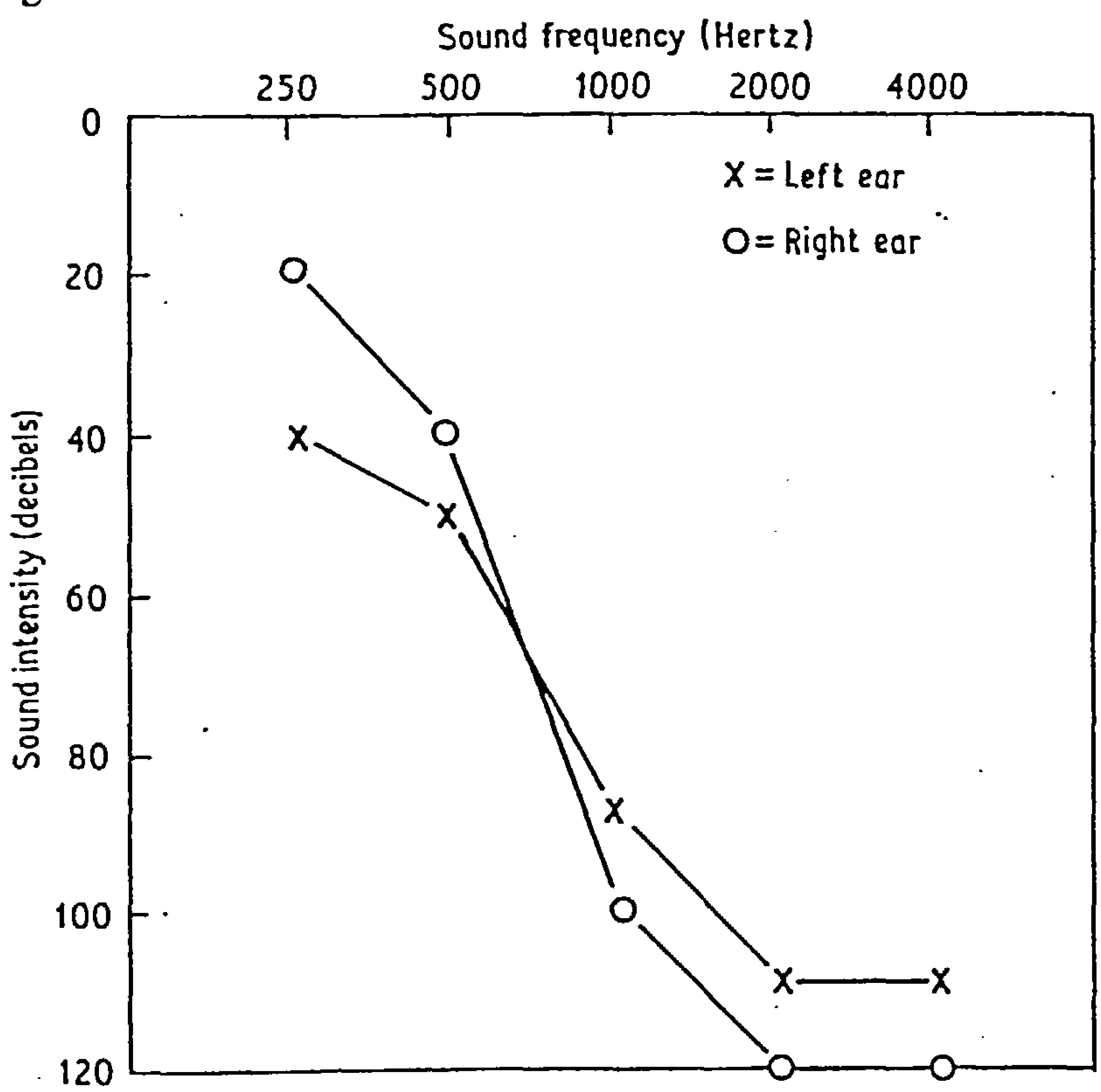
Objectively, deafness is defined in terms of hearing loss in decibels (dB), which is a logarithmic scale. Hearing loss is measured by comparing the intensity of sound required for detection by the subject with a baseline. The difference between the two is expressed in decibels. Conductive and sensori-neural hearing measurements are taken for five frequencies between 250 and 4000 Hertz. Hearing loss is then categorised according to the range in which it falls. Losses up to 40 decibels are Slight; between 40 and 70 decibels, Moderate; between 70 and 100 decibels, Severe; losses in excess of this Profound (British Association of Teachers of the Deaf, 1981).

Quoted hearing loss measurements are averages of loss over the range of frequencies measured, for the better ear. The mid range, 500 to 2000 hertz, are the most important for understanding speech. Figure 1.1 shows audiograms for two people with better ear losses of 80 dB. From the diagrams it can be seen that two people with the same quoted hearing loss can have differential access to sound, which in the case

Figure 1.1 Audiograms Showing a Severe Bilateral Hearing Loss of 80 Decibels in the Better Ear



Audiogram showing a severe bilateral sensori-neural hearing loss



Audiogram showing a severe bilateral high frequency sensori-neural hearing loss of a child will determine to some extent the probability of acquiring spoken language.

Deafness need not be continuous i.e. it may be intermittent. Also hearing loss may not be due to damage to the sensory mechanism (sensori-neural loss) but can be due to masking of the signal by, for example, tinnitus or glue ear (Otitis media) (conductive loss). Tinnitus may also be present with sensory loss. Finally, the etiology of deafness can vary from genetic to the capricious. Non-genetic causes of deafness include maternal rubella, birth trauma and meningitis. Some etiologies, e.g. maternal rubella, have an associated risk of C.N.S. damage over and above the hearing loss.

Speech Acquisition

The above criteria for deafness are purely mechanical. One of the most obvious consequences of deafness is its effect on speech, sometimes to the point where a person has no intelligible speech. Unsurprisingly, therefore, definitions of deafness are intimately bound with linguistic considerations. Webster (1986) suggested that deafness, may be better described as the deprivation of language. The audiograms in figure 1.1, both show average hearing losses of 80dB. However the relative distributions of loss across the frequencies demonstrates that even in the case of an identical quoted hearing loss, access to speech may be differentially affected. Speech information, particularly the nuance, is predominantly carried by the high frequencies. Mere access to sounds is not of itself enough to predict the development of speech, and hence ascribe deafness, as evidenced by those who are categorised as severely deaf who do not acquire speech and those who are categorised as profoundly deaf who do acquire speech.

When considering the speech implications of deafness an important factor is age of onset. Deafness occurring after speech development has begun has less serious affects on speech than deafness which is prelingual. The seriousness of the affect of post-lingual deafness decreases as the age of onset of deafness increases. A consensus view is that the age of two represents the dividing line between pre- and post-lingual deafness.

Whilst the hearing world defines deafness in terms of objective measurements and speech acquisition the deaf have their own criteria. These are usually based on practical and cultural considerations such as can a person use a telephone, and where and with whom a person chooses to spend their time.

Definition of Deafness Used here

The term deaf, without qualification, will be used here to denote those who are severely or profoundly prelingually deaf. This will also include those who, with respect to speech acquisition, behave as if they fell into these categories. This latter is necessary as the age of the subjects drawn from the nursery meant that reliability of their audiograms was uncertain. The term deaf will be qualified where necessary to avoid confusion. The slight and moderate categories will be referred to as partial hearing.

Language

Defining language is a difficult undertaking, for many reasons. Any person defining language, is a competent language user and brings intuitive knowledge of what language is to the task. Where language is to be the subject of empirical investigation, operational definitions are required, which must, of necessity, state precise boundary conditions for what is being studied. These two tend to lead to differing kinds of definition, functional, in the case of the former, and structural, in the case of the latter. A complete definition of language would seem to require both structural and functional components if it is to be intuitively acceptable and empirically useful. Finally, any definition, should be such that it clearly exemplifies which objects or events fall into the class and which do not. In the case of language in relation to deafness, this is especially important as what is defined as language has profound implications for the alleged linguistic status of deaf experimental populations.

Psychology, like all science, is heavily dependant on language. Psychology differs, in the extent to which language is necessary to access its raw data, unlike those disciplines which use language to explicate physically given raw data. In the final analysis, however, all science depends on some form of language, be it natural language, such as English or a formal language such as mathematics. The purpose of these languages is, to use Pask's (1980) term, to 'exteriorise' thought processes, such that they may be shared, pointed to, commented on, and reached agreement on. This view encompasses more than communication; it also includes representation. Science, and indeed, any form of culture, can only arise because homo sapiens has the ability to create and use generative, representational and communicative systems. This then forms my definition of language.

Definition of Language used Here

The term Language, is used here to mean any open, rule governed, generative system of symbols, which is capable of representation and communication in space and/or in time. A language can represent objects in the world, thought, or both. This definition has much in common with a symbolic interactionist view of language. Many kinds of symbol systems, such as mathematics, music and natural language, with diverse properties, attain the same status on functional grounds, without prejudice to structure. The essential point is that there is a set of rules or Grammar, which prescribes the ways individual symbols may be combined, and which in turn, allows decomposition of the string to recover the intended meaning. In other words the grammar is shared between users of the symbol system. Language Acquisition is the acquisition of both the symbols and grammar of a system which is shared by other members of a language community.

Languages may vary along a number of dimensions, as a function of the adaptive purposes and pragmatic uses of the language. For example, understanding natural language requires the use of presupposition, whereas mathematics is constructed to reduce presupposition to a minimum, and then to axiomatic cases. This allows mathematics to function in a more descriptively precise and unambiguous manner than is possible in natural language. This difference does not imply a deviancy of either language from some predetermined norm; it merely reflects their functional adaptation to a particular realm of discourse, each being adept at representing and communicating the intent (thought) of users in that domain.

Symbols: Oral Language, Sign Language and Sign Systems

The definition of language above, does not dictate the form the symbols must take, nor the medium in which they are transmitted. The word language, to the majority of people, means the language they speak, such as English or French. In these languages the symbols are words (morphemes) and the primary transmission medium is oral (speech). This is what I mean when I use the term oral language. Oral language may also be transmitted visually, i.e. in written form, and received visually by reading. A second way of receiving an oral message visually is by lip reading (speech reading) where the message is decoded from the lip patterns of the speaker.

Manual languages are those in which the hands and body are used to transmit the symbols. In British Sign Language (BSL) the symbols are signs, which are formed by the hands, face and body. The primary means of transmission is gestural (manual). There is no secondary medium, in that there is no written form of BSL. Not only are the symbols of BSL different from those of English, but also the grammar. Hence it is a distinct and autonomous language, denoted by the term Sign Language or Sign.

There are a number of other manual methods of communication, such as Sign Supported English (SSE), Signed Essential English (SEE), Makaton and Paget-Gorman (PG). These are not included in the term Sign language, although they fall within the definition of language. These sign systems may be thought of as pidgins, where the grammatical structure of one language (oral) is imposed on the symbol system of another (sign). This involves more than just making sign order follow, say English word order, but includes the creation of new symbols to represent grammatical markers not used in Sign language.

Thought, Cognition and Cognitive Processes

As with language, a precise definition of thought is complicated by a persons intuitions and common sense notions of what constitutes thought. In any event it is a term which carries a multitude of meanings. The debate concerning the relationship between language and thought implies that they are distinct entities, or can be contrasted (thought about!), at a theoretical level. In the next chapter, I specify my views on the relationship between language and thought and will, therefore, leave the definition until then. Suffice it to say here, that I use thought as a general and non-specific term to cover any psychological process which cannot be directly observed.

The terms cognition and cognitive processes, are used in a more specific way. These refer to subsets of thought, such as visuo-spatial processing, for which definitions, either theoretical or operational, are advanced and which imply a definite structure and/or function. For example, I would use the term cognition to refer to Piaget's schema.

CHAPTER 2: Area of Interest; Language, Thought and Psychology. Some Reflections on Constructivism and Innatism. The History of Deafness.

Introduction

In the preceding chapter I stated that I would endeavour to make my bias as clear as possible. Jahoda (1980) cautions psychologists against confusing the ontological with the conceptual. By this she meant that underlying any scientific enterprise, there is a set of beliefs, about how the world is, which are not necessarily articulated or specified in the conceptual framework of the enterprise. Whilst this is true for all science, Jahoda believes that the nature of the subject matter of psychology and the potential consequences of its findings, place a special responsibility on psychologists to be clear about their (philosophical and untested) beliefs. The first part of this chapter is a statement of those beliefs I hold, which are of direct relevance to the thesis. The second part gives a brief history of issues surrounding deafness and gives the context in which previous research was carried out.

Language, Thought and Humanity

The relationship between language and thought has been the subject of philosophical controversy for centuries. People have two attributes which are generally considered to set them apart from the rest of the animal kingdom; language and the possession of a self concept. In classical times, language was considered to be an innate (e.g. Herodotus) and necessary condition, for a person to be considered human. It was believed that without language the kind of thought which enables unique aspects of human intelligence, such as reasoning and foresight, are impossible. People who could not speak, such as the deaf, could not think and were, therefore, considered sub-human. This view was incorporated into Roman law and in turn passed into European law, so that as late as the 17th century the ability to speak was a legal necessity for inheritance etc. Indeed, it is this aspect of law which provided the impetus for the development of methods of teaching the deaf to speak.

The Relationship between Language and Thought

Until the advent of psychology, formal specification of the relationship between language and thought had been an esoteric undertaking and the province of philosophers. Language and thought, along with behaviour are the raw data of psychology and therefore, the construction of predictive theories required empirical, as well as logical substantiation, of any alleged relationship. In this context, the relationship between language and thought, takes on a new significance.

Another persons thoughts are never directly accessible. We can only 'see' into the mind of another, by observing their behaviour or their language and understanding the relationships between thought and language and behaviour. To achieve this understanding is the task which confronts all of us, in our everyday lives, from the time we are born. It is, of course, also the task of psychology. Psychology deals with the problem in two ways. The first, is to treat language and thought as distinct entities, defined in structural terms, and test explicit hypothetical relationships empirically. The arguments concerning the cognitive dominant hypothesis (e.g. Piaget, 1980), the linguistic relativity hypothesis (Whorf, 1956) and its variants (Miller & McNeill, 1969) and the behaviourist view of direct correspondence between language and thought (e.g. Watson, 1920) are well rehearsed, and will not be reiterated here. Dealt with in this way, the question is a direct descendant of philosophical considerations and remains esoteric, although not totally bereft of practical significance.

The second, and more general, way is to tacitly assume a functional relationship. This relationship is purely operational and implicit in the conceptual framework which generates the theoretical constructs and empirical practices. In other words, this takes the common sense view that in practice language and thought cannot be separated; that humans are thinking-speaking beings who have to be dealt with as a whole, rather than a thinking being and a speaking being who can be dealt with as a dichotomy. In many practical situations, such as in school, in the clinical psychologists consulting room, or in many psychological experiments, this is the reality. In such a situation whether cognition is dominant or relative to language, is largely irrelevant, as thought can only be inferred from language or other overt behaviour. Put another way Personal Constructs (Kelly, 1955) or Attribution Theory do not assume either language or thought to be dominant for their existence. They assume a cognitive structure, which can be observed through some form of language[1]. It is here where language is used to access raw data; where language is used as a metric, or in its mathetic function (Halliday, 1973). The minimum relationship required is that language can represent thought, and theoretical arguments are about what is represented and how.

From these considerations I would argue that the relationship between language and thought is fundamental to psychology. It is not merely an academic debate about which dominates which; without both, the debate would not possible. The relationship between language and thought is a structure-function dynamic which is at the very core of the practice of psychology. Language is the means by which we share our human experience, whether we are experimenter or subject, teacher or pupil. It is here were my interest lies. I believe that debates about dominance are as futile, in practical terms, as debates about the chicken and the egg. Like the ancients, I believe that language and humanity are inseparable, but unlike them, I do not believe, that spoken language is the only manifestation of whatever it is which underlies language. The questions which

1. Personal Constructs are usually elicited by means of a repetory grid. Kelly (1955) argued that this was a form of conversation albeit a formal one. Personal Constructs can be elicited by purely linguistic means; either in in conversation or by the technique of laddering.

concern me are how does a person come to know and represent their world and what does their language and behaviour tell me about their experience of the world. Underlying these questions are some philosophical beliefs about innatism and constructivism. Before I discuss these I will first outline my position with regard to the theoretical relationship between language and thought.

Language and Thought as a Dialectic

The title to this section signals that my views on the relationship of language and thought owe more to Vygotsky (1962) than Piaget (e.g. 1980). They also take into consideration, Fodor's (1972; 1978) arguments concerning the logical constraints on what can be acquired during development. I do not propose to give a full justification for these views as such an undertaking would require a thesis in itself. Those justifications that are given are those which have a material bearing on the work to be reported here.

We have only one way of making contact with and knowing the world; through our senses. Fodor (1978) has argued that language should be accorded the same status as the other senses. His argument is that a sense allows the brain access to information from the environment, and that each sense deals with information which is unique to it; for example, visual information is different from auditory information. Language conveys information which is culturally abstracted and independent of space and time and which cannot be gained directly by any other sense. By this token language can be thought of as a sense which is parasitic on another sense.

From the point of view of an observer, language and thought are both manifestations of information processing, as data (input) and as product (output). Language and thought may represent one another, but the relationship is not necessarily reciprocal and neither is capable of a full description of the other. Language is capable of direct communication, but thought can only communicate indirectly. Thought is capable of direct representation, but language is only capable of representation indirectly, via thought. Thought can be shared with others, indirectly by language; language is shared. Both language and thought allow functional adaptation to the environment.

Whatever the relationship between language and thought, at the level of brain processes information can only take the form of neural impulses. The sense organs are transducers, changing mechanical energy to electro-chemical energy. Theories such as that of Neisser (1976) postulate that information is processed into schemata, which are multi-modal in origin. These two taken together suggest that there is some underlying code which is common to all sense data irrespective of its origin.

This is the essence of Fodor's (1972) argument. Using a computational metaphor, he argues that there is a language of thought, a central computing language, into which all information is coded;

> "In such a language are performed the calculations involved in evaluating the auditory implications of visual inputs, the gustatory implications of olfaction, etc." (p85).

Given that language can be considered as a sense input (see above), then;

> "the problem of thought and language is primarily the problem of characterising these information exchanges between natural languages and the central computing language." (p85).

With this part of Fodor's argument I agree, and it is this kind of relationship with which the empirical work is concerned.

Constructivism, Innatism and Language

Piaget and Chomsky were the main protagonists in a debate concerning the extent to which cognition, including language is innate or constructed from experience (Piatelli-Palmarini, 1980).

The record of the debate is long and complex, involving contributions from, amongst many others, Fodor. His contributions to the debate, were concerned with the logical necessity of accepting an innatist position, such as Chomsky's if the arguments concerning the relationship between language and thought, sketched out above, are accepted. He argues that contructivist theories of cognitive development, such as Piaget's and Vygotsky's characterise development as the acquisition, by hypothesis testing, of a series of logics, each more powerful than and containing the preceding one, where contains is an asymmetric relation. The transition from the weaker logic to the more powerful, has to made with only the computational power of the weaker logic, which is weaker just because it cannot formulate the kind of hypotheses needed. Hence cognitive development is the extension of computational powers to wider areas. For example, the young child's problem solving skills are not informed by the same kind of computational power as underlies syntax, but as the child matures, such power becomes available for problem solving.

Putman (1980) points out that a logical consequence of Fodors model is that all concepts must be innate, in principle at least. Piaget disputes Fodors position, just because he believes that the human mind can and does acquire new structures or concepts, and that this can be observed, for example, in the phylogenesis of mathematics, which ontogeny mirrors. I disagree with Fodor's views on the impossibility of acquiring more powerful structures and with Piaget to the extent that I do not believe philosophy's conception of logic is necessarily a correct model of the mind. There are other models which would allow for both a progression of more powerful stages and their genesis. Petitot (1980) and Thom (1980) both discuss a Catastrophe model of the genesis of representational space, as a re-interpretation of the localist hypothesis. Pask (1980) has noted that models of non-reversable, non-linear self organising structures, such as Prigogine's (e.g. Prigogine & Stengers,1984) dissipative structures, can be seen as descriptive of many problems in language and cognition.

The main outcome of the debate, was that extreme conceptions of either innatism or constructivism are individually unable to give complete accounts of development and cognition and that some intermediary position is probably the source of a more accurate account. Within this framework, innatism and constructivism are opposite sides of the same coin. This is not altogether surprising as some form of interactionism is appealed to in most areas of psychology. I do not view interactionism as being some kind of 'soft option', which excuses one from rigour in either thought or practice. Rather, I see it as being the consequence of theory having to recognise practical reality; we have a genetic complement and we do interact with an environment. Biology has long had to recognise that genotype and phenotype may not have a one to one correspondence, just because genetic information can only be expressed as the result of environmental conditions. This is of course the basis of adaptation. By the same token, I believe that language and thought are the expressions of genetic predispositions, consequent on the environment in which that expression is made. This is part of what I mean when I use the term <u>functional adaptation</u>, in so far as the analogy holds. Language and thought become a part of the environment, for example, as culture, and thereby become available as resources with which to adapt. Therefore, functional adaptation describes the dialectic in which language and thought are both the enabling device of adaptation and the product.

Language, Thought and Deafness

The history of the deaf, mirrors the debate concerning the relationship between language and thought and the nature of language. Thinking about deafness, language (both sign and oral) and thought throws the issues just discussed into sharp relief, and also raises questions of a more fundamental nature. Some of these other issues will be discussed in Chapter 4, after a brief history of the deaf, and a review of the literature.

Scientific research is not conducted in a vacuum, it is set in the context of the prevailing social and cultural climate. Whilst this is true for all science, it is perhaps, especially so for psychology, due to the social and cultural nature of its subject matter. The study of deafness is no exception. We have already seen how definitions of deafness are intimately connected in non trivial ways with language, i.e. spoken language. A deaf actress recently won an Oscar for her part in "Children of a Lesser God". She used spoken language only once in the film and that was unintelligible. For the rest of the time she used American Sign Language (ASL). It has been known for at least 400 years that the deaf communicate amongst themselves in a visual gestural language - Sign language. However, this knowledge has been the basis for one of the longest running and most bitter disputes in special education; the oral - manual controversy.

The Oral-Manual Debate

The oral-manual debate concerns the correct medium for communication with and instruction of deaf children, i.e. oral or manual language. The debate is premised on assumptions about the quality of language possible in the two media and its suitability as a vehicle of thought, both intra- and inter-personally. I want to outline the historical origins of this debate because its impact has, I believe, influenced the kind of studies which have been conducted with the deaf and the assumptions underlying them. These in turn have implications for the interpretations placed on the resultant data.

Historical Context

Under Roman law the deaf were excused the rights and duties of a citizen. A person who could not speak lacked the defining human characteristic, i.e. language, and was, therefore, sub-human with respect to intelligence, having a soul etc.

Being excused the rights and duties of a citizen meant, amongst other things, lack of the right to inherit property and wealth. The legal status of the deaf persisted into 16th century Europe. Lack of succession rights had important political and economic consequences, such that a high ranking Spanish nobleman, offered a large sum of money to anyone who could teach his deaf heir to speak. This was accomplished and is the first reported suggestion that the deaf were educable and marks the beginning of the oral tradition. Oral teaching of the deaf began to be practiced throughout Europe.

Up until the mid eighteenth century, the emphasis in deaf education was on speech and manual alphabets were seen as aid to teaching oral language. The beginning of the manual method, the use of Sign language, is marked by the work of a French priest, De l'Eppe and his student Sicard. De l'Eppe believed that the "language of signs' was the natural language of the deaf, but even so did not consider Sign language as adequate as French for expressing abstract thoughts. However, his contribution that Sign language was both useful and natural for the deaf and could be used as a medium of instruction was an important one.

We now move to the 19th century. The fact that the deaf were educable was by now firmly established, as were schools for the deaf in Europe, England and America. Both manual and oral methods were in use, however, which method was best and should be universally adopted was fiercely debated. The argument was not so much about which method produced the best results in terms of achievements by the deaf but was, and still is to some extent, fundamentally premised on the nature and role of language. There are several strands to the argument; 1) the deaf have to function in a hearing world, where commerce is in oral language. 2) If the deaf are allowed to sign the motivation and/or ability to learn oral language will be reduced. 3) Sign language is not a real language, but rather a loose coll ection of iconic and mimetic gestures and pantomime.

4) Sign language does not have a syntax (grammar) and is not capable of expressing the same subtlety of thought as oral language.

The conference of Milan in 1880 was convened to settle the question and passed the following resolution;

> Considering the incontestable superiority of speech over signs in restoring the deaf-mute to society, and in giving him a more perfect knowledge of language ..... The oral method ought to be preferred to that of signs for the education of the deaf and dumb" (cited in Savage et al, 1981).

As a result of this conference the vast majority of children in this country were, and still are to a large extent, educated by exclusively oral methods. The emphasis on oralism was such that any use of the hands for communication, including natural gestures such as any hearing person might make, were prohibited and their use punished. Despite the conference manual methods continued to be used in some quarters as the main method, and in oral regimes when it became obvious that oral methods were failing individual children (around the age of 11 or 12 years). The debate continues to the present day.

This then is the context within which the earlier research was set. It is clear that much of the thinking revolved around beliefs relating to language; language is necessary for intelligence, language is necessary for thought, language is oral language, Sign is not a language. These beliefs are reflected in the issues addressed by the research which will be examined in the next chapter.

CHAPTER 3: A Conceptual and Methodological Review of the Literature.

Introduction

Deafness has an impact, or a potential impact, on just about every aspect of a persons psychology. This is reflected in the wide ranging nature of the extant literature. This review will be confined to the literature which comments on the relationship between language and thought from a cognitive perspective, and which has a potential to elucidate why the deaf child fails to achieve his/her academic potential as predicted by I.Q. tests. Hence, the work relating to psycho-social adjustment and that dealing with educational problems, including the teaching of oral language skills, such as reading and writing, will only be mentioned where it has a direct relevance.

A Review of Reviews

A second point is that the review takes as its focus the conceptual and methodological issues raised by the previous work, rather than a detailed description of individual studies. Such reviews are given by Myklebust (1966), Furth (1964 & 1971), Ottem (1980), Rosenstein (1961), Vernon (1967) and Meadow (1980). With the exception of Ottem, these reviews are concerned with establishing the necessity and influence, or otherwise, of language for and on the development of cognition. Emerging from all these reviews is that the data is equivocal, if not contradictory. The taxonomies used by different reviewers for grouping studies are not always consistent. Rosenstein (1961) comments;

> "Investigators have used labels for perceptual and conceptual functions that do not necessarily mean the same things. For example, the same label abstract ability has been used to refer to a visual memory task, a test of nonverbal reasoning by analogy, and an arithmetic reasoning task. In other contexts, the same tasks have been assigned different labels.." (p276).

The purpose of these taxonomies, is to elucidate underlying regularities in the cognitive data, which can be related to language and or deafness. However, such attempts are often frustrated by the fact that different results can be recorded for the same task by different workers. For example, Furth & Youniss (1965) and Kates (1969), both report equivalent performances in the use of logical symbols by the deaf and hearing, but in a discovery task, involving logical symbols, Kates reports equivalent performance by the deaf and hearing, Furth and Youniss an inferior performance by the deaf.

Ottem's (1980) review was also concerned with discovering a classification system which could consistently separate the deaf and hearing with respect to performance. His system was based on the number of minimum data, which an observer outside the experimental situation would need to know, to decide if an experimental subject had understood the solution to a problem. His analysis of the above example, was that in the case of the Furth & Youniss discovery task two minimum data were required, whereas only one was required in the case of the Kates task.

This review of reviews and a first reading of the literature, suggested that nothing new would be added to the debate by merely reiterating the range of studies conducted during the past 90 years and creating yet another taxonomy. Ottem's analysis, indicates that the pattern of results may be as much a function of methodology, as deafness. It was also noticeable that Myklebust (1966) and Furth (1964) come to different conclusions using very much the same data. In other words, disagreements about the psychological consequences of deafness are disagreements about interpretation of the data overall, rather than the interpretation of specific aspects of the data. In all the reviews, except that of Ottem (1980), it is the extent to which data is able to comment on the relationship between language and thought which has been examined rather than the ability of the conceptual frameworks and methodologies to produce data which is a comment on the psychological consequences of deafness.

Summary of Findings

Despite nearly a hundred years of research the educational prospects of the deaf are depressingly low. It has provided little in the way of data which is useful for formulating effective curricula for the deaf. A review of the research shows that the potential of the deaf child, in terms of I.Q. scores, is within the normal range. This would predict that the deaf child should have no problems in school, yet academic achievement scores do not reflect this. This then raises the question of what factor or factors are instrumental in preventing the deaf from achieving their potential. Does deafness affect the way intelligence is structured or used? The most obvious concomitant of deafness is failure to develop oral language. The question then asked is can this lack of oral language account for the discrepancy between potential and performance? This is a reformulation of the classical language and thought debate, i.e. is language crucially related to thought or independent of it. With respect to the deaf the question can be asked in two ways, by examining cognitive development and structure, or by examining language development and structure.

In terms of cognitive development and structure, the most widely held view, that of Furth, is that the deaf do not differ significantly from their hearing peers, and any differences are developmental delays due to restricted experience, rather than lack of language. Language has no direct effect on cognition, but rather lack of language leads to an experiential deficit, which may delay development, but these delays are not permanent or real differences in cognition.

In terms of language development the deaf are found to develop oral language slowly, if at all, whether the medium is speech, reading or writing. Furthermore, that oral language which is acquired is characterised as deviant even in the earliest stages (e.g. Gregory & Mogford, 1981). Also the deaf make characteristic mistakes, which are never made by hearing language learners, be they first or second language learners (e.g. Ivimey, 1976).

If, as Piaget argues, it is cognition which underpins language, and language is deviant, then the underlying cognition must be deviant. However, according to Furth, cognition is not deviant. If these arguments are accepted then we are left with an apparent paradox, and it follows that research carried out within the existing conceptual frameworks can never provide an internally consistent psychology of deafness which would provide answers to the problems of deaf school children and their teachers.

If this is the case, then how is it that this state of affairs was arrived at and what needs to be done, such that research can provide the empirical base on which to devise effective curricula for the deaf? In order to answer these questions I will examine the assumptions, both implicit and explicit, which underlie previous work with the deaf.

Deafness, Intelligence and Scholastic Achievement

Once it became clear that the deaf could be educated, whether by oral or manual methods (see Chapter 2), it followed that they possessed human intelligence. The beginning of the century saw the beginning of intelligence testing, with the aim of predicting the academic potential of children. Pintner is credited with being the first worker to examine the intellectual potential of the deaf using intelligence tests. The studies reviewed in this section take no account of the possible influence of Sign language.

The most extensive study from this period is that of Pintner and Reamer (1920). Based on data from 2,172 children from 26 schools for the deaf in the United States, they concluded that the deaf had, on average, a mental age which was two years below chronological and an educational retardation of five years. They attributed the educational under achievement to a combination of the 2 years mental retardation, and the remaining three years to the language handicap consequent on prelingual deafness. Implicit in Pintner's conclusion is the idea that deafness could have effects over and above the concomitant language handicap.

If deafness has an effect on intelligence independent of any effects which may be due to language handicap, then it is necessary to develop methods of testing intelligence which do not have recourse to language. It was partly in response to the necessity of developing appropriate tests for deaf children that non-verbal performance scales were devised. These included Pintner and Paterson (1923), Drever and Collins (1936) and Arthur (1947). A number of studies were carried out using these and similar tests, through the 20's and 30's. A review by Myklebust (1964) concludes that on the basis of these early studies the deaf were of below average intelligence. This deficit was alleged to be due to a reciprocal effect of deafness itself, exacerbated by language limitations.

The data on which the above conclusion was based was collected from studies using group administered tests. From the mid 1940's individual testing, using for example the W.I.S.C., became more widespread, and it is this type of testing which remains the norm. Reviews by Vernon (1967), Myklebust (1964) and Meadow (1980) all come to the same general conclusion; that the deaf fall within the normal range of I.Q. scores, although with a slightly lower mean than hearing groups, when nonverbal tests or performance scales are used. Scores become depressed when verbal items are included. The major problem to be overcome in administering test scales, is that of communication. This is currently the accepted position and appears to be one of the few uncontentious conclusions in the area of deafness.

One obvious feature of the research reviewed above is the change in the reported level of deaf children's intelligence over time. One possible reason for this has already been mentioned, i.e. the change from group administered to individual testing. A second point to note is the increased use of performance or non-verbal scales. A third possible reason is changes in the deaf population, especially with respect to etiology of deafness. Liben (1978) has noted how advances in medicine and public hygiene has altered the distribution of causes of deafness, with a decrease in etiologies which have an associated risk of C.N.S. damage over and above deafness and a consequent decrease in mental retardation.

The aim of intelligence testing is to predict academic achievement. If deaf children fall within the normal range of intelligence then their academic potential does not differ markedly from that of the hearing. However, this is not reflected in their academic achievements. For example in a longitudinal study reported by Fielder (1969) involving 20 deaf students, although their I.Q. scores on the WISC performance scale were in the range 90 - 142 only 3 were not considered educationally retarded at age 16. Their mean grade level was 4.9 being 5 to 5.5 years behind.

Given the importance of reading in education, there has been much assessment in this area. A second point about reading assessment is that it often used to assess the language level (oral) of the child. Conrad (1979) conducted a survey of all the deaf students aged 15 to 16.5 years, in special education in England and Wales. He found 40% to be totally illiterate for prose comprehension. 50% with hearing loss in excess of 85 dB had no reading comprehension at all, as did 25% of those with less severe hearing loss. On average reading age is 8/9 years, and shows little improvement in adulthood; reading achievement plateaus at the level where reading for meaning becomes important (Brooks, 1978).

There is some evidence to suggest that the reading scores just cited may in fact be overestimating the reading capability of many deaf children. Wood et al, (1986) present evidence which indicates that deaf children's test taking strategies differ from those of hearing children. Error analysis indicates that the deaf child understands less of the text than the scores indicate. These strategies appear to be specific to language tests as the same strategies are not found in tests of mathematical ability. Whilst mathematical abilities are also delayed, it is not to such a great extent as reading (Wood et al, 1983).

Unlike the results from I.Q. studies, there has been no increase in the reported level of the deaf child's academic achievements over time. The I.Q. data on which claims of normal potential are made is almost invariabley performance or non-verbal data. It is well established that verbal tests of intelligence are the most highly correlated with academic achievement, and hence, predictive of it. Hence, it could be that the academic potential of deaf children is overestimated, and their academic achievement scores merely reflect this.

However, it will be recalled that non-verbal testing was introduced just because the deaf had limited oral language skills, to allow an assessment of potential which was not confounded by lack of competence in oral language. Many tests of academic achievement do require competence in oral language. Hence, the criteria for assessing potential and performance are based upon different skills, which makes interpretation of any discrepancy problematic. In the area of mathematics, which is not so dependant on linguistic skills (Suppes, 1974) we find the discrepancy between potential and performance is much less. Furthermore, non-verbal or performance tests are the best methods available for assessing potential in deaf children, and although verbal tests have higher correlations with academic performance than non-verbal tests, it still remains that these tests are predictive. On the basis of this it would be predicted that deaf children's academic performance would be higher than that which is reported.

Cognitive Development

Given the discrepancy between potential and performance, it seems natural to ask what underpins this discrepancy. There are two obvious candidates; 1) Linguistic influences, e.g. communication problems, difficulties in learning language per se., the influence of language on cognition. 2) Cognitive processes, i.e. deafness has an effect on cognitive processes and/or their development. These are the two factors which Pintner cited as being causal in the underachievement of the deaf.

Four general characteristics of deaf thinking are often referred to in the literature (e.g. Wood et al, 1986). In comparison with the hearing the deaf are said to be;
1) more rigid or less flexible in their thinking. This summarises studies which have looked at concept transfer or reversal shifts (e.g. Oleron, 1951; Furth, 1963; Furth & Youniss, 1964; Andre, 1969) or colour form preferences (e.g. Doehring, 1960; Suchmann,1966). In the case of reversal shifts or concept transfer, the general finding is that the deaf are less likely to transfer or shift spontaneously than the hearing, although the deaf will accomplish the task after suggestion. These studies also indicate that on problems which are more likely to be mediated linguistically, the deaf do less well than the hearing.

2) The deaf are more concrete or less abstract. This is a generalisation from studies which examine concept attainment, including Piaget type tasks, and sorting behaviour (e.g. Templin, 1950; Oleron, 1962; Furth, 1964; Furth & Milgram, 1965; Watts, 1979). These studies show that concepts are attained and classification is successful when these rely on concrete, i.e. perceptually given attributes of the stimulus material. Attainment of concepts and sorting is less successful when these depend on more superordinate, or less perceptually obvious, aspects of the stimulus, such as a knowledge of classes or the discovery of a principle. Again, these are

instances where linguistic knowledge or mediation, may be helpful. For Piaget type tasks, concepts such as conservation are acquired by deaf children, but with a developmental delay, on average, of five years.

3) The deaf are more egocentric or less aware of the perspective of others, and 4) more impulsive or less likely to take thought or consider alternative courses of action. These generalisations are derived from a range of studies, involving psycho-social development (e.g. Lewis, 1968 on personality) as well as observations of behaviour during some specifically cognitive task (e.g. Chulliat & Oleron, 1955). In other words, these are claimed to be general behavioural characteristics, often advanced as explanations of deaf children's inferior performance. There are some studies which examine these constructs directly; for example, egocentricity in communication Hoemann (1972) and impulsivity Harris (1978).

It will be noted that, of the specifically cognitive studies, the latest date mentioned is that of Watt's (1978). A DIALOGUE database search of psychological abstracts, indicates that emphasis has now shifted away from basic cognitive issues, to concerns with test administration, educational issues, and sign language studies (see below).

These characteristics are fairly robust observations, and indeed, were observed in the studies I will report, for example, behaviour which could be described as impulsive (4 above) is reported in Chapter 5. The arguments which surrounds these findings is whether they are indicative of deafness affecting the development and structure of cognition (e.g. Myklebust, 1966) or whether they merely reflect the consequences of limited language, and are examples of delayed but otherwise normal (in hearing terms) development (e.g. Furth, 1966; 1973).

At a functional level, it seems impossible to separate language and cognition in any meaningful way, yet just such a separation is necessary if we wish to examine the relationship between language and thought or the consequences of deafness for both or either of these is to be elucidated. This is reflected in the literature on cognitive development in the deaf by the nature of the assumptions, especially with respect to language, which inform the collection of data and its interpretation.

Within this area two distinct traditions can be discerned, typified by Myklbust and Furth. Both of these were investigators as well as major reviewers and they, more than anyone else, have given accounts of the psychology of deafness, which have attempted to integrate the empirical findings into a coherent conceptual framework. Myklebust (1964), saw the need to create a 'special' psychology of deafness (Wood et al, 1986). Furth (1966) argued;

> "...there is, strictly speaking, no such thing as a "psychology of the deaf" and we wished to avoid any such implication in our research" (p71)

and that the data from deaf populations could be explained within Piagetian theory. The positions of Furth and Myklebust are often portrayed in the literature as representing opposing views with respect to deafness and its psychological consequences. A close examination reveals similarities as well as differences. The ensuing discussion will take the form of a comparison of these two workers, as this best highlights the a priori assumptions, both implicit and explicit, which are brought to the study of deafness.

The Deaf Are Just Like The Hearing Except They Cannot Hear?
Myklebust (1964) works within the tradition implied by Pintner and argues that when studying the effects of deafness one should take care to distinguish between the effects due to deafness per se and those due to lack of language. His theoretical position is reminiscent of say Neisser (1976), in that he views experience as being intersensory, through the processes of synesthesia. In other words, our knowledge of the world is a product of information gained from all the senses,

which is integrated by our psychological processes. His central tenet is that the deaf person, by virtue of his loss of hearing has a different sensory experience and hence comes to organise his psychological processes in a different way to those with intact senses, in order to maintain the necessary contact with the environment. He argues that;

> "The point of view that a person with deafness is just like everyone else, except that he has impaired hearing, is unsatisfactory as a frame of reference from which to progress in the study of the psychology of deafness." (p54).

However, he did not wish to imply that the total experience of the deaf was different from that of the hearing, but rather that deafness would exert an influence in those areas of psychological functioning, where deafness most compromised functional adaptation. He expressed this by saying that the task of a psychology of deafness "is to ascertain the ways in which such sensory deprivation alters modes of growth and manners of adjustment." (p45). Implicit in this line of reasoning are the predictions that the deaf and hearing will show equivalent performance in some areas of functioning and differential performances in others. It is worth noting that differential performance can include superior as well as inferior performances by the deaf when compared to hearing norms. I make the point because in many instances differential performance is taken as synonymous with inferior (e.g. Furth, 1964).

In order to understand the effects of deafness, on cognitive processes, Myklebust argued that quantitative comparisons of deaf and hearing alone are insufficient. Whilst a deaf person may achieve an identical score to a hearing person, that score may reflect differential cognitive strategies, either in part or whole, due to the task being perceived differently or the knowledge/skills required for successful completion being structured differently. Hence, he argues, there is a need for qualitative data. His (implicit) definition of qualitative data, appears to be a consideration of test battery profiles. For example, Myklebust (1964) presents data concerning memory abilities in the deaf (see Chapter 11) which shows that in some areas of memory functioning, (e.g. memory for design) the deaf achieve higher scores than the hearing, whilst in other areas (e.g. digit span) the deaf achieve lower scores than the hearing. Therefore, one cannot make general statements about the effects of deafness on memory, only statements about effects on specific areas of functioning.

Furth (1964; 1966; 1971; 1973) starts from quite a different perspective. Furth's position requires the assumption that deafness itself has no impact on cognition. Indeed, he says "the discovery that the deaf were educable - that they were in fact normal apart from their deafness..." (1966, p8). This is also implicit in his experimental design, where the dependant variable is cognition and the independent variable is linguistic status and not hearing status. On first reading this last statement may seem at least contentious, if not wrong. Furth's research was carried out within a Piagetian framework. This theory predicts that lack of language will not affect cognitive development. To test this prediction an alinguistic population is required, and also one which differs only in this respect, if the requirements of experimental methodology are to be satisfied.

Most of Furth's work with the deaf, in contrast to Myklebust, is comparative and quantitative, i.e. a group of hearing children and a group of deaf children are asked to complete the same task and their scores are compared. If the scores are the same then it is argued that no differences in cognition exists between the groups. Such direct quantitative comparisons are only possible if it is assumed that the groups differ only in terms of the independent variable, such that any differences in the dependant variable can be ascribed to the independent variable and no other uncontrolled for variable. For Furth to be able to make his claims it is necessary for him to assume that deafness per se is not a significant variable otherwise it would be necessary for him to first quantify and then partial out statistically the effects of deafness. As he does not do this we must conclude that, unlike Myklebust, Furth assumes that a deaf person is just like a hearing except he cannot hear.

In any experiment, designed to generate quantitive data, it is possible for two results, acceptance or rejection of the null hypothesis. Where the hypothesis being tested is that lack of language has no effect on cognitive development, accepting the null hypothesis, would give support for Piagetian theory, whereas rejecting it would not. Considering first accepting the null hypothesis, two interpretations are in fact possible. The first is that there is indeed no difference between the groups. The second is that the groups may differ qualitatively but not quantitatively. Considering rejecting the null hypothesis we have to conclude that there is a quantitative difference between the groups, but this does not preclude the possibility of qualitative similarity. Quantative data alone cannot decide between these alternatives. This is, in fact, a reformulation of Myklebusts position, which is not inconsistent with a Piagetian perspective. With respect to cognitive behaviour Piaget said;

> "our real problem is to discover the actual operational mechanisms which govern such behaviour and not simply to measure it" (1954).

In this respect Myklebusts approach seems more in the spirit of Piaget that of Furth, who expressly set out to examine the impact of deafness with respect to Piagetian theory.

The vast majority of studies involving the deaf, including those reported in later chapters, are comparative. Any cognitive developmental theory is initially constructed on observations of a (hearing) population. Before say, Piaget, his 'norms' for children were not possible. Piaget's method was to observe children and mark regularities in their behaviour, i.e. the theory was constructed on the basis of within group regularities. After empirical substantiation these regularities accrued the status of norms. To then measure deaf children against these norms, implies that they have a psychological (cognitive) structure to which these norms apply. Or to put it another way, observations of deaf children's behaviour, and elucidation of their within group regularities could lead to the construction of an identical theory to Piaget's. In this way theory testing becomes an attempt to reconstruct the theory in another group. This holds true for any theory which the deaf might be used to test.

That hearing norms do apply to deaf children is again implicit in Furth's paradigm. By contrast the converse is implied by Myklebust's position. Reviews by Furth (1964; 1971) and Ottem (1980) cover 97 studies involving 124 non verbal tasks. Compared to the hearing the deaf showed inferior performance on 53 tasks, but on 71 tasks they were not inferior. Included in the not inferior performances are some superior performances by the deaf. The logic of hypothesis testing dictates that the null hypothesis is never directly tested or confirmed, a point which Furth (1966, p144) admits. Considering the performance of the deaf against hearing norms, with a Piagetian hypothesis is, in effect, a test of a unidirectional hypothesis; that lack of language will result in inferior performances by the deaf. A finding of superior performance is contra-hypthesi but cannot be recognised as anything but grounds for rejecting the experimental hypothesis and accepting the null hypothesis. The point is a theoretical one, but the implications are of practical significance. Devising effective curricula and educational strategies for deaf children surely depends on a complete knowledge of what deaf children can and cannot do. This would require a knowledge of superior as well as inferior abilities.

Linguistic Status

The above discussion was concerned with the consequences attendant on the assumptions made concerning the status of deafness per se as a relevant variable in the development and structure of cognition. We have already seen how definitions of deafness are intimately connected in non trivial ways with language, i.e. oral language. The discussion which surrounds language and deafness is perhaps some of the most confused in psychology. This arises from a combination of the wide ranging and complex nature of the subject, lack of precise and consistent definitions of terms used to speak about language, sign language and deafness and the assumptions held concerning the nature and functions of language, and the capacity of sign language to fulfil these functions.

Myklebust's (1964) description of the relationship between language and thought embraces ideas from both Piaget (cognitive dominance) and Vygotsky (language as a tool). He describes that relationship, and the impact of deafness thus;

> ".... experience constitutes the basis of all behaviour, including language behaviour. Language is the instrument, the tool, the means whereby experience is symbolised and communicated. If experience itself is altered, if it is constituted differently, then meaning is changed." (p224).

He sets the place and role of language within a hierarchy of experience which varies along the concrete abstract dimension from sensation to conceptualisation (see Fig. 3.1) which he argues can be shown empirically, to apply equally to the deaf and hearing.

	ABSTRACTION	
E	Conceptualization's	H
X		I
P	Symbolisation	E
E		R
R	Imagery	A
I		R
E	Perception	C
N		H
C	Sensation	Y
E		
	CONCRETENESS	

Fig 3.1 Heirarchy of Experience (After Myklebust, 1964)

Within this hierarchy changes at one level will affect the levels above it. Therefore, in the case of deafness, which affects the level of sensation all levels above, from perception to conceptualisation will be affected. He suggests that the deaf person;

> "is highly dependant on imagery, especially visual imagery, which may be a predominant factor in the restriction imposed on his psychological development as well as the concreteness which results." (p229).

Language operates at the level of symbolisation, which, to use Myklebusts terms, can be both verbal and non-verbal. Here language is equated with verbal symbolisation, which is, in turn, considered necessary for the attainment of certain types of abstract functioning. He does not argue that the deaf lack symbols and concepts, but rather that their nature is altered as a function of a differential experience.

Myklebust uses the term verbal, as do many writers, to describe oral language and the term non-verbal as a contrast for other types of symbolism such as art and music. The use of the term verbal becomes problematic when both oral and sign language are being considered, as often it is not clear whether verbal is being used as a description, i.e. as a synonym for oral language or as a theoretical construct which refers to the patterning of arbitrary symbols in any linguistic system. Used in the first sense, verbal never applies to sign language; used in the second sense verbal may or may not apply to sign language depending on whether or not oral and sign languages are considered functionally equivalent. Unless stated otherwise, my use of the term verbal is in the second sense.

In comparing sign and oral language in these terms Myklebust states "The question of which is most effective must be determined in terms of which *is superior as a language*." (p241, authors emphasis). Following Clodd's (1900) classification of the evolutionary stages of language behaviour, he describes sign language as an Ideographic language, i.e. "a picture which is representative and symbolic." (p241). Within this scheme ideographic languages are less well developed than verbal languages, in the sense that they are less symbolic, and lack the precision, subtlety and flexibility of verbal language. With reference to his model of experience he viewed sign language as operating mainly at the level of imagery and being tied to the concrete aspects of experience. Hence, for Myklebust sign language is clearly not a verbal language and "The manual sign system must be viewed as being inferior to the verbal as a language." (p242). Given his statement that ".... only through a verbal language can we expect the human being to attain his highest potential." (p243) it follows that ,failure to acquire verbal language imposes a limit on development, which cannot be remediated by sign language.

To summarise, Myklebust views language as being rooted in experience, and at the level of symbolism having a reciprocal effect, in that verbal symbolism allows development of and access to more abstract levels of functioning. Deafness, which occurs at the experiential level of sensation, affects all other levels of experience, including symbolism and conceptualisation. Dependence on imagery, especially visual imagery and failure to acquire oral language result in a failure, by the deaf, to achieve their potential, by restricting the development of certain kinds of abstraction. The deaf are retarded in all aspects of language development, sign language being non-verbal and hence functionally different from oral language which is verbal.

Whilst Myklebust regards the deaf as linguistically deficient, Furth (1964; 1966; 1971; 1973) makes the much stronger claim that the deaf are functionally alinguistic. Furth (1973) states;

> "If we want to understand early profound deafness we must become familiar with this unfamiliar state of affairs: *a deaf child is a human child without a language*." (p13, authors emphasis).

Unlike Myklebust, Furth does not deny sign language linguistic status. For example he states, "The gestures that are used in the deaf community are without doubt a human language." (p14). Moores (1978) lists several more such quotes from various writings of Furth's, to highlight the apparent contradiction of his position - that the deaf are alinguistic, yet sign language is a real language.

Furth (1966) defines language thus "The term "language" is here taken in the narrow sense of the natural, verbal language of a society." (p18). However, when defining linguistic competence he is not so specific as to the form a language should take "Linguistic competence denotes mastery of the basic structure of a language" (Furth, 1966. p15, my emphasis). Given that Furth accedes that the deaf readily learn sign, then presumably they have linguistic competence in a language, but not in oral (verbal) language. However, no attempt is made to assess the linguistic status of the deaf in anything but oral language, but then his definition of language actually excludes sign language. Even so he still feels it necessary to exclude the possibility of sign language by arguing that a) 90% of deaf children are born to hearing families with no knowledge of sign, b) sign (at the time of his writing) is not formally taught in any school before the age of twelve, if at all and c) the majority of sign language acquisition takes place in interactions with other deaf people within the deaf community. Despite this he still maintains that,

> "For all practical purposes, however, the typical deaf person, whether adult or child, is a language deficient person both in his present functioning and his past experience." (Furth, 1966 p.15),

which is difficult to reconcile with his statement

> (Furth, 1973) "... perhaps after the age of twelve it is no longer true that the deaf person has no language, ..." (p15).

Furth's definition of language includes the term verbal which he applies only to oral language. Even a close reading does not make it clear in which sense he uses the term. Implicit in Furth's definitions, statements and experimental design is the assumption that only verbal, and hence oral, language has relevance when considering the thinking process and its relationship to language. Furth does not deny that the deaf have symbols, even while maintaining their alinguistic status. He states (Furth, 1966);

> "If society does not provide the child with conventional symbols, he can still develop intellectually, but the symbol system which embodies his thinking will be different from the verbal system, so much so that the two systems may be actively opposed." (p209).

In this respect he comes very close to Myklebust's position.

Experimenting with Deaf Subjects

When considering linguistic status a corollary is the difficulty the experimenter faces in communicating with deaf subjects. In many comparative studies there is obviously a vast difference in the ease with which the experimenter can communicate instructions to the hearing compared to the deaf group. The procedure sections usually state that instructions are given to the deaf child by use of oral language, mime, gesture, and demonstration. Again this places a burden on the interpretation of results. How can one be sure that the deaf are involved in the same experiment as the hearing? If the deaf children are at a disadvantage from failure to grasp the instructions fully, then this would tend to depress the scores of the deaf. The implications of this are that the data reflect an inability by the deaf to understand the experimenter's attempt to communicate rather than the ability or inability to do the task. Of course the observed results could be true, but their credibility is compromised. It is worth noting here, that Vernon (1967) makes the point that as experimenters become more experienced in working with the deaf, they are less likely to find differences in performance. Such a potential source of 'experimenter effect' (cf Silverman, 1977) should not be overlooked when interpreting data, yet it is seldom commented on in the literature.

Consequent on communication difficulty, and the subject's perceived linguistic status has been the almost universal adoption of 'non-verbal' testing methods. As with the term verbal, there is clearly a problem of definition. Conrad (1979), Myklebust (1964) and Furth (1966) all make a similar point. Furth's (1966) definition is typical;

> "By "nonverbal" I do not imply situations suspending all language behaviour in the subject. Obviously, this is impossible. In using this term, I mean tasks in which words are not used either as stimuli or as response, or as the criterion of success. Language in the sense of connected verbal language is not an essential part of the experimental situation. Linguistic competence is not assumed, and verbalisation of any kind is discouraged." (p73).

Given this state of affairs, Conrad's (1979) point is that insufficient attention is paid to precisely what language is necessary for, say, understanding the instructions, and what difference it might make if the task were solved linguistically, even though language is not logically necessary.

A further point relates to the kind of questions which will be asked of the data. Suppes (1974) argues that many reasoning tasks given to the deaf are extremely elementary. This is also the case with many other tasks. If we assume, for the sake of argument, that a particular test is nonverbal, e.g. it can be successfully completed by some infra-human species, and if data is to comment on the relationship between language and thought, as in Furth's work, in what sense can a non-verbal task tell us something about language and its relationship to thought? Secondly, if the task can be completed by an infra-human species, in what sense can the data comment on aspects of specifically human intelligence and its relationship to language?

To summarise, Myklebust and Furth are both essentially constructivist in orientation. Both see development as being a product of interaction with the environment. Both view language behaviour as being based in experience, but disagree on its importance as a factor in cognitive development. They disagree on the linguistic status of Sign language, but neither places any significance on Sign language in their experimental design or interpretation of data. They depart most radically in their a priori assumptions regarding the impact of deafness per se on cognition.

Both appeal to experiential factors to explain the data; Myklebust claiming that deaf experience is necessarily different, Furth that deaf experience is restricted. In principle it seems that the theoretical positions of Furth and Myklebust make quite clear contrary predictions, which could be tested empirically. However, the situation is confounded by the language variable. Furth is, by his own admission Piagetian, whereas Myklebust has more in common, especially with respect to linguistic influences, to Vygotsky. If the deaf are assumed to be alinguistic then Piaget would predict no differences in cognitive development for the deaf and hearing (though granted lack of communication may obscure the fact), whereas Vygotsky would predict differences, in the sense that the deaf child (of hearing parents) would not have the 'scaffolding' i.e. access to the consciousness of another, to allow him/her into the zone of proximal development. Hence, any data which potentially reflects on the correctness of the two theories can be explained by appeal to some linguistic aspect of the situation, varying from use of language for instruction to language as a form of experience.

When comparing Furth with Myklebust, the greatest difficulty one faces is the contrast in the internal consistency of their respective theoretical positions. The apparent contradiction, within Furth's account, concerning the linguistic status of the deaf has already been raised. A similar case can be made for Furth's views regarding the relationship between language and thought. Consider, for example;

> "Piaget is the only great psychologist who holds a theory of thinking that makes sense of the fact that deaf children can grow up into thinking human beings even though they do not know much language." (Furth, 1973, p106).

> "Language is a principal and a preferred medium of thinking for a developed mind,....." (Furth, 1973. p107)

> "....Piaget rejects the notion that mature logical thinking finds its explanation or base in the verbal symbol." (Furth, 1966. p194).

Taken in conjunction with his statements concerning private symbol systems in the deaf (e.g. see above), and his definition of language, it becomes increasingly difficult to find a consistent line in his theorising. As Furth (1966) himself notes, considering the problems of deafness causes one to consider and question some fundamental assumptions in psychology. Such questioning will raise contentious issues and highlight the inherent paradox such reasoning is bound to have (Godel, 1962; 1979).

Relative Status of Furth and Myklebust

In general Myklebust is seldom referred to in the literature. For example, Furth (1966) makes only one reference to a study by Myklebust and never discusses his theoretical position. There are two main reasons for this; 1) He is interpreted as implying that deafness imposes immutable limits to development, which in turn leads to models of deafness which describe deficiency and/or deviancy. 2) With respect to the oral manual debate, his position supports neither side;

> "in actuality, the child with deafness from infancy has a marked retardation in all aspects of language. Furthermore, no educational methodology known has been highly successful in overcoming this limitation." (p233).

To those advocating manual methods, his views on the relative merits of sign and oral languages are seen as supporting oralism. However, it should be noted that Myklebust specifically states and presents supporting empirical evidence that the use of Sign language does not impede or deter oral language acquisition, contrary to the strong oralist view.

Furth's is the most widely quoted, and generally accepted view of deaf cognitive functioning. His work was motivated by the discrepancy he perceived between deaf adults whom he knew as competent and contributing members of society and deaf children who were presented as academic failures. His work is seen as contributing to the decreasing trend to view the deaf as deviant or deficient (e.g. Moores, 1978). Vernon (1967) basing his conclusions on a review of I.Q. studies, comes to the same conclusions as Furth. He dismisses Myklebusts suggestion that the same results might be obtained by the deaf by different means as an improbable coincidence.

The major criticism which is levelled at Furth is that the data are insufficient to warrant the strong claims he makes. For example, his attribution of inferior performances by the deaf to developmental delays which will remediate through the experience gained by living is at odds with the finding that with respect to academic achievement the relative deficit increases with age rather decreases (Moores, 1970). Meadow (1980) points out that attributing developmental delay to an experiential deficit, consequent on lack of language, is still a delay due to lack of language.

Recent Developments

The emphasis of the work up to and including Furth was on cognitive structure and development and the relationship of language, or rather lack of it, to cognitive development. More recently the emphasis has shifted away from cognition per se. This shift in emphasis can be seen to derive from three basic sources. Firstly, the general conclusion of Furth and others, that the deaf and hearing do not differ significantly in cognitive structure and development, and that language, or lack of it, does not play a necessary role in development, necessitated that alternative factors be looked for which could reasonably account for the failure of the deaf to achieve their academic potential.

Both Furth and Myklebust, seriously questioned the efficacy of extant educational methodologies for teaching deaf children, especially with respect to oral language in all its forms. Both these writers argue that there is no logical reason why deaf children should not learn to read or write, even if speaking is not a realistic aim. This has led to a large body of work which deals with educational issues, especially with respect to forms of oral language. As this body of work is outside the scope of this project, it is not proposed to deal with it here, other than to say that with respect to oral language learning, the data is not very much different from that presented by Myklebust i.e. the deaf exhibit both delayed and deviant language learning (e.g. Vandenberg, 1971; Streng et al, 1978; Webster, 1986; Quigley & Paul, 1984; Savage et al, 1986 for reviews).

Secondly, the work of Stokoe (e.g. 1960) on American Sign Language (ASL) and others (e.g. Klima & Bellugi, 1979 on ASL; Woll et al (eds), 1981 on BSL; Kyle & Woll (eds), 1983 various Sign languages.) has demonstrated that sign languages in general have to be considered as true natural languages, in that they possess linguistic universals, e.g. duality of patterning, arbitariness and a grammar. In addition social and political changes have led to an increased acceptance of sign language and a demand by the deaf community that it should be recognised as their principal and preferred means of communication. This change in the social climate is reflected not only in the type of studies being carried out, but also in the assumptions underlying them. All this is not to say that the oral - manual controversy has been laid to rest, but rather that it has become increasingly difficult to deny the existence of sign language and maintain that the deaf are alinguistic. The result of this has been not only an increase in work on the linguistic aspects of sign language, but also its psychological properties, (e.g. Siple, 1978; Kyle, 1983).

This in turn raises questions about the appraisal of oral linguistic data in the light of knowledge about the grammatical structure of sign language. It was noted earlier that adherence to a cognitive dominant position, with respect to language and the deaf led to a paradox. Sign language may offer a solution to this paradox. For example, many grammatical deviations by the deaf, can be seen as transliterations of sign language grammatical structures.

Finally, much of the work in the Furth tradition was concerned with testing theories about language and thought. Within this tradition considerations of the (oral) linguistic consequences and influences on cognition were paramount, the influence of deafness per se being largely ignored or denied a priori. The third shift, evidenced in later work is characterised by the emphasis which is placed on direct observations of the deaf, and the use of qualitative data, as opposed to strictly quantitive comparisons with the hearing. This is very much in the spirit of Myklebust, i.e. the deaf are not necessarily just like everyone else except they cannot hear. Work in this genre includes Gregory (1976), Wood et al (1986) and Kyle (1983), and that which is to be reported here. I do not wish to imply here that any of these authors make claims, such as are credited to Myklebust, about deafness imposing limits to development, or that they agree with Myklebust's views on sign language. What this kind of work has in common with Myklebust is the idea that functional adaptation to the environment in the presence of deafness, may differ from such adaptation when hearing is present.

The new climate engendered by these developments allows the issues surrounding the oral - manual debate, i.e. those pertaining to language, and to the relationship between language and thought, to be viewed from a different perspective. If sign language is functionally equivalent to oral language, in a linguistic sense, then is this also true in a psychological sense? In other words do deaf children who have a sign language environment, behave differently from those who do not? If so, is this difference equivalent to the behaviour of hearing children and is sign language a sufficient explanation?

Deaf Children of Deaf Parents

Approximately 10% of deaf children are born to deaf parents. In many, but not all, of these families, sign language is the medium of communication. Within these signing deaf families the deaf child is in a directly comparable position with respect to language acquisition as the hearing child in a hearing family. Under these circumstances it is found that deaf children acquire sign language in an analogous way to hearing children acquiring oral language (e.g. Bonvillian et al 1981; 1983; Hoffmeister et al, 1974). For example, they develop a vocabulary of a similar content at a similar rate, progress from one sign to two sign etc. utterances, make analogous grammatical errors such as over generalisation, and erroneous pronominal references. If the two languages are indeed linguistic analogues then this is what would be expected. Currently there is no accepted formal way of assessing the linguistic level of a child in sign language. However, extrapolating from acquisition data would lead us to believe, that the deaf children of deaf signing families have linguistic competence of the same order as their hearing peers, albeit in a different language.

If language is a factor which influences academic achievement, then we might expect the performance of deaf children of deaf families to reflect this. If the academic achievements of deaf children of deaf families are compared with those of deaf children from hearing families the deaf children of deaf families achieve higher scores on a range of tests, including oral language skills (e.g. Meadow, 1968; Vernon & Koh, 1979; Stuckless & Birch, 1966; Stevenson, 1964). This advantage is also to be found for tests of psycho-social adjustment. However, attributing this improvement in performance to sign language is confounded by the fact that these manual samples are drawn from deaf families. Hence, the improvement in scores, which still do not reach those of hearing children, might be due as much to social, and emotional factors consequent on the greater experience, and thereby acceptance of deafness within a deaf family, as the use of sign language. This is suggested by data reported by Jensema & Trybus (1978) that similar educational advantage accrues where only one parent is deaf. Corson (1973) and Brasel & Quigley (1977) report studies which control for hearing status and method of communication by including deaf/deaf families who use oral communication exclusively. An additional factor included by Brasel and Quigley is the use by deaf parents of signed English. In both studies the deaf children of deaf families achieved higher scores on oral linguistic measures than the deaf children of hearing parents. This leads to the conclusion that method of communication is an insufficient explanation of the data.

Two factors which are seldom considered by either authors or commentators, on the influence of sign language and hearing status on academic achievement, are 1) that test materials both for stimulus and response are in a different language to that which is normally used by the child, and 2) the hearing status of the tester is invariabley different to the child. Cross cultural studies have highlighted the danger of assuming that norms derived in one cultural context apply and have the same meaning in another, leading to the concept of culture fair tests. Opponents of manual methods point to the fact the even though the deaf children of deaf families achieve higher academic achievement scores than their deaf peers from hearing families, they still do not reach the levels of hearing children, i.e. there is still a deficit between potential and performance. If one allows that these children are in a similar position to those from different cultural backgrounds, then the possibility of experimenter effects, which were raised earlier, applies in this instance too. The net result of this would be to depress the scores of the deaf children.

If the adaptive advantages which deaf parents confer on their deaf children are as much a function of their being deaf, as the language they use, then precisely what factors are operating? Work with pre-verbal hearing infants (e.g. Bruner, 1975) has shown that the basis for language acquisition is forged early in the child's life as the consequence of contingent interactions between the child and care giver. The caretaker 'interprets' the spontaneous actions of the child as meaningful and make their response to the child contingent upon this action.

A crucial aspect of this process, in relation to language development is the joint attention of care giver and child. This process is reciprocal, in that the care giver will mirror the child's visual exploration of the environment (Collis & Schaffer, 1975), but the infant, as young as four months, will follow the care giver's line of gaze when the care giver breaks eye contact with the child (e.g. Scaife & Bruner, 1975). This is referred to as the 'reference triangle' (Wood et al, 1986). The significance of this is that there is an increased probability that the child and care giver are attending to the same thing. In this way language and referent are brought together in a way which optimises the success of relating language and referent for the child. Implicit in this is that the child can attend to both referent and language simultaneously, the referent with the visual channel, language with the auditory channel.

Consider now the deaf child in a similar situation. Whatever language code is being used, the child must receive it visually, the same channel which is to be used for looking at the referent. Hence, the deaf child cannot look at and talk about something at the same time. This is often referred to as the problem of divided attention. This should not be confused with the use of the term in theories of attention, such as those of Treisman (1969) or Broadbent (1958) where the term applies to problems of monitoring and processing incoming information from the different senses. The implications of the term, as used here, are more akin to those raised in cross modality interference tasks (e.g. Brooks, 1968). The major problem attendant on divided attention for the deaf child is the difficulty of relating language to the referent. Given that deaf children of deaf families acquire sign language in an analogous way to hearing children acquiring oral language, it follows that the deaf parent must have strategies for developing contingencies and overcoming the problem of divided attention, which hearing parents do not.

Evidence in support of this argument comes from a series of studies by Wood et al (1986). Teachers, adults unfamiliar with the child and hearing parents were observed teaching a child how to solve a difficult puzzle. Oral deaf and hearing children acted as subjects. In general the deaf children were more difficult to be contingent upon than the hearing children. Irrespective of hearing status, children who were taught contingently did better than those who were not. The relevant point here is that non-verbal[1] contingencies and not verbal contingencies, were those which were predictive of success, and further that the relationship between non-verbal and verbal measures differed for the deaf and hearing groups. In the hearing group verbal and non-verbal measures were closely and directly related, whereas in the deaf group non-verbal and verbal measures were inversely related, i.e. those teachers most contingent nonverbally were least contingent verbally. Wood et al state;

> "The separation of verbal and non-verbal control is a symptom of the problem of divided attention facing the child and a consequence of counter-productive responses such as taking material out of task context to 'talk' about it." (p33).

Unfortunately, Wood et al did not include a deaf/deaf group. However, Gregory and Barlow (1986) observed deaf children interacting with their mothers, one group of mothers being hearing the other deaf. In play situations they found that

1. The verbal/nonverbal distinction made here relates purely to oral language. Hence nonverbal means use of phatics gestures etc.

deaf mothers were significantly more likely to be jointly engaged on a task, to act contingently on the child's actions. A similar pattern of results is reported for the child's actions. While this indicates that deaf mothers can and do engender the development of contingencies in a way that hearing mothers do not, it is still not clear how this is enabled.

Whilst the foregoing seriously undermines the assumption that the deaf are alinguistic for the deaf children of deaf families, and thereby poses problems for the interpretation of data collected under that assumption, such an assumption is not questioned for the 90% of deaf children born to hearing families. Feldman et al (1978) examined the gestural language development of a small group of deaf children between the ages of 17 and 54 months, from hearing families committed to a strict oral approach. The essential point here is that the extent of the children's hearing loss mean that the aural input was virtually nil, and the commitment to oralism excluded all sign language. Never the less the children's main form of communication was by gestures. The analyses to which the development of these gestures were submitted is detailed, complex and the rationale closely argued. The data showed that despite the fact that there was no contact between the children, there were marked similarities in the type and pattern of gestures developed.

In addition the development of the gestures was linguistic in form, in that close parallels could be identified with the development of oral language in hearing children. These parallels included type and range of vocabulary and rules covering combinations of gestures to form longer utterances. The authors tentatively concluded that even in the absence of structured linguistic input, these deaf children spontaneously developed a linguistic system which parallelled, both in form and complexity, the linguistic development of children who had a linguistic input.

Making inferences from a single study with such a small sample, within a limited age range, is likely to be speculative. However, bearing in mind arguments about innate predispositions for language, such a study weakens the strong claim of alinguistic. The claim is further weakened by the reports that even in strong oralist regimes, deaf children acquire sign language from each other, especially the deaf children of deaf families. Myklebust (1966) was aware of this, and in fact used this knowledge to compare signing and non-signing children, by comparing children from residential and non-residential schools, children at residential school being more likely to have deaf relatives. Furth too was aware of this but argued that signs acquired in this way were insufficiently embedded in the grammar of sign for them to be considered linguistic. If all the children were acquiring was a lexicon of signs this would be true.

However, work on pidgins and Creoles demonstrates the ability of children to impose a grammatical structure on an irregular input. That this process also occurs in deaf children is demonstrated in data reported by Livingstone (1983), which indicates that despite an input language model of signed English, effectively a pidgin, deaf children's output has a grammar which is akin to ASL.

Suppes (1974), notes that there is little work which examines cognitive issues, within a Sign language context. For example, when discussing the logical reasoning abilities of the deaf, he writes;

> "The real test will not be successful efforts to transform more sophisticated forms of inference into nonverbal contexts,......, but rather to test the ability to communicate and handle such inferences in sign language." (p162).

There is little work which is concerned with specifically cognitive issues, which includes sign in its design. This is the area which is most directly concerned with the work to be reported here and will therefore be discussed in the context of the relevant empirical sections.

The foregoing discussion has been concerned with the linguistic status of deaf children, and the implications current knowledge of sign language has on assumptions previously held. In my view this knowledge not only seriously undermines previous assumptions, but brings into question the interpretation placed on earlier data, if not its reliability. On a more positive note, accepting the deaf as linguistic, at least in so far as children are able to construct grammars (Creolise), helps to make some sense of the often contradictory nature of findings. Accepting that the deaf and hearing have different patterns of interaction, goes some way to accounting for the changing pattern of results as a function of experience in experimenting with the deaf, even if it does not explain it. These statements, in turn, imply a set of assumptions; specifically, the assumptions on which the work reported here is based. These will be discussed in the next chapter.

CHAPTER 4: Conceptual Framework, Assumptions and General Rationale

Introduction

The equivocal nature of many of the findings in the cognitive area, necessitates a reappraisal of the theoretical and methodological approaches used to study the psychological consequences of deafness if research is to offer an empirical base on which to develop effective cirricula for the deaf. Work since Furth indicates that such a reappraisal is taking place. This can be seen, not only as a result of dissatisfaction with the utility of previous approaches used with the deaf, but also as a consequence of wider changes within psychology in general, such as the decline of the influence of behaviourism, leading to a research climate which affords a wider choice of acceptable conceptual and methodological approaches.

In the previous three chapters I have outlined some definitions of relevant topics, given a synopsis of my philosophical beliefs and reviewed the existing literature on deafness and cognition. This chapter is essentially a synthesis of points raised in the previous chapters and will expand on these suggestions, and thereby set out the approach, and the assumptions, on which the work to be reported here is based.

The Psychology of Deafness

Like Myklebust, I have been using the term 'psychology of deafness'. This could be taken to imply that the deaf require a special psychology, that they are in some sense outside the scope of 'normal' psychology. Furth's attempt to explain the psychological consequences of deafness within Piagetian theory is, by his own admission, a denial of the need for a special psychology of deafness; a statement that the deaf are within the scope of normal psychology. This point is also discussed by Wood et al (1987). I do not believe that the deaf are outside the scope of normal psychology, but neither do I believe that an understanding of the deaf can be achieved by comparing the deaf to the hearing on the basis that the observations of the hearing population, and only those, are normal. When I use the term psychology of deafness, I use it to describe a psychology, in which data from deaf populations is given equal weight with that from hearing populations, on the basis that both sets of data are descriptive of normal human information processing capabilities. Having said that I now need to specify what is meant by normal.

Deviant, Different, Deficient and Normal

To those who are deaf from birth or soon after, being deaf is normal. They develop and adapt to their environment, always in the context of being deaf. I assume no-one would argue that the subjective experience of being deaf is the same as the experience of being hearing. When we ask the question "how do the deaf compare to the hearing?", and some discrepancy is found, the deaf are variously labelled deviant, or deficient, both having negative connotations. The problem arises because, in the case of deafness, we cannot accept a difference as being legitimate and normal, yet in many areas of psychology, including, developmental psychology, a theory is only considered as viable if it can demonstrate how the general (nomothetic) processes it postulates can give rise to individual differences (i.e. ideographic responses). In other words, difference is an acknowledged and acceptable part of psychology. Two analogies will help to illustrate my point.

Figure 4.1 is a well know visual illusion. It is a deliberately ambiguous figure which can be interpreted as either a young woman or an old woman. If this figure is shown to a group of naive observers both interpretations will be reported. In other words, the same objective stimulus, gives rise to different subjective experiences. This difference between observers is never referred to as deviant or deficient. They are different, but normal responses; ideographic results of the nomothetic process of perception. In other words a similar

Figure 4.1 Young Woman Old Woman Illusion

process can lead to a different response. Now imagine that the illusion had only ever been seen by people who only saw the old woman. The experimenter knows that two interpretations are possible, but only ever observes one being made. On the basis of these results our experimenter concludes that perceptual processes are such that seeing the old woman is the norm, and constructs a theory which describes and explains this. If the figure is now shown to a group of people who report both interpretations, how do we explain the behaviour of those who saw the young woman? We could look for some factor which distinguished the groups. If we could find such a factor, we could say that the observed difference in the behaviour of the two groups was due to this variable, rendering the young woman group, deviant or deficient with respect to the old-woman-theory. If no such variable could be found then we would be left with no alternative but to question the validity of the theory.

This analogy relates to the comments made in Chapter 3 where I questioned the applicability of hearing derived norms to deaf children and extends that argument. Our knowledge of a child's deafness predisposes us to ascribe any difference his/her performance to that factor which distinguishes him/her, to his/her deafness, making him deviant or deficient in theoretical terms, rather than question the capability of the theory to explain his behaviour, and thereby, ascribe deviancy or deficiency to the theory.

Qualitative Differences and Normality

In Chapter 3 I also questioned the utility of making purely quantitative comparisons; a point made by Myklebust. A second analogy is useful here. If we asked a group of Nazis and a group of Jews, to describe Hitler, a qualitative measure, then we would get quite different responses from the two groups, in effect two different people would be described. Further, these descriptions would not be recognised as being of the same person, by members of the opposite group, nor by an external observer, in the absence of the relevant stimulus. In other words qualitative data alone is insufficient. If we were now to show a photograph of Hitler, we could not separate the groups, in quantitative terms, in that both would give the response that they had seen a photograph of Hitler. In other words different processes give rise to an identical response.

Can we describe the qualitative behaviour of one group compared to the other as deviant or deficient? As an external observer, we can only say that the two groups are different. However, the groups may well describe each other with such terms as deviant, because each groups description has no validity in the experience of the other. By and large, the psychology of the deaf is written by the hearing. In this respect we are not external observers, but members of another group. This kind of argument is advanced as a caveat when evaluating cross-cultural data. Erting (1985) argues that deafness is a sociocultural phenomenon, similar to ethnicity, which in a school setting can give rise to culture clashes between deaf and hearing. Kyle (1983) makes a similar point with respect to research settings; in effect, that researchers bring an implicit ethnocentrism to their research.

By these analogies I have been attempting to demonstrate that what is considered normal, and by implication deviant or deficient, is relative rather than absolute and that it is possible for difference to be normal, and that we should take care not to ascribe deviancy or deficiency, just because some observation is outside our realm of experience. The second point is that both qualitative and quantitative data are required for a complete description of the events under consideration.

Legitimate Data

What is, or is not regarded as legitimate data within a discipline changes with time. A Positivist view of science, eschewed hypothetical constructs, such as gravity, considering only directly observable events, such as the effects of gravitational attraction, as legitimate data. In psychology the influence of positivism was evident in behaviourism. The decline of behaviourism, has led to a research climate, in which the range of legitimate data types is greatly extended, as are the legitimate uses to which data may be put, or the questions that may be asked of it.

I have been using the terms quantitative and qualitative without qualification. In the work to be reported here I distinguish between the two as much by the way data is treated, as by any inherent characteristics. Quantitative data is that which measures outcome, such as number of problems solved or reaction times. By contrast, qualitative data is any measure which is used to infer structure, process, or function, individually or in combination, which underlie an outcome. These data are no less quantifiable or amenable to statistical treatment, than outcome measures. Myklebust, described examination of test battery profiles as qualitative, in that they give information about the structure of, for example, memory abilities. This kind of structural approach has been used since, for example, by Savage et al (1981), using factor analysis and Norden (1975) using latent profile analysis, on outcome measures. In Chapters 5 and 9 I report on the use of a statistical model (Markov chain) to infer process from observations of visual behaviours during problem solving. In Chapter 8 I report on the use of observational data to infer the use of language during play.

Sign Language and the Cognitive Dominant Paradox

In the previous chapter it was evident that the paradigms used to study the psychological consequences of deafness involved a separation between language and cognition. This is a logical consequence of theories which ascribe dominance to language or cognition in the shaping of thought. Whilst such a separation may be possible at the conceptual level, by virtue of definitions etc, in practical terms the separation is more problematic. It was also noted that when viewed from the perspective of cognition in the assumed absence of language (Furth) the deaf are not considered deviant, but when viewed from the perspective of oral language development, the deaf are considered deviant. In cognitive dominant terms this is a paradox, to which, I suggested, Sign language may offer a solution.

If we accept Sign language as a natural language, and an analogue of oral language, then we can ask the question "Why is Sign language they way it is?" In innatist terms (Chomsky) sign language is the way it is because it reflects the innate capacity for language. The potential of Sign language to comment on the biological antecedents of language is well recognised; see, for example, the collection of papers edited by Bellugi & Studdert-Kennedy (1980). Bellugi (1980, p137) gives the nub of the argument;

> "We suggest that the abstract grammatical principles and constructs shared by natural sign language and spoken language arise from the shared central processing mechanisms, and that the more superficial surface differences are accommodations to the differences in the modalities. These differences, then, are the surface manifestations of the interface between thought and the particular nature of the linguistic signal."

In other words similar processes give rise to structurally different outcomes, which are functionally equivalent.
Piaget (1980, p23) sums up the constructivist position thus;

> ".... knowledge does not result from a mere recording of observations without a structuring activity on the part of the subject. Nor do any a priori or innate cognitive structures exist in man; the functioning of intelligence alone is hereditary and creates structures only through an organisation of successive actions performed on objects. Consequently, an epistimology conforming to the data of psychogenesis could be neither empiricist nor performatist, but could consist only of a constructivism, with a continual elaboration of new operations and structures. The central problem, then, is to understand how such operations come about, and why, even though they result from nonpredetermined

> constructions, they eventually become a logical necessary."

In constructivist terms, then, Sign language, or the structures which underlie sign language, is the way it is because it was constructed that way by the deaf subject. If these constructions are nonpredetermined, then the possible outcomes are only limited by the possible actions performed on objects. Assuming that the possible actions on objects are different in the presence of deafness, then sign language is <u>the construction</u> of language which is a logical necessary, and no other. If this argument is accepted then there is no paradox; sign language and the underlying cognitive structures are the results of deaf actions on objects.

Viewed in this way Sign language is a product of deaf cognition and as such, offers an insight into that which produced it. The potential of Sign language to comment on cognitive process, other than linguistic processes, is hardly explored, which is just the point Suppes (1974) makes.

Sign Language as a Manifestation of Normal Information Processing

The most noticeable difference between signed and spoken language is the extent to which they code information sequentially. Spoken language is of necessity linearly constrained in time; it is impossible to say two words at the same time. In Sign language it is possible to compress information such that more than one piece of information can be given simultaneously. This is not to say that there is no sequential aspect to Sign. Consider the following example. A child is discussing with his teacher his new sweatshirt, which has pictures of Batman and the Joker on the front (see p61).

The utterances in lines 1, 3 and 4 are sequential with respect to information. The utterances in lines 2 and 5 are examples of the capacity of Sign to transmit information simultaneously, in this case by distributing two signs in space. This is usually considered to be a function of the visual channel.

1. C ME NEW[1] points[2] (to sweatshirt)
2. T WHO points (Batman) WHO points (Joker)
3. C BATMAN points JOKER points
4. T BATMAN GOOD BAD WHICH?
5. C GOOD (sign made on the picture of Batman)
   BAD (sign made on picture of the Joker)

C=Child; T=Teacher; ⇓=simultaneous events; → =linear events

Consider now an orchestral piece of music, for example, a cello concerto. During a concerto information is transmitted in a simultaneous manner by the orchestra, and sequentially by the solo instrument. In Sign, spatial order can affect meaning, i.e. what is decoded. Orchestras are made up of sections of instruments, first violins, second violins, woodwind, etc. The arrangement of these relative to one another, i.e. their spatial order, affects what is heard. Some composers make use of this, by scoring pieces such that chords are heard including a note which is not actually played, or scored.

The point here is similar to that of Fodor (1972), discussed in Chapter 2, Bellugi's (1980) above and also, demonstrates my conception of interactionism. These two examples of information processing capacities suggest that humans have a capability to process simultaneous information, and that what is decoded is a function of the spatial arrangements of the elements of that signal. This statement is independent of any channel considerations, or of hearing status. The fact that this is observed occurring via different channels is, to use Bellugi's language "manifestations of the interface between thought and

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1. Uppercase words are Sign glosses.
2. Small case words not in brackets could be glossed, but are more ambiguous than upper case Signs. For example, in line 3 'points' could have been glossed as HIM or THERE or THAT ONE

the particular nature of the linguistic[1] signal". That it is observed in people with differential hearing status reflects functional adaptation.

The Use of Comparative Data

The above example is also indicative of the use of comparative data, in which each set of observations is given equal weight. The two sets of data are treated rather like a pair of simultaneous equations, to determine the values of common elements. It is from this point of view that I report comparative data, and not that in which the hearing (or the deaf) are a 'control' group.

Having said that, it still remains that I will be reporting, in the majority of instances on experiments, which by definition, involve the manipulation of variables. My criticism of the use of hearing norms to devise experiments, makes it incumbent upon me to find an alternative. Before we can begin to answer the question "why do deaf children fail to actualise their academic potential?", we need a more detailed description of deaf children's cognitive abilities than - more rigid, concrete, egocentric and impulsive. Are there occasions when the deaf can more abstract, for example? If so can this ability be related to aspects of deaf experience, such as Sign language? Do direct observations of the deaf suggest abilities or adaptations which would not be predicted from observations of the hearing? To what extent are simple descriptions, such as more concrete, the result of simple tasks? Will a more complex task give us a richer description? It is these kinds of questions which have informed my choice of task.

Summary

An examination of previous research on deafness and cognition,

1. Music came within my definition of language (Chapter 1). The perception of a non scored note is no less grammatical, or rule governed than the spatial grammatical devices of Sign. The rules which govern the perception of a non scored note are those of wave mechanics.

shows the results to be equivocal if not contradictory. The basic paradigm for much of this research has been to apply extant theories, developed with hearing populations, and test for goodness of fit. In general the results of such studies have shown that:

a) In some areas the deaf fit hearing norms

b) In some areas the deaf deviate from hearing norms, showing superior or inferior performances.

c) The patterns of (a) and (b) above are not consistent.

d) The patterns of (a) and (b) are not easily explained within current theoretical frameworks without recourse to post hoc explanations, e.g. social and linguistic explanations in Piagetian theory.

Myklebust's argument for the use of qualitative data was that, functional adaptation in the presence of deafness may result in the psychological processes of the deaf being organised in a manner different from those of the hearing. If, for the sake of argument, we accept that this is the case then what, as a consequence, would be observed? Considering this, with two further assumptions:

1) The deaf are just like the hearing in so far as they share a biological (genetic) heritage.

2) The deaf are different from the hearing in so far as they do not share a common experience (environment).

and assuming that functional adaptation is successful, then the pattern of observations would be just that found by previous research, i.e. the patterns of (a) and (b) above. Considering three further assumptions:

3) Language is a functional adaptation to the environment

4) Sign and oral language are functionally equivalent but structurally different.

5) The deaf are linguistic.

can observations, from this perspective, using a process oriented approach, suggest an explanation for (c), i.e. expand on (d).

Aims and Objectives

In Chapter 2, I made remarks to the effect that research is a product of the cultural context within which it is set. The work reported here is no less a product of its zeitgeist, and many of the arguments reflect just that. What I am proposing is a synthesis of old and new assumptions which reflects changes which have taken place in psychology and the wider cultural context in which research is set. Inevitably such a synthesis will reflect my own predispositions. In the course of these first four chapters I have tried to make my reasoning as clear as possible, and to demonstrate that the perspective I offer is coherent, and not an ad hoc arrangement of ideas. However, it remains that all I have offered so far is a set of theoretical arguments. Kelly (1955) and Einstein (1952), although from different fields of study, agree that the only real proof of any theory is its practical utility.

Therefore, the aim of this project is to assess the utility of the approach outlined here. This will be done by examining;
1) the possible influences of deafness on cognition
2) the relationship between sign language and cognition with the focus being on visuo-spatial processing and control of attention.

CHAPTER 5: Problem Solving Processes in Deaf and Hearing Six Year Olds for Lure Retrieval Tasks.

INTRODUCTION

Rationale for Problem Solving

Adapting to the environment requires that one solves the problems posed by the environment. Klahr (1986) has argued that the task environments created in experimental problem solving are miniature worlds which E can specify and over which E has more or less control. This allows the examination of real world skills in an environment in which the number of potential variables to which both E and S must attend is reduced, thereby easing some of the problems of interpretation of the resultant data. Hence, problem solving is a potential source of observations of adaptive behaviours which have real world implications. Many tasks which the child encounters at school, for example, reading, can be described as a type of problem solving. Therefore, knowledge of how deaf children approach and solve problems is of potential use, in remediating the discrepancy between potential and performance. Despite this, I could find only one study which specifically claimed to be investigating problem solving in the deaf (Stafford, 1962) and the two on which this study is based (Chulliat & Oleron, 1955 and Oleron, 1957) reporting on 'practical intelligence'. This is in contrast to the extensive problem solving literature for hearing children and adults. On this basis alone an investigation of problem solving in the deaf would be warranted.

It could be argued that there is an element of problem solving in any psychological experiment. I would agree with this, but argue that problem solving studies involve a different order of complexity, in both the experimental environment created and in the nature of the psychological processes which the subject must engage and hence, are available for investigation. A study designed to look at memory, for example, obviously requires that the S utilises other cognitive processes, such as perception, but it is used passively, as a necessary means of receiving information. Problem solving arises when there is a desired goal, the route to which is either not immediately obvious, or blocked, requiring the actively integrated and strategic use of cognitive processes to reorganise or restructure the situation such that the goal can be achieved. In this respect it is a situation in which it possible to collect both quantitative data (outcome) and qualitative data (e.g. method) which has a discernible relationship, thereby allowing an examination of process.

Selection Criteria for Problems

The problems chosen were three lure retrieval problems designed by Rey (1935) and used in a comparative study of deaf and hearing children by Chulliat & Oleron, (1955). These problems were chosen for a number reasons; some based on arguments advanced in the two previous chapters and some based on aspects of the previous research. Specifically these were:-

1) The problems should be theoretically neutral, e.g. non Piagetian. This is necessary if reliance on hearing models is to be reduced, thereby allowing the possibility of unique adaptations of the deaf to emerge empirically. Also the interpretation of data from such a task is not so constrained by expectations of norms.

2) There should be sufficient complexity in the task environment for process to be demonstrated externally (behaviourally). This is necessary if qualitative, as well as quantitative, analysis is to be possible and follows from (1) above. This then allows that comparison with hearing children can be of both process and outcome.

Problem Solving Characteristics of the Tasks

In a lure retrieval problem (LRP), a desirable object (in this case a sweet) is put in sight of but out of the immediate reach of the subject. The problem is to devise a way of retrieving the sweet (lure) with the available resources and within the constraints of the situation.

Problems can be classed as convergent or divergent. The LRPs are convergent in that they only admit of one solution, although the solution is one of principle rather than exact method. For each of the three tasks the child has to use an intermediary in a tool like manner. In one task (bottle) the child has to make a tool, a hook. There are a number of intermediaries available to the child, which are more or less efficient. In general the child has to reorganise the elements present to accommodate an intermediary and thus retrieve the lure. All stages are goal directed and perceptually given. In this sense the LRPs are concrete rather than abstract. Language is not logically necessary for the solution of LRPs as variants can be solved by infra-human species (e.g. Kohler, 1925). Also the visual nature of the problems and their construction is such that the necessity for instruction is minimised. Hence the deaf should not be at a disadvantage, even if their level of linguistic development is not the same as that of the hearing. This is not intended to mean that language will not or cannot influence either process or outcome.

On the basis of previous research, the visual, concrete nature of the problems, and the limited necessity of language should not disadvantage the deaf and therefore, there should be no difference in performance between the groups. However, other findings, for example Furth (1966), that the deaf are poorer at concept discovery than the hearing and Ottem's (1980) analysis that the requirement to attend to more than one element of a task results in inferior performances by the deaf, would indicate a differential performances by the groups on these tasks. The LRPs require that more than one element is attended to and that a concept is discovered. In the original study, Chulliat & Oleron (1955) reported differential performances by the deaf and hearing, with the deaf being inferior. In a replication, Oleron (1957) found equivalent performances by the deaf and hearing.

Aims

The aims of the study are:-

1) to examine problem solving processes in hearing and manually educated deaf children, and also

2) to assess the problems of conducting studies in sign.

METHOD

Subjects

Five severely/profoundly deaf and two partial hearing children (N=7), attending a partial hearing unit, attached to a mainstream infants school, and eight hearing children from a small Church of England primary school acted as subjects. The partial hearing unit operated a Total Communication policy. (see p105) All the children were second year infants, about 6 years old. Both groups were the total cohort for that age in their unit or school. Both groups used the same maths scheme and were at approximately the same level.

Apparatus and Description of Tasks

The apparatus described here is based on that designed by Rey (1935) as described by Chulliat & Oleron (1955). The pieces of equipment were constructed on the basis of the written descriptions given in the original french paper, and the present authors understanding of the tasks. As the descriptions were not entirely clear, and as no visual representation of the apparatus was given, the apparatus described here may not be faithful replicas of the original. However, it is felt that the essential aspects of the tasks have been retained. See appendix 5 for drawings of the apparatus.

Cage Problem

A modified wire hamster cage was mounted in a wooden baseboard. In the top of the cage was a hinged wire door, with a padlock. The cage was divided in a ratio of 4:1 by a perspex partition. The smaller portion of the cage had the wire removed from the bottom half of one of the short sides. The perspex divide had a small opening at the bottom centre. Mounted in the centre of the larger portion of the cage was a turn-table, with a 20mm upstand on three sides. On the turn-table was a small perspex box containing a sweet. In the initial state, the open edge of the turn-table was pointed away from (180^0) the opening in the perspex partition. The child's task was to retrieve the sweet via the opening in the perspex partition. Provided, in a box of 'tools', were two wooden rods; a grey rod 12mm in diameter which could only be inserted,with difficulty, through the top of the cage, and a yellow rod, 9mm in diameter, which could be inserted through any part of the cage. The yellow rod was the correct 'tool' to effect a solution. Also in the tool box were implements intended for other tasks.

Bottle Problem

A small toy bucket, containing a sweet, was placed in a glass jar. The opening of the jar was reduced to 3cm by means of a plastic insert. The child's task was to retrieve the bucket, without removing the insert, or turning the bottle upside down. Provided were pipe cleaners, which were too short to reach the bucket, and pieces of coloured, easily bendable wire. The correct solution was to make a hook with the wire.

Slider Problem

Two sliding shelves were fixed into a base by side runners, such that each shelf could be moved independently along half the length of the base. The shelves were prevented from contacting each other by a bar (throat bar) fixed across the centre of the base. The height of the throat bar from the base was such that the shelves could not pass underneath it. One of the shelves (sweet shelf) had a hole in it, which held the sweet. There was identical sized hole in the base of the apparatus through which the sweet could drop, when the two holes were aligned. This half of the apparatus was covered by a hinged perspex lid, which could be padlocked to prevent direct manipulation of the sweet shelf. The second shelf (slider) had a large wooden handle fixed to it. The child's task was to find a method of transmitting movement from the slider to the sweet shelf. Provided were coloured wooden bars of 12cm (orange, correct length), 2 at 6cm (grey), 4 at 3cm (green), 13cm (yellow) and 20cm (black). The apparatus was constructed such that the bars which were too long could not be placed in the throat. This also applied to the rods from the cage problem. The wires and pipe cleaners bent when attempts were made to use them (but see results).

The solutions given here as correct are those given by Chulliat & Oleron. Pilot studies, with older children and adults, in general confirmed this. Any solution discovered, which was possible by means of an 'illegal' tool i.e. not the one intended by E, was prevented by modifying the apparatus or the 'tool'. Two modifications were found to be necessary 1) increasing the size of the handle on the slider to prevent illegal bars and the rods from being inserted in the throat and 2) reducing the gauge of wire used both to make it easier for the children to bend and to prevent it from being used successfully for the Slider problem.

Design

A mixed design was used with independent measures between groups (deaf, hearing) and repeated measures within groups (problems). The order of presentation of problems, was that used in the original study, which was the same for all subjects, was Cage, Bottle, Slider.

Procedure

All the children were tested individually, in a room other than their normal classroom. All communication with the deaf group was both signed and spoken. For both groups I was introduced to the children, as a group, in their classrooms by their teachers. They were told that they would be invited by E to play some games and win some sweets and also that how to play the games was to be kept a secret by everyone, until all the children had played the games. The secrecy rule was violated once, by one of the hearing S's on the Bottle problem. The behaviour of all other S's indicated that they had no previous knowledge of the problems.

All subjects were videotaped. The camera was in view throughout the session and the children were told that they were going to be filmed. The children were shown themselves on the monitor and E chatted with the children until they were apparently at ease with the situation. Once engaged in the tasks the children tended to ignore the camera.

Communication

The sessions were conducted in sign and spoken English for the deaf group. In the main signs were made in English word order, but with no attempt to sign or finger spell those parts of English speech, e.g. articles, which do not occur in Sign. In these cases I did not use my voice. No finger spelling was used, except single letters for names. Hence, for the deaf group the code used was neither English nor BSL, but a pidgin (see Chapter 1 and Chapter 6).

My level of signing severely constrained my level of spoken English. Hence for the hearing group I attempted to use only that English which I could sign. Two independent judges confirmed that I had used the same vocabulary for both groups. My constrained English did not appear to cause any problems for the hearing group.

Instructions

For each problem, the children were introduced to the apparatus, shown the sweet and told they could have the sweet if they could find a way of getting it out of the apparatus. They were also shown the tool box, but initially they were not told directly that they could use the tools. For each problem

there is a time schedule (appendix 5) indicating when E should give assistance, in the form of suggestions, if the child is not progressing toward a solution. The schedules vary slightly for each problem, but all take the following form;-
if not progressing toward a solution after 3 minutes then suggest next step; if after a further 2/3 minutes the child is not using the suggestion or otherwise progressing then suggest

next step; and so on until the child successfully completes the problem.
The timings used by Chulliat & Oleron were adhered to wherever possible. However, there were some variations, dictated by circumstance, e.g. the child becoming bored, frustrated etc. Despite this, times taken to complete the problems did not vary significantly between or within groups.

RESULTS

Comparison with Chulliat & Oleron's Data

The child's performance on each problem was classified according to Chulliat & Oleron's categories. The data are in table 5.1, with Chulliat & Oleron's 1955 results for the deaf group and Rey's 1935 hearing data.

The most noticeable feature of these data is the apparently much poorer performance of the 1987 Hearing children, in terms of spontaneous solutions, compared to the 1935 group. The 1987 deaf group performance differs from both the 1955 deaf group and the 1987 hearing group. However the 1987 deaf - hearing differences are not so pronounced as in Chulliat & Oleron's data.

Some of these differences could be accounted for by the use of the above coding scheme which was taken from the original french paper and was not clearly explained, leading to similar solutions being recorded differently by the different workers. Also the present data was scored from video recordings, where as the earlier data was scored in real time.

Another possible explanation is the time scale of the different codings and the intervening cultural changes, and hence experience of the children, which could have affected performance. For example, the bottle problem require the child to make a hook. Hooks of all kinds were much more in evidence in the 1930's, e.g. in the butchers shops, in the kitchen for hanging utensils etc. This could be contributory to the large difference in the number of spontaneous solutions of the 1935 hearing group.

Cage	Deaf 1955	Deaf 1987	Hearing 1935	Hearing 1987
Without stick	0	0	9.09	0
Inefficient use of stick	36.36	71.43	0	12.5
Empirical	45.45	28.57	0	62.5
Spontaneous	18.18	0	90.9	24.0
Bottle				
Can't solve/ bad choice of hook	62.5	33.3	0	28.57
Primitive or	12.5	0	0	0
empirical	25.0	33.3	0	14.28
Makes hook after suggestion	0	33.3	12.5	71.54
Spontaneous	0	0	87.5	0
Slider				
Can't solve/ generalise	20	0	5	0
Can't solve but can generalise	46.66	85.7	20	25
Empirical or can use suggestion	33.33	16.6	45	62.5
Spontaneous	0	0	30	12.5

Table 5.1 Comparison of Results

Thirdly, in the original study the children were only given those 'tools' which related to the on going task. In the study reported here the children had available the 'tools' relating to all of the tasks the whole time. This almost certainly added a level of complexity to the task, by extending the choices necessary to select the correct tool for the job. There was also the possibility of interference, in that the last successful tool was first choice for the next problem. An inspection of the video tapes indicated that this was very often the case (see below, for an analysis of relevant data). The effect of this would be to reduce the number of spontaneous solutions.

In view of the above and in order to examine, in more detail than the above scheme allowed, qualitative aspects of the problem solving process, an alternative strategy was devised. The video recordings of each child were transcribed as a series of discreet behavioural acts (See Appendix 5 for an example of transcription). All subsequent analyses use the transcripts as raw data. Two transcribers, in addition to the author, coded two children selected from the corpus at random. Inter-judge agreement on number of acts per child per problem was in the order of 98% for all comparisons. A content check was made by examination of the transcripts.

Method Analyses

Each problem was treated separately, and a coding scheme devised which took account of a) necessary conditions for a solution; b) Suggestions made by E; c) behaviour of S with respect to suggestions. In view of these considerations coding schemes for each problem were necessarily different.

Cage Problem

Transcripts were scored for the following categories:-

1. Total number of attempts (A)
2. Number of attempts before tool use (AT)
3. Appropriateness of first tool chosen (T)
4. Solves before suggestion is given (S)
5. Solves after suggestion is given (SE)
6. Uses turn-table (TT)

NB Variables 3 to 6 are categorical. Group totals are for positive (+) instances only.

Table 5.2 gives the scores for each subject in each group.

This is the easiest and least language dependant problem of the set as demonstrated by the fact that infra-human species can solve variants of this problem (e.g. Kohler, 1925). Inspection of the data shows very little difference in performance between the two groups, 2 children in each group solving the problem un-aided and the rest completing the problem after one suggestion by the E.

Subject	A	AT	T	S	SE	TT
D1	1	1	+	-	+	-
D2	4	0	+	-	+	-
D3	3	1	-	-	+	-
D4	1	0	+	-	+	-
D5	2	2	+	-	+	+
D6	8	1	-	+		+
D7	3	1	+	+		
Total	22	6	5	2	5	2

Table 5.2a. Method Scores for Cage Problem: Deaf Group (N=7)

Subject	A	AT	T	S	SE	TT
H1	1	0	-	-	+	-
H2	8	2	+	-	+	+
H3	8	2	+	-	+	-
H4	2	0	+	-	+	
H5	1	0	+	+		
H6	1	0	+	+		
H7	2	0	+	-	+	
H8	6	0	+	-	+	
Total	29	4	7	2	6	1

Table 5.2b Method Scores for Cage Problem: Hearing Group (N=8)

The two errors which were made on this problem were 1) using the wrong diameter rod, which made manipulation difficult, and reduced the number of points in the cage bars through which the rod could be inserted. 2) Only inserting the rod through the side bars of the cage, which made manipulation difficult. The suggestion made by E was to correct one of these errors. Attempts made prior to selection of a tool were concerned with finding a way to open the padlocked door at the top of the apparatus. These included picking the lock and jemmying the door! Deaf and hearing groups did not differ in this behaviour.

Few children in either group made use of the turn-table. The fact that the shelf, on which the sweet box stood, turned had to be discovered by the child. Use of the turn-table makes the task easier by reducing the distance the sweet box has to be pushed with the rod and also by eliminating the need to change the direction in which the box is pushed. Very few adults (hearing) attempting the task make use of the turn-table. All the children accidently moved the turn-table, but only 3 (2 deaf & 1 hearing) deliberately used this knowledge to aid recovery of the sweet.

Bottle Problem

The transcripts were scored for the following categories:-

1. Total number of attempts (A)
2. Number of attempts before first suggestion (AS)
3. Number of direct suggestions (S)
4. Spontaneously bends wire (B)
5. Bends wire after demonstration (BD)
6. Modifies hook (M)
7. Chooses large hook (L)

NB Variables 4 to 7 are categorical. Group totals are for (+) instances only. Scores for each subject in each group are given in table 5.3.

Inspection of the data suggests that the deaf children made more attempts than the hearing (deaf mean 8.6; hearing mean 6), but with less overall success in terms of the relative number of suggestions required by S's for a solution. Inspection of the video tapes showed that the deaf children gave up on something which did not work rather more quickly than the hearing but would repeat the behaviour later, often several times. This perseverance in pursuit of ineffective solutions was noted by Chulliat & Oleron.

Only one child (deaf) solved this problem un-aided. The commonest error in both groups was to attempt to retrieve the sweet with the yellow rod i.e. the correct solution to the preceding problem. Once the wire (correct 'tool') had been selected only 1 deaf and 1 hearing child spontaneously bent the wire and only the deaf child proceeded to solve the problem without suggestions from E. The groups differed in their performance subsequent to E demonstrating bending the wire. 5 hearing children used the suggestion to solve the problem compared to 1 deaf child. Of the remaining 4 deaf children, 2 failed to choose the correct (i.e. smaller) hook of the two offered by E as did the two remaining hearing children.

Subject	A	AS	S	B	BD	M	L
D1	8	3	4	-	-	-	+
D2	5	1	3	-	+	-	-
D3	16	6	3	-	-		-
D4		data discarded					
D5	5	2	4	-	-	-	+
D6	9	5	1	+		+	
D7	9	7	1	-	+	+	
Total	52	24	16	1	2	2	2

Table 5.3a. Method Scores for Bottle Problem: Deaf Group (N=6)

Subject	A	AS	S	B	BD	M	L
H1	3	1	2	-	+	+	
H2	10	2	3	+		-	+
H3	8	5	2	-	-	-	+
H4	3	1	1	-	+	+	
H5	3	1	1	-	+	+	
H6			data discarded				
H7	7	4	1	-	+	+	
H8	8	5	2	-	+	+	-
Total	42	19	12	1	5	5	2

Table 5.3b. Method Scores for Bottle Problem: Hearing Group (N=7)

From this it can be seen that the differences in the performances of the two groups are almost entirely accounted for by their differential ability to make use of suggestions offered by E.

Slider Problem

Transcripts were scored according to the following categories:-

1. Number of Attempts (A)
2. Tries impetus i.e bangs throat bar hard with slider (I)
3. Number of events before discovery of throat (T)

4. Solves correctly i.e. by using 12cm bar or combinations of bars up to 12 cm (S)
5. Partial Solution i.e. solves by a method other than above (PS)
6. Number of events to solution after a partial solution (NS)
7. Experimenter gives correct bar (E)

NB Variables 2,4,5 & 7 are categorical. An E in a category indicates that the experimenter gave the child that variable. Group totals are for (+) instances.

Scores for each subject in each group are given in table 5.4. These data show more between groups differences than those for either of the two preceding problems. Again the data suggest that the deaf make more attempts than the hearing. However the difference is almost entirely accounted for by the very high score of D2, mean scores being comparable (6 v 6.5) with D2's score excluded.

The solution requires that movement is transmitted from the slider to the sweet shelf. The use of impetus is one potential solution to this kind of problem. In this case it will not work as the constricting throat bar and base are sufficiently massive to absorb most of the energy. All the deaf children tried this solution but only 1 hearing child. Hearing adults who attempted the problem were more likely to behave like the deaf children than the hearing children.

This difference, in the use of impetus, is possibly accounted for by the fact that 6 of the 8 hearing children immediately discovered the throat connecting the two halves of the apparatus, in contrast to only 1 deaf child. Of the two hearing children who did not discover the throat immediately 1 also attempted an impetus solution. When watching the video recordings this difference in behaviour is most striking; the hearing children appear to be actively searching for the opening, whereas the deaf children appear to discover the opening by accident, if at all. E had to point out the opening to 2 of the deaf children. This behaviour of the deaf children is counter-intuitive, in that one might expect a group of children who rely so heavily on visual input for information to be more inclined to visually search novel objects.

Subject	A	I	T	S	PS	NS	E
D1	5	+	2E	-	-		+
D2	27	+	18	-	+		+
D3	7	+	1E	-	+		+
D4	5	+	0	-	-		+
D5	5	+	2	-	-		+
D6	6	+	1	-	-		+
D7	8	+	2	-	+	4	
Total	63	7	26	0	3	4	6

Table 5.4a. Method Scores for Slider Problem: Deaf Group (N=7)

Subject	A	I	T	S	PS	NS	E
H1	2	-	0	-	-		+
H2	7	-	0	-	+	3	
H3	8	+	1	-	+		+
H4	5	-	2	-	+	1	
H5	3	-	0	+			
H6	10	-	0	-	+	7	
H7	8	-	0	-	+	4	
H8	9	-	0	-	+	5	
Total	52	1	3	1	7	20	2

Table 5.4b. Method Scores for Slider Problem: Hearing Group (N=8

Only 1 child (hearing) solved the problem un-aided. Partial solutions were defined as solutions which used a 'tool' other than the 12cm bar or a combination of bars to 12cms. 3 deaf and 7 hearing children offered partial solutions. The most common solution offered by both groups of children was to push the sweet shelf with a wire (i.e. the correct 'tool' in the preceding problem). This solution was counted as illegal as the sweet shelf was moved by applying force directly to the wire, and not by pushing on the slider. When the children tried this solution they were stopped by E and asked if they could think of something else they could use instead of the wire. Of those children offering partial solutions 5 hearing children went on to give the correct solution.

One deaf child was also counted as having solved the problem after offering a partial solution, even though he did not use the bars to solve the problem. His solution was to bend the wire into a 'U' shape and insert the wire into the slot such that the force applied to the slider was transmitted through the point of the 'U' down the two arms, which had the maximum possible separation at the sweet shelf. This allowed the sweet shelf to be moved without the wire bending, which it did if a single strand was used. The arrangement of the wire was deliberate and the solution was counted as correct as the motive force was applied to the slider.

Of the remaining children 6 deaf and 2 hearing children had to be shown the correct solution (i.e. given the 12cm bar and told where to put it). All the children, irrespective of solution offered, were given the generalisation task. All the children successfully generalised the solution whether they had discovered it for themselves or had been given it by E.

To summarise, inspection of the data shows that the deaf children's first attempt at a solution was always impetus. In contrast the hearing children actively searched for, and discovered, the throat. The hearing children were more likely to offer a partial solution and were more able to use this experience to discover the correct solution. However, once the solution was known both groups could use the information equally well, in that both successfully generalised the solution. These data are in line with Furth (1966) who showed that deaf children were poorer at concept discovery than their hearing peers, but equally able to use the concepts when supplied.

Behavioural Analyses

The preceding analyses have suggested that while the two groups do not differ in terms of overall success, i.e. number of spontaneous solutions, they do differ in their ability to make use of information supplied by E, or discovered in the course of problem solving. Watching the video tapes three things were immediately obvious in the behaviour of the deaf children; 1) The high level of activity; 2) the high frequency with which the children looked at E other than for communication; 3) the low frequency of visual exploration of the materials.

Table 5.5 shows the total number of behaviours transcribed for each group for each problem. As there was little difference in the amount of time the children spent on any one problem, either within or between groups, time is not taken into account in analyses.

		Cage	Bottle	Slider	Total
Deaf	Σ	526	420	421	1367
	n	7	6	7	20
	x	75.14	70	60.14	68.35
Hear'g	Σ	247	221	294	762
	n	8	7	8	23
	x	30.48	31.57	42	33.13

Table 5.5 Number of Behaviours for each Group for each Problem

Inspection of the data shows that the deaf group engage in approximately twice as many acts as the hearing group. Mann-Whitney U tests show this difference to be significant for all three problems (Cage U=1; p=.0006: Bottle U=0; p=.0012: Slider U=10; p=.04; all tests two-tailed, ties uncorrected). As time taken does not vary between the groups it can be concluded that the difference between the groups is in level of activity per se, thus confirming observation 1.

The test the observation (2) that the deaf group looked at E more often than the hearing group, the percentage of behaviours which were looks at E and not part of a verbal (speech or sign) act, were calculated for each problem. These data are shown in table 5.6.

These data confirm the observation (2) that the deaf children looked at E more frequently than did the hearing group. It is not only the absolute frequency which is greater, but also the percentage of total behaviours which looks to E accounts for. The difference in the proportions is significant for the cage (X^2 = 11.47; df 1; p<.0001) and bottle problems (X^2 = 18.15; df 1; p<.0001), but not the slider problem. The data for this problem show that both groups change their behaviour with respect to E, but in opposite directions; the hearing group increasing the frequency of looking at E, the deaf group decreasing the frequency.

	Deaf		Hearing	
	Σ	% of total acts	Σ	% of total acts
Cage	125	23.76	32	12.95
Bottle	102	24.28	22	9.95
Slider	68	16.15	42	14.28
All Problems	295	21.58	96	12.58

Table 5.6 Percentage of Behaviours Which Were Looks to Experimenter

Given that the looking behaviour examined above is independent of direct verbal acts either from or to E, the question arises as to what function, if any, such behaviour serves for the deaf group. Observation 3 suggested that, for the deaf group, there was a relatively low frequency of visual inspection of the materials, even though this is an important aspect of the problem solving process. A crucial aspect to the solution of all the problems is the selection and use of an appropriate tool and visual behaviour is likely to be important as a means of gathering the necessary information for tool selection. The problem solving environment of the children contained four potential sources of information; the apparatus, the tools, the experimenter, and the child's own experience in trying to solve the problem. The relative saliancy of these sources may become apparent by examining the distribution of the child's behaviour to these.

To test observation 3 and to examine the functional relationship of visual behaviours to the problem solving process, the acts immediately preceding a tool change were coded according to the following scheme:-

Experimenter (E) - S looks at E while choosing tool or looks at E before using tool or E gives S tool

Apparatus (A) - placed previous tool in box then looked at apparatus then selected tool

Tool Box (T) - placed previous tool in box then looked in box then selected tool

Use of Tool/Empirical (U) - swopped tools and returned to task with no interruption of movement or pause

This scheme coded the data exhaustively. The data summarised in table 5.7 shows the percentage of tool changes preceded by each category, for each problem. The data are also shown graphically in Fig. 5.1. (Raw data is in appendix 5)

Inspection of the data shows that S's behaviour is differentially distributed across the categories, both between groups and between problems. As the nature of each problem is different, then one might expect that different aspects of the problem solving environment become more or less salient to the problem solving process. The distribution of behaviours by the deaf and hearing is most different for the Cage and Slider problems. For all problems E is the most frequent event preceding a tool change for the deaf group, whilst for the hearing group T is the most frequent preceding event. For both groups A is the least frequent preceding event.

	Cage		Bottle		Slider		All	
	Deaf	Hear	Deaf	Hear	Deaf	Hear	Deaf	Hear
E	70.00	24.13	46.93	33.3	52.94	14	53.39	23.68
A	0	13.79	8.16	9.52	2.94	14	4.85	12.28
T	5.00	48.27	16.32	21.42	26.47	53.49	17.47	40.35
U	25.00	13.79	28.57	35.71	17.65	18.6	32.74	23.68

Table 5.7 Distribution of Events Preceding Tool Change

As with any form of group data, information is lost regarding the behaviour of individual S's. Inspection of individual data (appendix 5) shows consistencies not apparent in the group data. The individual data emphasises the saliancy of E for the deaf group, e.g. for the cage problem 6/7 S's scoring 100% in the E category.

Whilst the above data demonstrate the saliency of E for the deaf group in absolute terms, they give no indication as to the relationship between this behaviour and success in solving the problem. Table 5.8 shows the distribution of events preceding choice of the successful 'tool' expressed as a percentage of successful choices. The data are also shown graphically in fig. 5.2.

	Cage		Bottle		Slider		All	
	Deaf	Hear	Deaf	Hear	Deaf	Hear	Deaf	Hear
E	100	75	66.6	14.29	85.71	37.5	85	39.1
A	0	25	0	0	0	12.5	0	13.04
T	0	0	0	0	14.29	37.5	5	17.39
U	0	0	33.3	85.71	0	12.5	10	30.43

Table 5.8 Distribution of Events Preceding Successful Tool Choice.

Looking at individual problems, we see that for the cage (first) problem the majority of successful choices are preceded by E for both groups, 100% of choices being accounted for in the deaf group. As this was the first problem of the set then one might expect factors such as test anxiety, strangeness of the situation and the of E etc., to increase the child's need for reassurance. As this could only come from E, it would increase behaviours directed towards E, for both groups.

For the Bottle (second) problem, two categories, E and U, account for all successful choices in both groups, but the relative distributions differs; E being the predominant category for the deaf group, and U for the hearing group. From the method analyses it was evident that the difference in performance of the two groups was in the differential ability of the hearing group to use suggestions made by E to discover the solution. The suggestion made by E was a demonstration

Figure 5.1 Distribution of Visual Behaviours Preceding Tool Changes

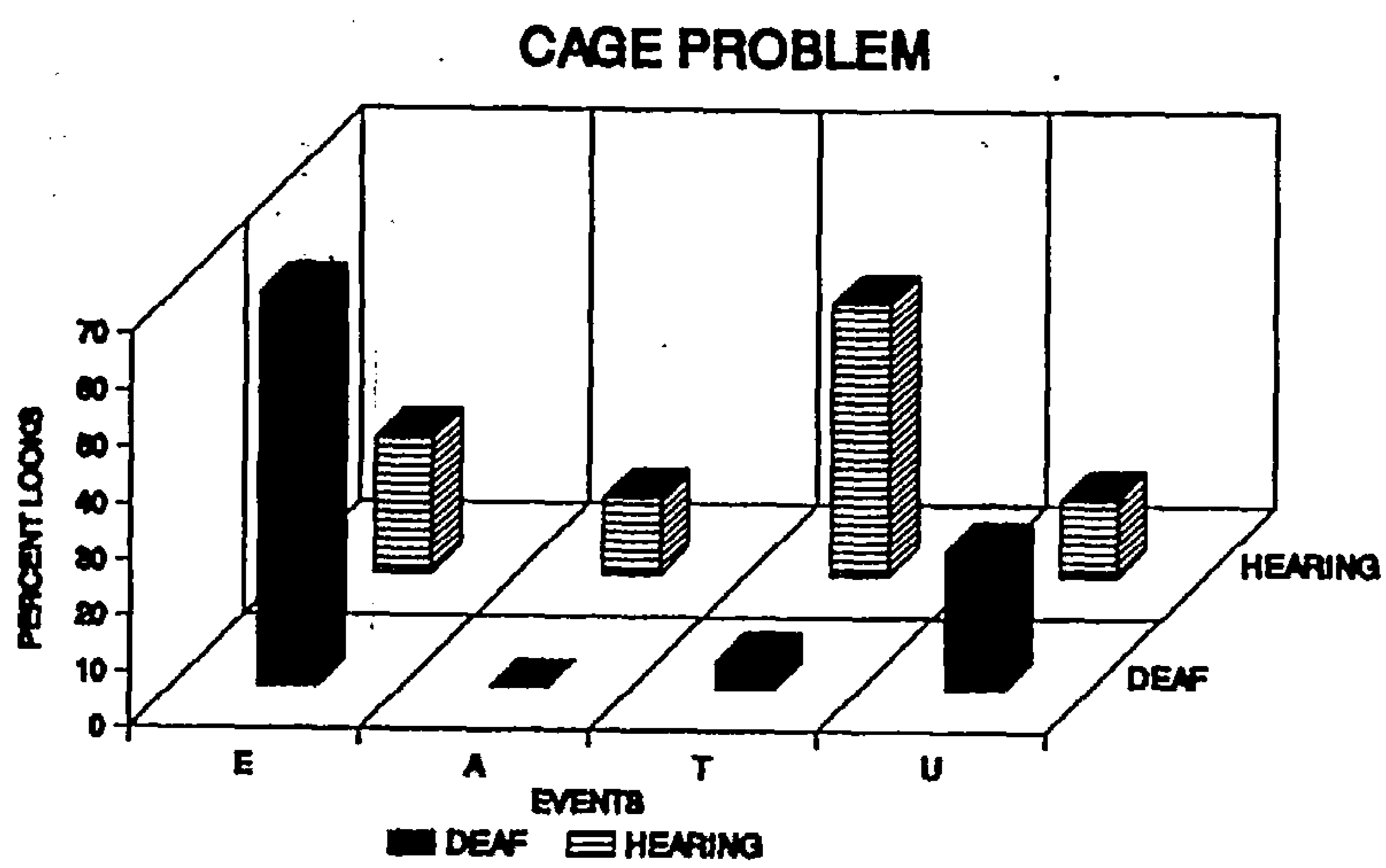

Fig 5.1a Distribution of Events Preceding Tool Change

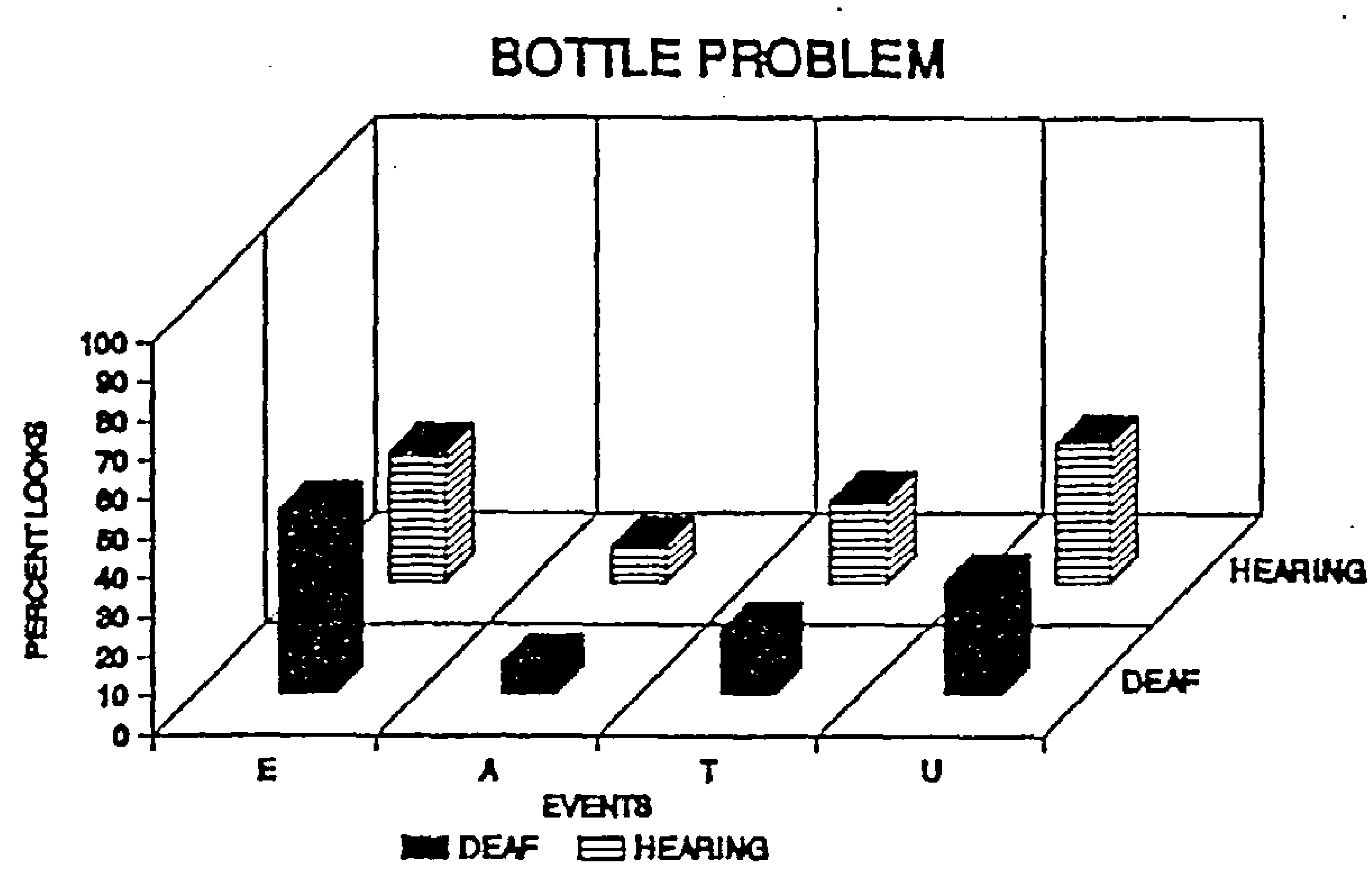

Fig. 5.1b Distribution of Events Preceding Tool Change

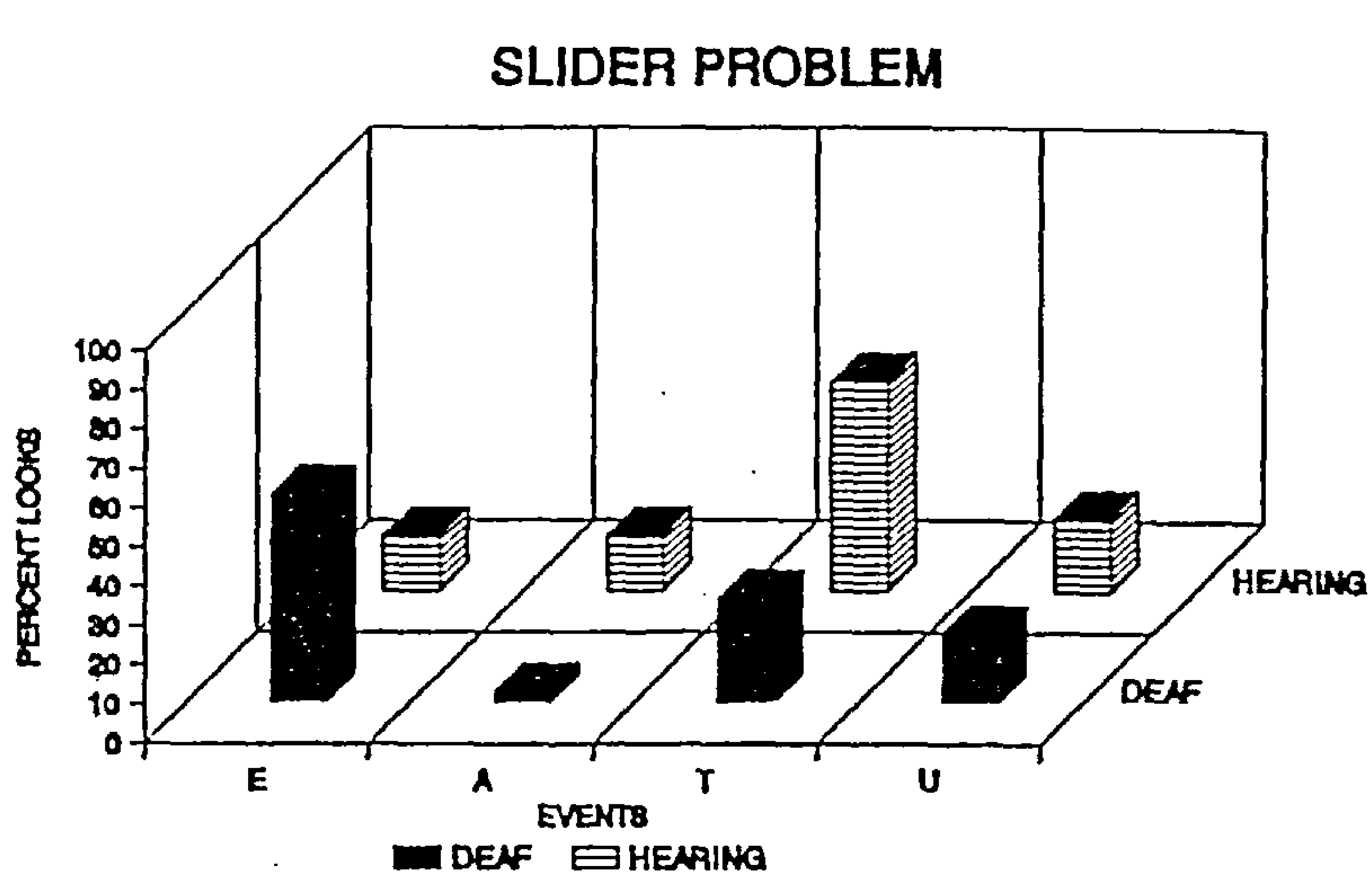

Fig 5.1c Distribution of Events Preceding Tool Change

that the wire bent, but without E making a hook. To discover the solution from this would involve the child manipulating and modifying the wire until a serviceable hook was made, resulting in a final preceding event of U. This was the case for all children (2 deaf and 6 hearing) who contribute to the U category.

For the Slider (third) problem, E again is the most frequent event preceding the choice of a successful tool for the deaf group. For the hearing group, the majority of preceding events (approx. 2/3) are in categories other than E, T being the most frequent and equal to E. All the children who were successful following discovery of a partial solution (1 deaf and 5 hearing) had a final preceding event in a category other than E, hence E is not related to success. Again events preceding successful choice of tool and the ability to make use of information gained in the course of problem solving can be related.

Whilst the above data may be indicative of process in the hearing group, it still fails to provide an adequate description of the behaviour of the deaf, and hence only goes some way towards explaining the differences between the groups. In discussing the solution of concrete problems Saugstad & Raaheim (1960) wrote;

> "In problem situations of such a concrete nature the solution is attained by the use of definite objects in definite ways and, in the attainment of a solution, the objects may be said to serve definite functions...... The solution may be conceived of as the arrangement of a number of functions into some definite sequence.".

Using this as a definition of process, two further analyses were carried out, which made use of the series of events, in terms of tool changes, leading to the solution. These were an analysis of the dominance of the categories and a Markov chain analysis.

Figure 5.2 Distribution of Visual Behaviours Preceding Choice of Successful Tool

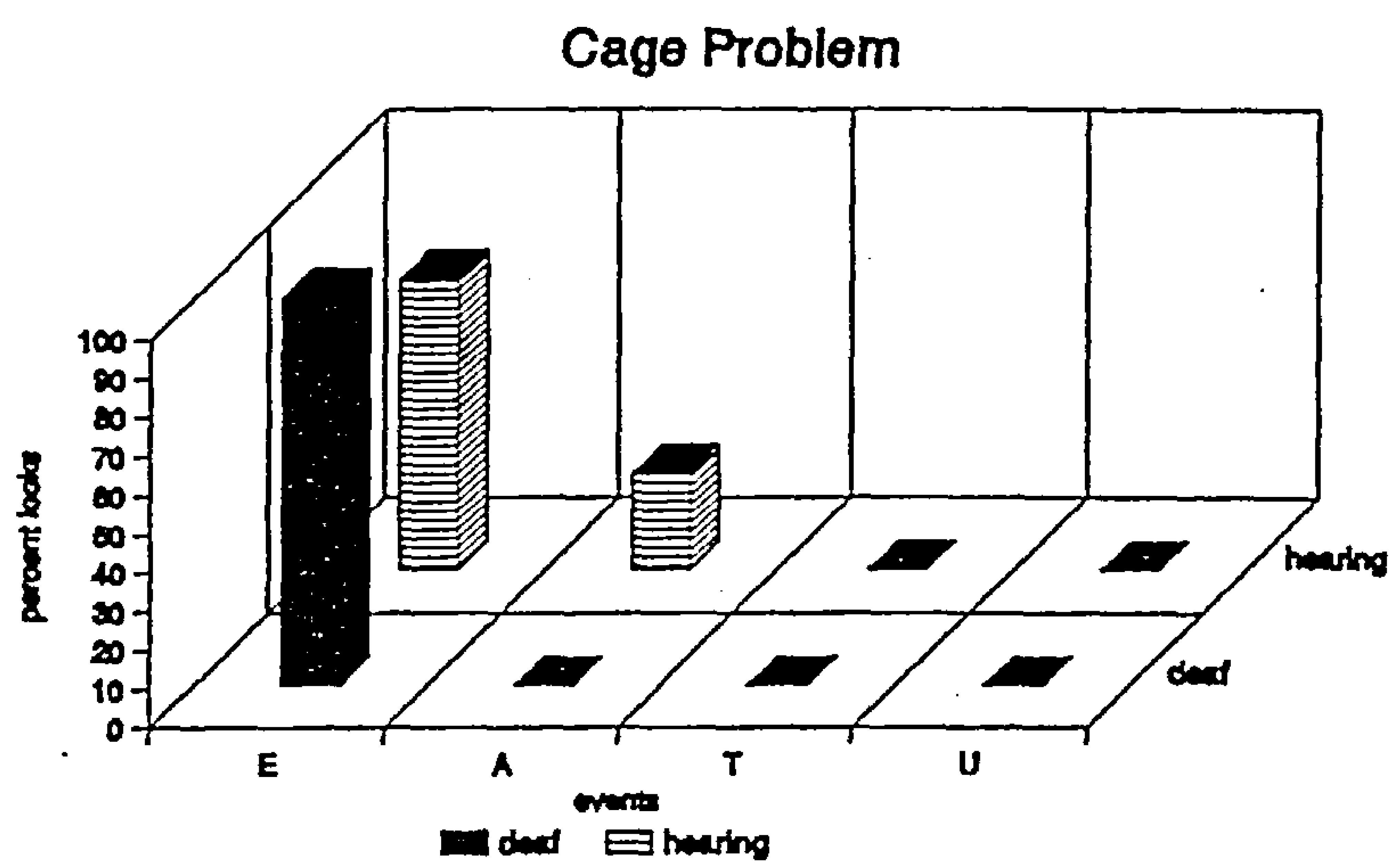

Fig. 5.2a Events Preceding Successful Tool Choice

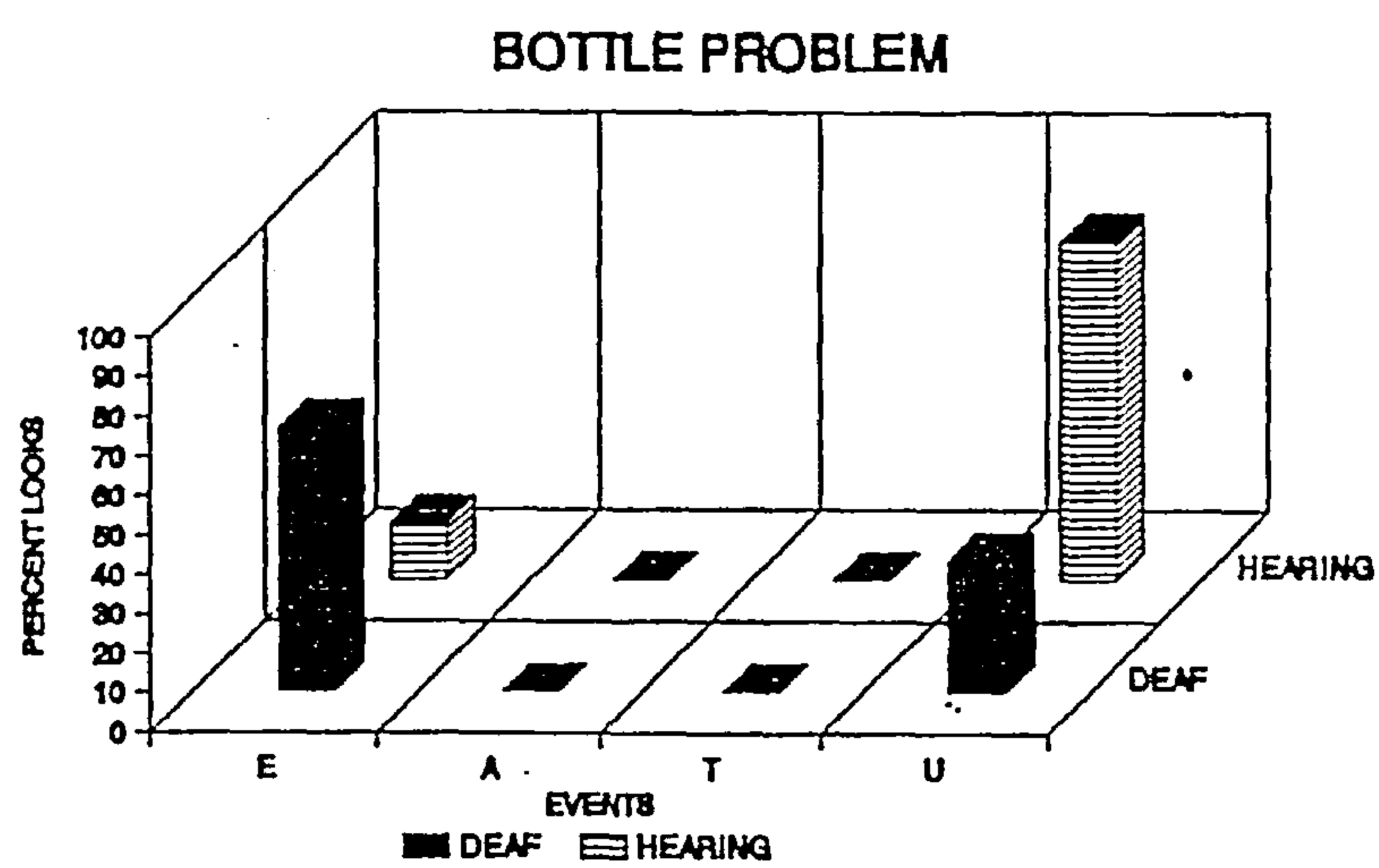

Fig. 5.2b Distribution of Events Preceding Successful Tool Choice

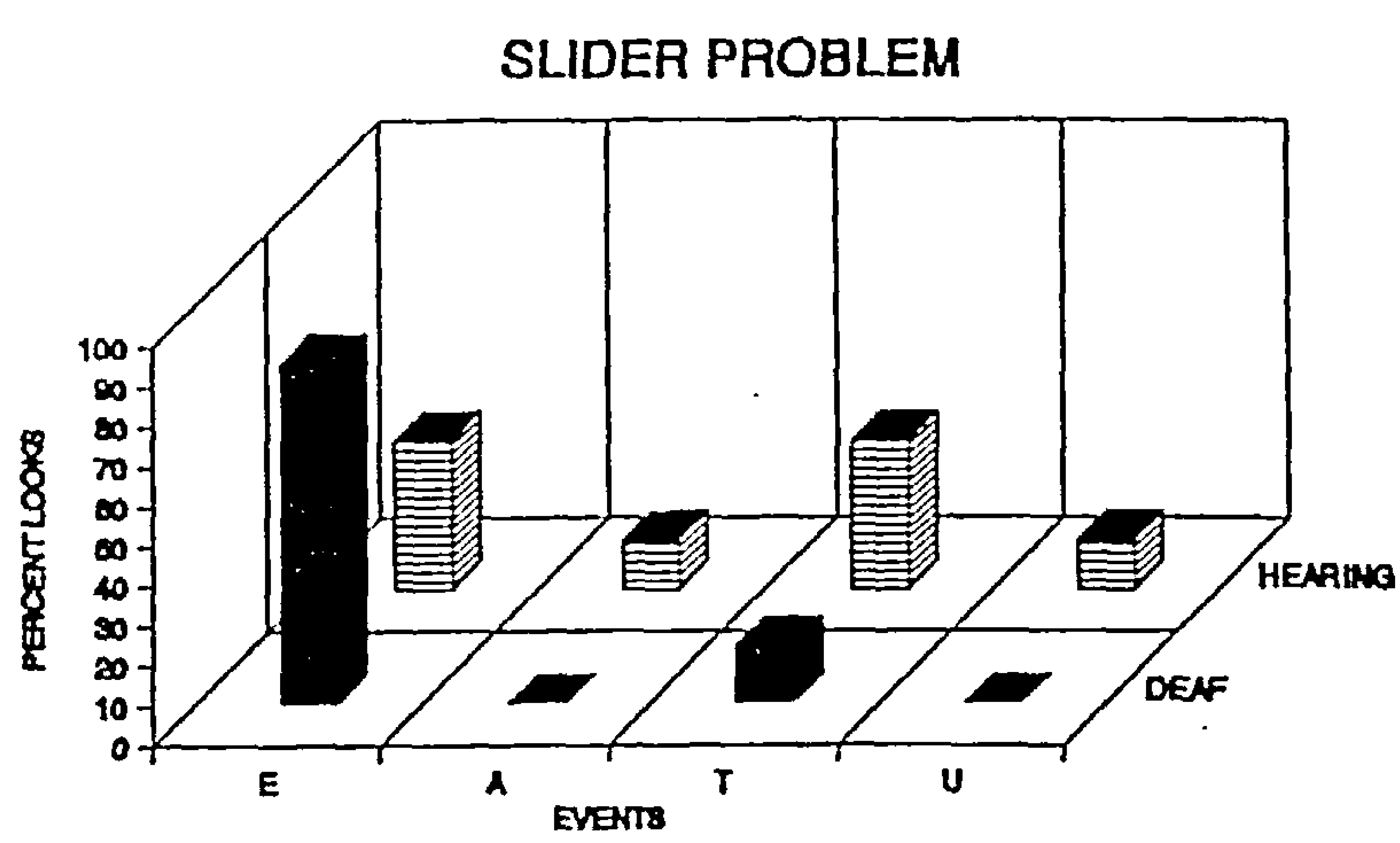

Fig 5.2c Distribution of Events Preceding Successful Tool Choice

Matrix Analyses

The category preceding each tool change was listed in the order in which it occurred, for each problem, for each child in each group. The relationship between each successive pair of tool changes was recorded in a 4 (preceding category) x 4 (succeeding category) matrix. The frequency matrix thus produced is given as table 5.9.

Cage Problem

DEAF	E	A	T	U	HEARING	E	A	T	U
E	7	0	0	0	E	1	0	0	0
A	0	0	0	0	A	0	0	1	1
T	0	0	0	1	T	1	0	6	2
U	1	0	0	4	U	0	0	3	1

Bottle Problem

DEAF	E	A	T	U	HEARING	E	A	T	U
E	13	0	1	6	E	5	0	0	7
A	2	0	0	1	A	1	0	0	3
T	2	0	3	3	T	4	0	4	1
U	4	1	3	4	U	3	0	3	4

Slider Problem

DEAF	E	A	T	U	HEARING	E	A	T	U
E	12	0	1	1	E	3	0	0	0
A	0	0	1	0	A	0	0	2	3
T	2	0	4	1	T	1	1	13	4
U	1	0	1	4	U	1	0	5	1

Table 5.9. Frequency Matrices of Events Preceding Tool Change

From these frequency matrices, dominance matrices (D) were constructed. Dominance between any pair of categories was determined by the relative frequencies with which each member of the pair was a succeeding category. In general terms category X was considered dominant to category Y if the frequency of Y to X transitions was greater than X to Y transitions. For example, in table 5.10a, the entry in cell U,T (3) is greater than the entry in cell T,U (1). Therefore, T is considered the *dominant* category of the pair. This is recorded in the Dominance matrix (table 5.10b) by assigning a value of 1 to cell T,U and a value of 0 to cell U,T.

Cells in the main diagonal, i.e. those representing self dominance for a category are given a value of 1, if there is an entry in that cell, otherwise a value of 0 is given. The complete set of dominance matrices (D) are contained in appendix 5. These matrices give the first order relationships between categories. By raising the matrices to the power of n, nth order relationships, i.e. indirect dominance of categories n steps apart, can be calculated (Bradley & Meek, 1986).

	E	A	T	U
E	5	0	0	7
A	1	0	0	3
T	4	0	4	1
U	3	0	3	4

5.10a

	E	A	T	U
E	1	1	1	0
A	0	0	0	0
T	0	0	1	1
U	1	1	0	1

5.10b

Table 5.10 Example of Frequency and First Order Dominance Matrices for Bottle Problem (Hearing)

A number of criteria can be used to determine the number of times the power of the matrix is raised. Here the degrees of freedom (categories - 1) was used and hence the matrices were raised to the power of 3. The second order matrices (D^2) and third order (D^2)D, i.e. D^3. The second and third order matrices were weighted by dividing the cell entries by the power of the matrix. A summary dominance matrix (S), was calculated for each problem, according to the following formula:-

$$S = D + D^2/2 + D^3/3$$

The dominance score for each category was found by summing the values in the cells in each row. These row totals were then ranked. The rank order of dominance for each category, for each problem is given in table 5.11 below. These data show that, for each problem, there is no significant difference in the rank order dominance of the categories between the groups. For the Cage and Slider problems, E emerges as dominant for both groups, Whilst for the Bottle problem U is the dominant category.

Relating these data to those for category preceding final choice of tool and success, a difference in the behaviour of the two groups is indicated. For the Bottle problem successful children, predominantly hearing, were those whose final tool choice was preceded by the dominant (U) category. This further supports the view that the difference between the groups performances, on this problem, was their differential ability to make use of information gained in the problem solving process.

	Cage		Bottle		Slider	
	Deaf	Hearing	Deaf	Hearing	Deaf	Hearing
E	1	1.5	2	2	1	1
A	4	4	4	4	3	4
T	2.5	1.5	3	3	3	2
U	2.5	3	1	1	3	3

Table 5.11 Rank Order Dominance for Categories Preceding A Tool Change.

The data for the Slider are more problematic. E is the dominant category for both groups, however, a final tool change preceded by this category is not related to success; success being related to a final category other than E; predominantly T, i.e. the second (joint for the deaf) ranked category. The dominance matrix reduces the original frequency information to binary data. Referring back to the original frequency matrix we find that the relative frequency of T and E being succeeding categories is reversed for the two groups; E having the higher frequency for the deaf group and T for the hearing group. This difference is almost entirely accounted for by the entries in the E,E and T,T cells, i.e. the frequency with which the same category followed itself.

Markov Chain Analysis

The preceding analyses have all indicated that the problem solving processes of the deaf and hearing differ with respect to their utilisation of information. Another emergent factor is a consistency in the data of the deaf across problems which is not so apparent in the data of the hearing, even though the hearing are relatively more successful at solving the problems. Given that the nature of the problems changes, then if the hearing children are learning to solve the problems, this might account for the absence of consistency in their data. That the behaviour of the deaf children remains relatively consistent across problems, would then be taken to indicate that they were not learning to solve the problems per se, but were engaged in some other, more constant activity. If this is indeed the case, then we should be able to use the earlier behaviour of the deaf children to predict their later behaviour, whereas with the hearing children their earlier behaviour would not be predictive of their later behaviour. A model which allows such a test is that of a Markov chain process.

By casting the original frequency matrices into transitional probability matrices (i.e. a matrix in which the row totals are 1), we can set up a Markov chain model to test this hypothesis. A Markov model requires two assumptions regarding the process under consideration;

> " 1) The transitional probability matrix does not change as the process moves from one stage to the next and 2) the state of the process at any given stage depends only on these constant transition probabilities and its state at the immediately preceding stage." (Bradley & Meek, 1986).

These assumptions are consistent with the arguments advanced to account for the behaviour of the deaf children. If our hypothesis is correct then the data of the hearing children will be in violation of these assumptions, leading to a failure of the model to predict the behaviour of the hearing children.

If the data being considered here represents a Markov process, then the state of the process at time t is the probability of being in one of the four categories. This is a row vector [pE pA pT pU]. The transition matrix at t1 represents the probability of moving from one category to another. If this matrix, t1, is premultiplied by the row vector of the immediately preceding stage, t, the resultant row vector, v1, is the state of the process at time t1. If the process is Markovian then the predicted state of the process, calculated by the premuliplication will be the same as the observed state of the process. Raising the power of the matrix at t1 by n will give the transitional probabilities for the process at tn. Premultiplying the matrix tn by the row vector for vn-1 will give the state of the process at time n.

As the Markov process continues, the probability of being in a given state increasingly reflects the transition process, becoming independent of the starting state and tending towards an equilibrium state. If the power of the matrix, t1, is raised repeatedly then the rows of the matrix will become identical. Any row in this matrix is equal to the equilibrium probability vector. Premultiplying the matrix, tn, by the equilibrium probability vector will give the state of the process at time n. This is a direct consequence of the two Markovian assumptions.

The transitional probability matrices, derived from the frequency matrices in table 5.9 are given in appendix 5. The associated probability vectors (observed vectors) are derived from the column totals of the frequency matrices. Assuming that the start of the process is the state immediately preceding the cage problem, and that at the start of the process the probability of being in a given state is at chance level, then the probability vector will be:

E	A	T	U
.25	.25	.25	.25

If the process is Markovian, then premultiplying the cage matrix by this probability vector, will give a row vector which is the same as the observed row vector for the cage problem. The results of this for both groups are tabulated below (table 6.13).

	DEAF				HEARING			
	E	A	T	U	E	A	T	U
Observed row vector	.61	0	0	.38	.33	0	.476	.19
Predicted row vector	.3	.25	0	.45	.36	0	.425	.223

Table 6.13 Observed and Predicted Probability Vectors for the Cage Problem.

Inspection of the table shows that the predicted probabilities, and the observed probabilities, are in close agreement for the hearing group but not the deaf group.

Model for the Deaf Group

Still assuming a Markovian process, these data would indicate that for the deaf group the process immediately preceding the cage problem, is in a state determined by some factor other than chance. Alternatively these data might indicate that the process cannot be described by a Markov model. Premultiplying the bottle problem transition matrix by the observed probability vector of the cage problem will decided between these two alternatives. The observed and predicted probability vectors are given in table 5.14. Inspection of these data shows that there is close agreement between observed and predicted probabilities (all X^2 n.s.). The observed probability vector for

	E	A	T	U
Predicted probability vector	.538	.026	.116	.307
Observed probability vector	.488	.023	.163	.326
Equilibrium probability vector	.467	.025	.164	.312

Table 5.14 Predicted, Observed and Equilibrium Probability Vectors for Bottle Problem. (Deaf Group)

the Bottle problem is close to the equilibrium probability vector, which is reached by raising the bottle transition matrix to the power of 8. Premultiplying the Cage problem transition matrix by the equilibrium probability vector gives a predicted probability vector which is in close agreement with the observed vector (X^2 n.s.) (table 5.15).

	E	A	T	U
Predicted probability vector	.529	0	0	.414
Observed probability vector	.61	0	0	.38
Predicted probability vector Sep	.622	0	0	.32

[Sep - Slider equilibrium vector]

Table 5.15 Predicted and Observed Probability Vectors for Cage Problem. (Deaf Group)

From these data we can conclude that the process under consideration is described by a single Markov chain model, and that the state of the process immediately preceding the first observed step (cage problem) is not described by chance.[1]

Hearing Group Model

The predicted and observed probability vectors for the cage problem were in close agreement. Assuming a Markovian process, then premultiplying the cage matrix raised to the power of 3 ($[C]^3$) will give a predicted probability vector for the slider problem (see table 5.16). Inspection of the data shows that there is little correspondence between the two vectors. Further the observed vector for the slider problem cannot be predicted from the immediately preceding state, i.e. the probability vector for the bottle problem (Bp). However, premultiplying by the chance vector (Chp) does predict the observed probabilities. Hence the process cannot be described by a single Markov chain model.

	E	A	T	U
Predicted probability vector Chp	.298	.023	.448	.238
Observed probability vector	.147	.029	.588	.235
Predicted probability vector $[C]^3$	.687	0	.235	.077
Predicted probability vector Bp	.442	.01	.442	.103
Predicted probability vector Cp	.381	.024	.46	.13

Table 5.16 Observed and Predicted Probability Vectors for Slider Problem (Hearing Group.)

The first step of the process, from chance to cage vector, was consistent with Markovian assumptions. If the bottle transition matrix is premultiplied by the observed cage probability vector (Cp), the resultant vector accurately predicts the observed probabilities, as does premultiplying the bottle matrix by the chance vector (Chp) (see table 5.17). The observed probabilities for the bottle are close to the equilibrium probability vector reached by raising the bottle transition matrix to the power of 8. Premultiplying the cage matrix by this vector gives:

1. The models for both groups can be further proved by varying the permutations of vectors and matrices used for premultiplication. These can be found in appendix 5, with relevant Chi-squares.

E	A	T	U
.464	0	.391	.13

Reference to table 5.13 shows that this predicts the observed probabilities for the cage problem. These data suggest that two Markov chain models are required to describe the hearing groups processes. The first to cover cage and bottle problems, the second the slider problem. However, raising the cage transition matrix to successively higher powers produces an equilibrium vector of:

E	A	T	U
1	0	0	0

which does not agree with the bottle equilibrium vector. Hence, the cage and bottle do not represent two steps of the same Markov chain. Raising the power of the slider matrix gives an equilibrium probability vector identical to the cage equilibrium vector. As premultiplying the slider matrix by the observed cage probability vector does not predict the observed slider vector (table 5.16), the cage and slider cannot be steps in the same Markov chain.

	E	A	T	U
Observed probability vector	.371	0	.2	.429
Predicted probability vector (Cp)	.401	0	.262	.318
Predicted probability vector (Chp)	.352	0	.185	.451
Equilibrium probability vector	.371	0	.215	.398

Table 5.17 Observed and Predicted Probability Vectors for Bottle Problem (Hearing Group)

To summarise, the data is sufficient to claim that the processes under observation are Markovian. However, they cannot be described by a single model, but require a different model for each problem. The state of the process immediately preceding the observed state is at a chance level for each problem, but this vector operates on transitional probabilities specific to each problem. For the cage and slider problems, the equilibrium state of the process is identical.

Comparison of the Deaf and Hearing Markov Models and Relationship to Hypothesis

In line with the hypothesis, a single Markov chain model is sufficient to describe the behaviour of the deaf, whereas the behaviour of the hearing requires three models. The state of the process before the first observation is described by chance for the hearing but not the deaf, suggesting that the process which the deaf group brought to bear on the problem solving tasks was not a function of the problem solving environment per se.

One interesting point of overlap between the groups is the probability vectors for the bottle problem. The observed vectors show similarity as do the equilibrium vectors which are reached at the eighth power of the transition matrix in both cases. Chi-square analysis of a contingency table comprising of the observed totals in each category for each group, and predicted totals obtained by multiplying the equilibrium vector of one group by the total number of tool changes (grand total for bottle frequency matrix) of the other group shows the distributions are not significantly different (X^2=4.28; df 9; n.s.) The reason for this is not immediately obvious.

A second point of interest is the equilibrium states of the cage and slider problem processes for the hearing group. These predict that ultimately the responses of the hearing group will be exclusively in the E category. From earlier data, it might have been expected that this was descriptive of the deaf group rather than the hearing group.

Interference

It was noted earlier that the children had available all the 'tools' relevant to all the problems and that this may have increased the difficulty of the task compared to the original study, by introducing an element of interference. Table 5.18 shows the order of tools selected by S's for the bottle and

Slider problems. This data shows that, for the bottle problem,

Subject		Bottle	Slider
Deaf	D1	Rod	E
	D2	Rod	Rod Wire E
	D3	Rod	Rod Wire E
	D4	-	Rod E
	D5	Rod	Rod E
	D6	Rod	Rod E
	D7	Wire	Rod Wire Bar
Hearing	H1	Rod	Rod E
	H2	Rod	Bar Wire Bar
	H3	Rod	Rod Wire E
	H4	Wire	Bar Wire Bar
	H5	Wire	Bar
	H6	-	Bar Rod Wire Bar
	H7	Rod	Wire Rod Bar
	H8	Rod	Rod Bar Wire Bar

Table 5.18 Tool Chosen First for Bottle & Slider Problems

5/6 deaf and 5/7 hearing S's selected the previously successful tool first. This would support the hypothesis of interference of previous learning, which affects both groups equally.

For the slider problem, the deaf again show a preference for the rod (successful tool in first problem) 6/7 choosing this first. 3/7 children made a second choice, which was the wire (successful tool in the second problem), in all cases. The behaviour of the hearing children was less uniform. 4/8 Chose a bar, 3/8 a rod, and 1/8 a wire. Here interference is less clear, although the data could be indicative of successful learning. The tool box contained three classes of tools; Bars, rods and wires. A different class of tool had been used for each of the preceding problems and successful learning of this would lead to the selection of a tool from a different class i.e. a bar.

DISCUSSION

Summary of Results

The results showed that there was little difference between the groups, in terms of spontaneous solutions. However, more detailed analyses demonstrated group differences on a number of measures. To summarise, three groups of analyses were carried out: method analyses which examined the functional aspects of the children's problem solving in terms of, for example, number of attempts, use of suggestion, etc.; behavioural analyses which examined the behavioural correlates and their relationship to the problem·solving process: and Matrix analyses.

The method analyses showed little difference between the two groups for the Cage problem, but for the Bottle and Slider problems group differences were apparent in the ability of the children to use suggestions made by E, or information gained in the problem solving process, the ability of the hearing group exceeding that of the deaf group.

The behavioural analyses showed that the deaf children, were significantly more active than the hearing, performing approximately twice as many acts for each problem, and were significantly more likely to look at the experimenter, looks not concerned with direct verbal (speech or sign) acts, being three times more likely for the deaf children.

The visual behaviour of the children and its relationship to success was examined further by categorising the visual behaviour immediately prior to a tool change. Four categories, Experimenter, Apparatus, Tool Box, and Use exhaustively coded the data. For the Cage and Slider problems the behaviour of the two groups was differentially distributed across the categories, for all tool changes. For the final, i.e. successful, tool change the distribution across categories was again different for the groups, but for all problems. For the Cage problem Looks to the experimenter were associated with successful choice of tool for both groups. For the Bottle and Slider problems final success was associated with a category other than E.

The purpose of the matrix analyses was to examine the functional saliency of the visual behaviours as a process. A dominance analysis showed no significant difference in the rank order dominance of the categories between the groups. For the Cage and Bottle problems there was a clear relationship between success and a final tool choice being preceded by the dominant category. For the Slider problem the data were less clear cut, but were suggestive of a differential use of information by the two groups.

A Markov chain analysis indicated that the behaviour of the deaf group could be described by a single model and that the state of the process immediately preceding the first observation (problem) was not described by chance. The hearing group required a model for each problem, with the state of the process immediately preceding each observation being determined by chance.

The order in which tools were chosen was examined for the Bottle and Slider problems, to examine the extent to which previous learning influenced subsequent problem solving. For the Bottle problem, interference was found for both groups, the majority of children selecting the previously successful tool as their first choice. For the slider problem, the deaf group again showed evidence of interference, the order of selection of tools being the order in which tools had been successful for the two preceding problems, i.e. rod, wire. The hearing group, however, showed evidence of successful learning, in that 5/8 chose a bar, i.e. a tool different from those which had been previously successful.

Interpretation of Results

The foregoing results admit of a number of interpretations. If one considers only spontaneous solutions, then one must conclude that there is no difference between the deaf and hearing in this kind of problem solving. This would be in line with the data from Oleron's (1957) replication, but not the original 1955 study. As the coding scheme used by Chulliat &

Oleron was considered unreliable and to enable a more detailed analysis, the coding schemes reported here were developed.

The most consistently emerging result is the failure, on the part of the deaf children, to make use of information discovered or supplied in the course of problem solving, to discover the solution. On the basis of these data we would have to conclude that the deaf are less able than the hearing to discover solutions in this kind of problem solving. The question then arises as to why this should be the case, given that they are concrete visual problems and they do not logically require language for their solution, the deaf should not be at a disadvantage, even if the level of language development differed in the two groups.

Problem solving was chosen as a first study into deaf cognition as it offered the potential for the analysis of both environment and process and their interactions. The analyses have all assumed that the deaf and hearing were engaged on the same task, i.e. solving the actual problem, which the experimenter set, and hence interacting with the same environment. The results of the dominance analysis can be taken as indicative of the extent to which the deaf children were engaging with the problem solving environment and organising it in similar ways to the hearing. Despite this the outcomes for the two groups are different. It could be the case that the deaf group are engaged in a different kind of problem solving than the hearing.

The dominance analysis takes only partial account of relative frequencies of the visual behaviours, and only in relation to tool changes. Overall the deaf were significantly more likely to look at the experimenter than the hearing, and from the analysis of tool changes and inspection of the video tapes, this appears to be at the expense of visual exploration of the apparatus and tool box. This lack of visual exploration, on the part of the deaf, is counter intuitive, for a group who, of necessity, must rely more heavily than the hearing, on their vision for environmental information. If the deaf are indeed engaged in a different kind of problem solving to their hearing peers, then what problem are they solving and in what way does their environment differ?

Meadow (1980) has suggested that the biggest problem the deaf child has to solve is that of communication. If this is indeed the case then the children who acted as subjects here, will at 6, be well rehearsed at solving this kind of problem. Also the experimenter differed in hearing status from the deaf but not the hearing children. In this respect the problem solving environments of the two groups differed and it is to this aspect of the environment that the behaviour of the two groups differed. The Markov chain analysis was suggested by the observation that the data of the deaf children showed more consistency than that of the hearing group. It was argued that as the nature of the problems change, learning to solve the problems per se would lead to a lack of consistency in the data across problems; consistency would be the result of some other, more constant, activity. As the experimenter remained constant across problems it is entirely possible that the problem which the deaf children were learning to solve was the experimenter. The result of the Markov chain analysis is certainly consistent with this argument. A single model, not preceded by chance, was sufficient for all three problems. The probability vectors of the bottle and slider problems were near equilibrium, indicating the process was well advanced.

If the deaf children were employing strategies developed for solving the problem of communication, then this might involve visual monitoring of E for cues, unconsciously signalled by E, as in the Clever Hans phenomenon. Numerous instances of this kind of behaviour can be found on the video tapes; for example, the deaf children would commonly feel around in the tool box with their gaze constantly fixed on E. This would give rise to the high frequency of looks to E reported here. It would also lead to an apparent increase in level of activity as any task related behaviour would also require an associated look to E to monitor the appropriateness of the behaviour. This is consistent with the finding that the deaf performed approximately twice as many acts per problem as the hearing children. For the Slider, which is the most difficult problem, the frequency of both looks to E and the overall number of behaviours changes for both groups, but in opposite directions. Also for this problem all but 1 of the deaf children were given the correct solution by E, which, if their strategy was to elicit the solution for E, indicates that they were highly successful.

If these arguments are correct then one cannot conclude that the deaf are less able to solve the kind of problems used, as they were not engaged in the same task as the hearing group. However, these arguments are clearly post hoc and, therefore, speculative. The crucial premise of the argument is that, for the deaf group, the differential hearing status of the experimenter is the most important aspect of the problem solving environment and consequently the one to which problem solving strategies are directed. The obvious test of the arguement is to repeat the experiment, using a deaf experimenter. This will be examined in a later study.

CHAPTER 6: Establishment of a Pre-school Sign Language Nursery

Introduction

The second objective to the study reported in the previous chapter was to gain insights into experimenting with deaf children in Sign and the attendant data collection. This second objective was felt to be necessary for a number of reasons. Vernon (1967) reports that as experimenters become more experienced at working with deaf children they are less likely to find differences in the performance of the deaf and hearing. I had little previous experience of deaf children, and none in the role of experimenter with deaf children. In addition, communication with the children was to be in Sign where, again, my experience was limited. The limited availability of deaf subjects meant that extensive piloting was not a practical way of gaining experience.

Conducting Studies In Sign

Languages are not static systems of communication, but dynamic processes which evolve to meet the needs of the communities which use then. For example, when members of different language communities have to live together, and neither community knows the language of the other, a common language will emerge, which is a pidgin (see Chapter 1). One aspect of a pidgin is its lack of a consistent grammar. Children whose input language model is a pidgin, will produce an output language which differs from the pidgin to the extent that a grammatical structure is imposed. This is a Creole.

BSL and English are languages which have evolved to serve the needs of the deaf and hearing respectively. The interaction of the deaf and hearing and their languages produces a continuum of languages from BSL through Creoles and pidgins to English. This is especially likely to be the case where manual methods of communication are used, although it can apply to vocal and written communication too.

Which language an individual will use, or where on the BSL-English continuum his/her language will fall, will vary as a function of the language model(s) to which the person is exposed, the age of exposure, hearing status, in so far as it affects access to oral language models, previous language learning and motivational factors.

Approximately 90% of deaf children are born to hearing families. Typically these families have no previous experience of pre-lingual deafness and no knowledge of Sign language. It is also the case that the vast majority of teachers of the deaf are hearing with oral language as their first language. Where either teachers or theses parents use Sign they use it as second language learners. Most Total Communication systems involve the use of both spoken English and signs with signs being made to follow English word order. Where deaf children are exposed to language models from deaf adults, these may vary from Signed English (pidgin), Creoles or BSL. Livingstone (1983) presents evidence that deaf children, like hearing children exposed to pidgins, Creolise Signed English input.

This then raises the question as to what language deaf children use, for themselves and as an output language and where on the BSL-English continuum does it fall? Is it more BSL-like or more English-like? It also brings into question the nature of the language used by the experimenter in the previous study, and the extent to which it equates with the language used by the deaf children (see below).

The foregoing discussion indicates that there is a problem in the use of the terms Sign, Sign Language and BSL, and the languages (on the continuum) to which they apply. The criteria for deciding are not clear cut, neither are they purely linguistic, with cultural and political considerations playing a part. However, experimental design requires operational definitions. In the case of the studies reported here, where I am the experimenter, the Sign language used is almost certainly a pidgin (but see below). However, I refer to it as Sign as it is not intended to be a sign system as defined in Chapter 1. I may not speak French very well, but the language I use is still referred to as French. Although I used voice when Signing, my intention was to use Sign as far as possible. Also I had been taught Sign by deaf adults who intended to teach me BSL and not Signed English. Hence I would use Sign alone when signing English word order was physically difficult, or it contravened what I knew as grammatical in Sign. Where the experimenter is deaf, then the language used is BSL. This is the term she uses to refer to her language.

Previous studies (see Chapter 3) have demonstrated that the deaf children of deaf parents show enhanced scholastic achievement over deaf children of hearing parents. A consensus view of the evidence is that where hearing status and language (Sign or English) are not confounded, language is not a sufficient explanation of the data. In line with this, in the previous study it was suggested that the hearing status of the experimenter may be an important aspect of the experimental situation and hence explanatory of the data. It was suggested that this may be tested by having a deaf experimenter. From the previous discussion it is clear that a change in the hearing status of the experimenter also means a change in linguistic status. This means that where hearing status and/or linguistic status are appealed to explanatory factors they are inevitably confounded in the research reported here. This problem is not unique to current research, however, the issues are somewhat different to those involved in the interpretation of the Furth or Myklebust positions. There hearing status was confounded with the presence or absence of language. Here language is actively acknowledged, the problems of interpretation arise because of an imperfect knowledge of which language is being used by whom. This point will be discussed further in Chapter 9.

The study highlighted a number of practical consequences with respect to the use of Sign, which highlight some of the issues just discussed.

1) My productive Sign exceeds my receptive skills, which is not uncommon in hearing signers, and the Sign language of some of the children was more advanced than my own. These two taken together meant that communication was largely one way. Whilst I could give instructions in Sign answering questions, or recognising that I had been asked one, was difficult. This was further compounded by the fact that children's signing can be 'childish' in the same way that hearing children's spoken language is.

2) My deaf sign teachers tell me that I use signed English i.e. signs in English word order, with some BSL constructions. The children used both codes. I was not skilled enough to know which code I was using and had no way of knowing which code the children thought I was using. Jordan (1983) suggests that code confusion may result in poorer performance by deaf children.

3) Related to (2), the level of my signing made giving complex or

abstract instructions problematic. This arose partly from my lack of competence with BSL grammar, but also from a lack of knowledge of the area under study; how do the deaf represent problems to themselves?

4) The data clearly demonstrate my lack of sensitivity to the nonverbal communicative aspects of the situation. I feel that this arose a) because I am not deaf and b) again lack of knowledge of the area under study; where and how do the deaf obtain their information?

There appeared to be three possible solutions to these problems; 1) devise studies in which the child acts without an experimenter or rely purely on observational data, 2) improve my signing skills and 3) use a deaf experimenter.

Other Problems and Considerations

The requirement that studies should be conducted with children with experience of Sign limited the potential pool of subjects. The acceptance of Sign language and consequent, total communication policies, in schools is relatively recent and still not widespread. Also, Sign is subject to regional, or residential school based, dialects. For these reasons, and limited funding, my subject pool was confined to Leeds children.

Visits to two of the partial hearing units in Leeds and discussions with teachers impressed upon me the problems associated with teaching the deaf. Of particular relevance here, was the length of time required to compensate for the deaf child's lack of incidental learning, not only of oral language but of knowledge in general. This was especially apparent where follow up work was being done on a subject taught in an integrated class, i.e. not by specialist teachers of the deaf. In addition there were already a number of demands on the deaf child's time in classroom, from the audiologist, the speech therapist, educational psychologist, etc.. Therefore it was felt that, however well intentioned the research may be, it would be ethically unacceptable to propose studies which made high demands on the deaf child's time in the classroom.

Any data collection which involves the use of sign clearly requires the use of video recording. This study demonstrated that both parties in an interaction need to be directly in front of the camera. To do this without changing the nature of the interaction, involves using two cameras and a live mixer. A portable set was not available, nor the funding to acquire one. However, a fixed system was available in the department.

Solution

As the department had a purpose built child development unit with spare capacity, complete with observation facilities and a video studio the obvious solution was to run a nursery group for the deaf. The L.E.A. was approached and happily this idea coincided with their own plans. The result was the inception of a playgroup for deaf pre-schoolers in October 1987, which is still in operation.

Aims and Objectives of the Nursery

The Hearing Impaired Service* in Leeds operates a Total Communication (TC) policy. TC can mean many things to many people, depending on how manual communication is seen in relation to oral language; as a distinct language or as support for English. The emphasis in Leeds at the inception of the nursery was moving towards bi-lingualism, i.e. a recognition that BSL is as distinct from English as French or Punjabi, and hence teaching methods appropriate to each language are required. In the ideal case, those severely and profoundly deaf children, for whom oral language was not expected to develop normally BSL would be their first language and English taught as a second language. Conversely, for those who would develop oral language manual communication would be used as support in the form of signed English. Currently there is no reliable way of predicting, from an early age, who will or will not develop oral English. Audiogram data alone is insufficient (see Chapter 1), and is in any case only partially reliable for very young children.

Bilingual, in this context, implies more than recognition of language and extends to aspects of culture. For those who adopt the Soviet view of development, language and culture are inextricably bound. Erting (1985) and others, make the case for there being a deaf culture which is distinct from that of the hearing world and to which, many deaf children of hearing families have no access until their teens. Anecdotal evidence indicates that it is possible for deaf children to grow up never meeting a deaf adult, and thereby acquiring a belief that they too will be hearing when they grow up. Whatever credence one gives to this, it cannot be denied that there is a high incidence of emotional and behavioural disturbance amongst the young deaf (Denmark et Al, 1985). These authors also present evidence that early manual communication is preventative of such disturbance.

To summarise, commitment to a TC policy, with an emphasis on bi-lingualism in its fullest sense, combined with evidence that deaf children of deaf families tend to achieve better scores on a range of scholastic and adjustment tests than the deaf children of hearing families (see Chapter 3) provided the motivating force for the nursery. As there is no reliable way of predicting which language code the child will ultimately prefer or be most able to use then both should be provided to the child. It is always recognised that the child must learn English if he or she is to participate fully in education and the hearing world in general. The children already had access to hearing role and language models both at home at school, and deaf role and language models were provided by the L.E.A., both in school and for home visits. If the advantages which accrue to deaf children of deaf parents are a function of deaf/deaf interaction per se, rather than the code used, or the parent-child relationship, then there is the potential for these to occur with deaf adults in general, and if so observing these deaf/deaf interactions may be instructive for both parents teachers.

Hence, for one afternoon a week the children were provided with an environment, in which being deaf is the norm. As well as providing the children with an unambiguous linguistic and social environment, it provided the opportunity for parents and teachers to observe the children and the deaf adults and their ways of interacting, and to collect data on levels of development etc.. The sessions also acted as an informal support group for the parents.

Physical description of Nursery

The child development unit is self contained and consists of an entrance hall with shoe lockers and coat pegs, a large playroom, with adjoining toilet and kitchen facilities and a small playground. Separating the playroom from the video studio is a large one way observation screen. There is a second, smaller, one way screen in the wall of an adjoining storeroom. The playroom is equipped with the usual range of preschool equipment, such as sand tray, climbing frame, play house and ride on toys.

Recording Equipment

Initially, the nursery was served by a single tripod camera, located behind the one way screen and one remote control camera located in the playroom. Dummy cameras were fitted to two other camera points until functional cameras were installed, in the autumn of 1988. This gave a total of three remote control cameras, fitted with pan and tilt units and motorised lenses. Signals feed to a Panasonic special effects unit, allowing feeds from any two cameras to be live mixed and a date and time signal added. There are no microphones in the nursery and therefore, no sound tracks on any recordings.

Social Description of the Nursery

The nursery came into being to fulfil the aims and objectives of both the L.E.A. hearing impaired service and this project.

The distinguishing feature of the nursery is that it is staffed by deaf adults whose first or preferred language is BSL. Hearing teachers of the deaf observe sessions from behind the one way screen, as do parents if they chose to come.

Characteristics of the Children

During the course of the project, 24 children between the ages of 2 and 6 years have attended the nursery. Six of the children were from ethnic minority groups. Of these, three had parents whose mother tongue was not English.

All the children were considered to be severely or profoundly deaf, on the basis of audiogram data, where this was available, and the extent to which the child was developing oral language. All the children used Sign as their primary means of communication in the nursery. As part of the L.E.A.'s provision, the children were visited at home by a deaf instructor and both parent and child given Sign language instruction. Some of the older children attended an integrated (deaf/hearing) nursery on a daily basis, which the deaf instructors also attended part time.

Etiology of hearing loss was unknown for approximately half the children. Known causes included, maternal rubella, consanguinity, Hurley's syndrome and meningitis. Three children were multiply handicapped with motor and or visual impairment and developmental delay. All the children were from hearing families, although three had deaf siblings.

Activities

To a casual observer, the activities in the nursery do not look any different from those to be found happening in any other pre-school group. As has already been stated the equipment was standard. This was checked by visits to hearing nurseries. A typical session comprised of a free play time, with access to the playground and ride-on toys. After approximately half an hour the children were brought in from the playground and freeplay continued in the playroom. During this part of the session the children were encouraged, although not compelled to take part in table based activities such as form boards, painting, etc. Other activities were available to the child, such as sand and water tables, playhouse, shop, dressing up box etc. After the free play all the children and deaf adults came together for 'tea-time'. During tea-time the children were given food and drink, which varied from week to week. The purpose of this was to provide a setting for more formal language work and to develop the group 'listening' and turn-taking skills which would be needed once the children started school proper. The length of tea-time was extended as the children grew older so that language games and stories could be added at the end of the session.

Details of which activities were to be included in each session and also the layout of large equipment and tables was at the discretion of the deaf instructors. It was envisaged that the role of hearing teachers of the deaf was to be advisory. In the early stages the deaf instructors were reluctant to assert their ideas and the majority of the activities were instigated by the teachers. The furniture and equipment layout was determined by myself so as to facilitate video recording with the limited equipment then available. Four different floor plans were used for the first three months (see appendix 6). Changes which took place during the course of the project will be discussed in Chapter 7.

Matters Arising - Yet More Problems!

Solving one set of problems invariabley seems to create another set, and this case was no exception. In one sense, the nursery itself was experimental; we could find no other group which was functioning in a similar way. Hence, there were no yardsticks or guide-lines which could be appealed to. Hence, there was a sense of insecurity in the early part of the project, amongst all concerned. Not all teachers or parents were initially enthusiastic about the idea, some being very suspicious of the whole venture. This wariness arose in part from the location of the nursery in a department of psychology and partly from the controversy which surrounds the oral/manual debate.

The deaf instructors were also unsure of their position and their role. They were acutely aware of not being qualified as teachers and found it difficult to believe, after their own experience of the education system, that their views, as deaf people, would be taken seriously. It took some time for them to fully accept that the focus of interest was in how they as deaf people, chose to structure both events and environment in the nursery. Once they did accept this, they began to take a much more active part in planning the nursery, and imposing their own structure on it.

As the deaf instructors grew in confidence, they also took a much more active interest in the research possibilities which the nursery offered. By the middle of the first year of operation, regular discussions took place between myself and the deaf instructors concerning the integration of research objectives into the planning of activities. I was concerned that the major influence on the nursery should be the deaf instructors and not my own ideas and prejudices on what I thought ought to be the case. The formula which was arrived at, was that I would indicate broad areas of interest, e.g. symbolic play, and details of how that was to be included in the program was left to the deaf instructor. One of the deaf instructors had agreed to act as experimenter and experimental studies were discussed in detail with her and the other deaf adults.

The nursery was, and still is, very much a working nursery, integrated into the L.E.A's provision for the deaf as a whole. An inevitable consequence of this is an instability in the population as children are transferred to other schools, either because of age or educational requirements. However, a core group of children, albeit a small one, have stayed with the nursery throughout the life of this project, and these form the main group of subjects for whom data is reported.

It was hoped that the nursery would solve the problems of regular access to subjects, without undue interruption to their education, conducting experiments through sign and recording. In most respects the nursery was successful in this. However, the eventual subject pool was, at the best of times, small. No child was forced to participate in a study against his or her will and parents were encouraged to exercise their right to refuse permission for a child to be a subject in a study. This latter was felt to be necessary to counteract any pressure the parents may have felt themselves to be under, given that the nursery was a part of the L.E.A. provision. These two conspired to reduce the actual number of subjects in studies to very small numbers.

Access was not always as regular as it might have been. All the children who came to the nursery did so in transport and with escorts provided by the L.E.A.. Unavailability of transport, people being ill or leaving, and industrial action have all caused problems, particularly towards the end of this project, resulting in fewer experimental studies being completed than were planned.

Postscript

The end of this project has not seen the end of the nursery. It has now become an established part of the Hearing Impaired Services provision for pre-school deaf children. The number of sessions is planned to increase from two to four a week. One of the most encouraging and exciting developments is the introduction of a reception class. All the first year infants from the resourced schools in Leeds come to the child development unit, now doing duty as a classroom, for one afternoon a week. As before, only deaf instructors are in the classroom with the children, hearing teachers of the deaf observing from behind the screen. All of these children have previously attended the nursery, and for many of the children this is their third year at the University.

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* The term 'hearing impaired' is considered as derogatory by many deaf people. It also carries the negative connotations associated with the deficit model of deafness. I use the term in this chapter and elsewhere as the proper name for the L.E.A.'s service for deaf children.

CHAPTER 7: Some Observation of Deaf Children Playing

Introduction

Whatever theoretical position one takes regarding the function and significance of play, it cannot be disputed that children spend a lot of time doing it. Conceptions of the functional significance and hence the value, of children's play have changed markedly over time, in a way that reflects the changing conceptions of childhood. Current conceptions of play, are integral parts of developmental theories, with play being seen as important in the development and maintenance of the child's intellectual, social and emotional well being. Play is not a uniquely human attribute, it being observed in the young of many species. However, the uniquely human attribute of language, and its interaction with play gives rise to questions which are only pertinent to the human child. Is play necessary for language to develop? Is language necessary for play, or certain types of play? These questions are, of course, contextual variants of the question "what is the relationship between language and thought?".

This chapter is intended to be a relatively informal look at the play observed in the nursery. It was these observations which led to the emphasis on visuo-spatial processing and control of attention. The chapter begins with a subjective report of the play of the children attending the departmental nursery. This was written after the nursery had been in operation for two months and before the extant literature on deaf children's play was examined. This was a deliberate ploy on my part, in an attempt to be as naive an observer as possible. This subjective report will then be discussed with reference to the literature on deaf children's play. I will then report on the changes in the running of the nursery, effected by the deaf adults over the course of the project, and some further observations of the children's play.

Subjective Report of Deaf Children's Play

The following is an attempt to characterise the nature of deaf pre-school children's play in a semi-structured playgroup setting. The salient aspect of the group is that the playgroup leaders are themselves profoundly deaf and all communication is in BSL.

GENERAL CHARACTERISTICS

Activity level and Attention.

Overall the activity level of the children is very high. The most popular toys seem to be the ride on toys. The children move about the room a great deal, but with little apparent purpose. They seem to be easily distracted. The distraction takes two forms. 1) their attention span with some activities seems very limited. These are activities which one might suppose require thought or imagination on the part of the child, such as form boards, building bricks, dolls house etc. 2) Other children coming into their line of sight. When the child is playing in the presence of an adult the adult often acts to redirect their attention to the task; when the child is alone this seems not to be the case.

Paradoxically the children do appear to be capable of quite long periods of concentration. This is especially apparent at the group table sessions such as teatime and to a more limited extent story time. The distinguishing feature of these activities in the nursery setting is the social element and usually the presence of an adult. The sand pit and water table are also areas where the children will play for quite long periods. This is almost invariabley solitary play, although some parallel play does occur. Very little co-operative play is observed; that which is tends to be with adults or when adults are present. The playground is one setting where both sustained attention and co-operative play is seen, without the presence of adults.

The children spend a lot of time watching. This often occurs as a result of a distraction and is also evident when a child and adult are interacting in the presence of another child. The watching child often exhibits highly sophisticated turn taking skills, correctly anticipating change overs in the interactions.

GENERAL SYMBOLIC FUNCTIONING

Symbolic Play

In symbolic play situations the children seem to have very limited scripts which recur frequently. These are often easily recognisable daily routines such as making food or drink. There is little evidence of pretend games which require/involve planning, and very few games develop which involve more than one child taking roles. These are much more likely to occur when adults are involved with the play. There appears to be a tendency for the children, some at least, to exhibit highly stereotypical movements. However this could just be a signal that the activities are pretend or play.

Linguistic Mediation.

The children do exhibit behaviour which indicates that sign is used as a cognitive mediator in the free play situation. The best example of this is signing in the mirror during play in the play house or sand-pit etc. However there is also evidence that the children sign to themselves when making decisions during table based activities.

Drawing Activity.

The children do not voluntarily draw or engage in behaviour which is analogous, with any frequency. Paints, as opposed to crayons tend to be preferred. When the paints are out the children tend to paint the whole page in one colour. On one occasion a child did start to paint what looked like a man then seemed to become distracted part way through and went on to fill in the whole paper in one colour. Again the presence of adults seems to act as a focus and in this situation where the adult actively participates in the activity verbally the child begins to paint/draw in a manner which suggest the ability to behave symbolically. Painting activities which produce whole shapes, e.g. potato prints, or non-representational tasks, e.g. string painting,are the most preferred painting activities. In these instances there does not appear to be any attempt on the part of the child to create a structured pattern.

Use of Books and Pictorial Material.

The children do not use the book corner with any frequency. Those that do tend to be the older children, either school age or just pre-school. Apart from one child, the time the children spend looking at the pages of the books is limited, i.e. the children turn each page very quickly. The design of the playroom means that there is little available wall space for hanging pictures, posters etc, at a level which is clearly visible to the children. Those few posters which are displayed are rarely looked at or pointed to.

Conclusions.
The main impression gained from the above is that the children prefer those activities which involve movement or use of or manipulation of materials, and those in which an adult is involved. Despite the high level of activity, much of it appears aimless. Activities which require visual manipulation or which have a high visual requirement, such as drawing, form boards etc are not sought out by the children. The range of types of play seems to be limited, for example there is little evidence of agonistic play or indeed any other type of play which involves peer interaction. Interactions with adults appear to more frequent and sustained than one would expect in a hearing nursery group. The presence of adults serves to increase attention span by reducing distractability and by redirecting the child's attention to the on going activity.

Previous Research on Deaf Children's Play

There is very little research which looks specifically at play in deaf preschoolers, and none involving an all deaf BSL. environment. That which does exist gives an overall picture very much like the subjective report (e.g. Darbyshire (1977)

Higginbotham & Baker (1981) investigated the free play of orally educated deaf children, with a view to determine the relationship between language and play. Social participation and cognitive play were observed in deaf (age 47 to 66 months) and hearing (age 47 to 63 months) children, attending separate pre-school nurseries, during free play sessions. Social participation and play were coded according to the scheme developed by Higginbotham & Baker (1980).

For the social participation categories, they found that the deaf children spent significantly more time in solitary play and less in cooperative activities. For cognitive play categories, it was found that the hearing children spent significantly more time in dramatic play than the deaf. Within groups, the pattern of play differed with the deaf spending significantly more time in constructive play than dramatic or functional play. The hearing group spent approximately equal amounts of time in dramatic and constructive play, and significantly less time in functional play.

Combining social and cognitive play categories, they found that as social participation increased in complexity, from solitary to cooperative, the hearing group spent increasing amounts of time in dramatic play; for the deaf group this trend was reversed with the deaf spending significantly more time in solitary dramatic play. These authors concluded that the differences between the play of the deaf and hearing, were due to the hearing children's use of language, allowing more complex play patterns.

Whilst these authors implicated language they also suggested that other social factors, such as the type of nursery, integrated against segregated, or teacher style may affect the patterns of play. The subjective report above, was written very early in the life of the nursery and it is possible that play patterns may change as the influence of the deaf instructors grows.

Changes in the Nursery

As the nursery became more established and the confidence of the deaf instructors grew, they began to take a much more active role in the organisation and planning of the nursery curricula Whereas at the beginning of the project I had been totally responsible for furniture and equipment layout and had a large influence on the types of the materials which were provided, by the end of the first year of operation the deaf instructors had assumed complete responsibility for this.

The most noticeable change was a reduction in the visual complexity of the environment. Current practice in nursery and reception classes is to provide a visually rich and stimulating environment, with posters and displays of objects to introduce the children to topics with the purpose of stimulating curiosity language etc. It is also common practice to divide playrooms into distinct areas such as the home corner, wet area etc. Increasingly there is a trend to make these areas such that there is restricted visual access from other parts of the room. The deaf instructors created an environment which was almost the opposite of this. Furniture was reduced to a minimum and laid out such that any part of the room could be seen with a minimum of head movement, and also to leave a large area of clear floor space. To my eyes, and the hearing teachers of the deaf, the playroom looked spartan and uninteresting. When questioned directly about their choice of arrangement the deaf instructors usually replied that it helped them to see all the children all of the time. Spontaneous comments were usually concerned with the feeling of space created, and that this felt more comfortable and was much better.

It will be recalled that the playground was an area where the children displayed sustained attention and co-operative play without the presence of an adult. A playground is, of course, an open unstructured and visually uninteresting space. In the case of the playground attached to the nursery, it is surrounded by a high wall on two sides and buildings front onto the other two sides. One other observation is relevant here. During the first summer the children were taken on a picnic to St Georges Field, a large open green space on the campus. I was not especially worried about taking a group of children who could not be controlled at a distance by voice into such a situation as I assumed that they would display exploration behaviour typical of the under fives, i.e. short excursions with frequent returns to the caretakers. In fact I assumed that their lack of hearing would increase the likelihood of their staying close to the caretakers. In the event I was totally wrong. The children immediately strayed long distances from the caretakers and had to be brought back rather than come back voluntarily. They did however always maintain visual contact.

The changes which the deaf instructors made were disquieting to those of us with conventional ideas and training about what constituted an optimal nursery environment. The changes did not appear to reduce the level of the children's activity but the play seemed to become more purposeful and easier to empathise with. The deaf instructors were quite clear that their purpose in the group was increase play participation and facilitate language development. If their structural changes were a means of improving these then we might expect to see some changes in the character of the children's play and interactions.

Interactions

The description of the children's play given above indicates a high rate of adult/child interaction and a low rate of child/child interaction. To confirm the validity of this observation the children's interactions were monitored. Each child was observed for a five minute period during the first two play sessions of January 1988. Observations were made from behind the smaller one way screen. The interactions were categorised on the basis of the initiator and recipient, the three categories being Adult to Child (AC); Child to Adult (CA) and Child to Child (CC). The CC category included only those interactions which were initiated by the child under observation. The teatime activity was included in the sessions with the specific aim of facilitating the development of language skills. If this were succeeding then this may be reflected in the relative frequency of initiations. Hence, data for teatime and free play sessions were recorded separately. The data are summarised in table 7.1.

	AC	CA	CC
Free play	43.63	38.18	18.18
Teatime	28.12	56.25	15.625

Table 7.1. Percentage of Initiations in Each Category

These data confirm the observation that interactions involving adults are the most frequent type, accounting for over 70% of the observations. The context in which the interaction takes place, free play or teatime, affects the relative frequency with which child and adult initiate interactions. The child is twice as likely to initiate an interaction at teatime as the adult, whereas in free play the adult and child are equally likely to initiate interactions.

Considering only child initiated interactions (CA & CC) the recipient is significantly more likely to be an adult than a child in both free play and teatime situations.

The children's interactions were monitored 6 and 11 months after the original, using a modified coding scheme. Originally only the parties involved in an interaction were noted. This was extended to include the method of getting attention and the number of turns each interaction lasted, and instances of the children signing to themselves.

Coding Scheme and Rationale

1. METHOD OF INITIATION

The purpose of this section is to gain information regarding the child's attention getting strategies in social interactions. The categories chosen reflect the possible methods available to the child, and piloting indicated that the four categories, as defined below, exhaustively coded the data. Deaf adults use all four methods, choice of method being a function of hearing and linguistic status, proximity and age of the recipient.

Voice	any vocalisation directed to another person signalled by eye direction or body posture
Touch	contact with the body or clothing of another person, e.g. tapping, pulling clothing, moving face, etc
Sign	a recognisable formal BSL sign made in the direction of, or in the eyeline of another person, or to self. It may be preceded by

eye contact or a short wave.

Mixed Any combination of the above, or a non-sign gesture

2. DIRECTION OF INTERACTION AND STATUS OF PARTNER

All interactions in which a child was involved, either as initiator or as recipient were scored. Categories:-

2a Interactions directed to the child by: Adult Child

2b Interactions from the child to: Adult Child Self

(the child forms a signed utterance where there is no obvious recipient).

The self category was included as it had been observed that children would sometimes sign to themselves during play (see Chapter 8). It was included here to allow an indication of the frequency with which the children engaged in this behaviour relative to social interactions.

3.NUMBER OF TURNS.

This is a count of the number of times control of the interaction changes. The number of turns in a an interaction can be taken as a measure of language functioning (Wood, 1980).

Method

Each child was observed for a five minute period, during the free play session, and all interactions scored on a prepared sheet (see appendix 7). Observations were made in the playroom or playground, depending on the location of the target child when observation began, in view of the child. E was well known to the children and her presence did not appear to disrupt the activities of the children. Previous piloting, under the same conditions had prompted interest from the children, leading to E being asked questions. Hence, at the time of data collection her presence was both commonplace and understood. An alternative strategy would have been to use video to follow the children. However, at this point in the project, the equipment was unavailable owing to rebuilding work in the studio.

A second set of data was collected 5 months later using the same method and coding scheme,(Elf, 1988/9). Part of the piloting work referred to above, had included familiarisation of Elf with the coding scheme. This had involved independent coding, by the two observers, of the same child during the same five minute period. Inter-rater reliability was checked again after the second data collection by both observers coding a video recording of a five minute period of one child.

Results

The results are summarised in table 7.2. The January figures (group A) are included for comparison. Data for group C 13 months, is from Elf (1988/9). Elf observed the children for up to 4 sessions. The data reported here is taken from the last observation made for each child.

		Method				From child to			To child from		Turns
Group	Age	V	T	S	M	A	C	S	A	C	x
A 2mths	47.4	/	/	/	/	.68	.32	/	1	/	/
B 8mths	53.6	.18	.02	.49	.31	.54	.23	.23	.7	.3	1.08
C 8mths	50.2	.12	.1	.38	.4	.44	.44	.11	.54	.46	1.6
C 13mth	55.6	.1	.17	.53	.19	.41	.56	.03	.54	.46	1.57

N.B. Number of months after group letter, is number of months that group had attended the nursery

Table 7.2. Proportion of Interactions in Each Category.

Inspection of the data shows that sign and mixed methods of initiation, are those most frequently used and that use of sign tends to increase slightly, at the expense of mixed methods as length of time in the nursery increases.

The length of time the child spent in the nursery also affects the relative frequency with which the child directs interactions to an adult or a child. Early observations indicated that 70% of the child's interactions were directed to adults. After eight months other children and adults were equally likely to be the recipients of an interaction. It will be recalled that the children knew one another and the adults, before the start of this nursery, from their integrated nurseries. This would reduce the probability of these trends being due to increased familiarity, although it does not rule out the possibility.

Social and Cognitive Play

At the beginning of the second year of the nursery an observational study of the children's play was undertaken by Elf (1988/9), using the categories devised by Higginbotham & Baker (1980). Elf compared the social and cognitive play of two age groups of children from the nursery, and also the data from Higginbotham & Baker. Of interest here are the data from the older Leeds group and the data from Higginbotham and Bakers deaf and hearing groups. Tables 7.3 and 7.4 give the percentage of time each group spent in each cognitive (7.3) and social (7.4) play category.

	Functional	Constructive	Dramatic
Leeds Deaf	30.89	31.53	31.75
H & B Deaf	10.24	57.86	18.74
H & B Hearing	7.77	45.48	41.79

Table 7.3 Percentage of Time Spent in Each Cognitive Play Category

	U	O	S	P	A	C
Leeds Deaf	.78	9.41	34.8	24.38	28.98	2.04
H & B Deaf	1.51	11.67	39.68	21.99	18.81	6.35
H & B Hearing	.94	5.94	12.31	14.99	28.19	37.3

Key: U - unoccupied; O - onlooker; S - solitary; P - parallel; A - Associative; C - Cooperative

Table 7.4 Percentage of Time Spent in each Social Play Category

Inspection of these data shows that the distribution of play across cognitive categories shows the Leeds deaf to spend equal amounts of time in each category. In this respect they are different to either of the other two groups.

The distribution of play across the social participation categories shows little difference between the two deaf groups, with the exception of the associative play category. Within groups, the Leeds deaf spend roughly equal amounts of time in the solitary, parallel and associative categories. By contrast the Higginbotham deaf spend more time in solitary play than parallel or associative.

One of the reasons for creating an all deaf nursery was that the advantage which accrues to the deaf children of deaf parents, may also be gained by the deaf children of hearing parents, if other significant adults in the child's life are deaf. Elf's (1988/9) data, indicates that even though the play profiles of the Leeds children are not identical to the hearing, there is a trend toward play which would be considered age appropriate in hearing terms. A second point is that this trend is evident in an environment created by the deaf adults, to be comfortable to them, an environment I characterised as spartan and uninteresting.

Symbolic Functioning

The subjective report indicated that drawing was not an activity which the children voluntarily entered into with any frequency. Also when the children did engage in either drawing or painting the nature and qualities of those drawing differed from those observed in a comparable hearing nursery. It was also the case that the children seldom used the book corner, or spent time looking at pictures.

Reviews of I.Q. studies of deaf children have suggested that deaf children have I.Q.'s within the normal range, but with a depressed mean. The Goodenough-Harris Draw-A-Man Test fulfils the non-verbal criteria, and has often been used with the deaf. Results give rise to a depressed mean (e.g. Vernon, 1967). Vernon feels that research using the Goodenough test has to be disregarded because;

> "the directions it requires are beyond the language comprehension of a large number of deaf groups to which it is administered." (p329).

He argues that administration would require a demonstration drawing which would then act as a model for the testee, thus, presumably negating the results. However, if this were the case, one might expect that the children's drawings show an increase on average rather than the depressed means reported.

Also Harris (1962) suggests that young children's drawings are not, on the whole, influenced by models but reflect what the children believe to be the case, or their model of the referent. If this is the case then one can assume that if the children produce a drawing then the instructions have been sufficiently understood, and the score should reflect the child's ability. However it still remains to be explained why the deaf consistently score below hearing norms, given that this is not the case with other non-verbal I.Q. tests, nor what would be expected from a sampling distribution. Vernon suggests that any comparison of the cognitive abilities of the deaf and hearing should take into account the possible existence of CNS damage over and above the deafness and also that "the deaf come from a somewhat submerged socio-ecconomic group" (p330), as both of these factors are associated with lowered cognitive performance. However, these should equally influence other test results.

A case in point is the WISC test. Vernon cites the results of four studies using WISC. In three of the four the mean I.Q. of the deaf is normal. WISC correlates well with the Draw-A-Man test in hearing samples, yet of the four instances of the Draw-A-Man test cited by Vernon, none report a normal mean.

Twelve of the children, aged 42 to 60 months (average 48.3 months) were given the Draw-a-Man test by a deaf instructor. On the first occasion the testing was done in the playroom, on an informal basis as part of the free play period. The child was invited by the deaf instructor to draw a man. If the child seemed to be reluctant or not to understand then the instructions were repeated using Daddy.

This procedure produced 2 scoreable drawings from 9 that were completed. In view of the low number of scoreable drawings, it was decided to make the testing situation more formal, and in view of the general reluctance of the children to draw, to offer an incentive.

On the second occasion, one week later, the children were invited by the deaf instructor, to go to a small room off the main playroom. They were told that if they drew a very good picture of a man they would win some sweets. All the children were asked to draw a man like Daddy. After completing this they were given a half formed stylistic man, based on that used by Gesell, and asked what was wrong with him and could they make him better. After the completion of both tasks they were given a small packet of sweets.

This procedure produced drawings for the draw-a-man test with raw scores in the range 0 to 14, which when converted to age norms, gave standard scores in the range, 58 to 95, with a mean of 76.25 (S.D. 10.98). None of the children tested were considered below average intelligence by their teachers, and certainly not to the degree suggested by these scores.

Explaining these results is problematic. The observation that the children preferred painting activities which produced whole shapes, suggested that their performance on the Gessell test would show an improvement over the draw-a-man test. Given Harris's assertion that children are less influenced by models than what they believe to be the case, a higher score on the Gessell test would indicate that the children knew what should have been drawn, but that this was inhibited for some reason, on the draw-a-man test. If language is a factor in the draw-a-man test, then the visuo-spatial demands of the language and the task are potentially interfering. The Gessell complete-a-man would effectively reduce visuo-spatial processing load, thereby making the task easier for the deaf children. The completed Gessell figures were certainly suggestive of this. Unfortunately, an extensive search failed to discover a set of norms for the Gessell test and I was unable to devise a method of comparing results in which I had any confidence.

Cartoons

It was noted that the children spent little time looking at books or other pictorial material. It was also noted that the children were highly sensitive to movement. Considering these together led to the idea that moving pictures may be of more interest to the children.

During one free play session video recordings of a familiar cartoon (Tom and Jerry) and an unfamiliar cartoon (Pluto) were played. The children's attention was not specifically drawn to the cartoons. None of the children showed any interest in these during free play, and only one child commented on the cartoons during tea time.

Summary

The observations in the nursery indicate that within this all deaf environment,deaf children develop patterns of social and cognitive play, which, with time, begin to approach those of hearing children. Visual aspects of the situation are important; observations in the playground indicate that in this kind of visually simple environment, the children show sustained periods of attention and increased cooperative play. Also the deaf adults reduced the visual complexity of the environment within the playroom.

Sustained attention was also noted in the presence of adults, and it was suggested that the adults served to increase attention, by redirecting the child's attention to the on going activity. The third place sustained attention was noted was when the children played in front of the mirror. Wood et al (1986) discussing the importance of contingent interactions to develop the child's ability to concentrate say;

> "The most important single resource in the classroom is, for us, the teacher and other adults." (p45).

The next chapter suggests that the deaf children here have discovered another, possibly more potent, resource - themselves.

CHAPTER 8: Mirror Interactions

INTRODUCTION

The Child Development Unit, in which the nursery is held, contains two one way screens, hence there is a large area of mirror surface in the room. It was noticed early on, that the children made use of this as a personal resource, especially the large mirror which separated the unit and the video control room.

Initially it was felt that the novelty value of mirrors in a classroom, could reasonably account for the children's interest in them. However, mirrors are not novel per se, being common items in everyday use. I expected, therefore, that as the children became familiar with the new environment, the mirrors would loose their attraction. This did not appear to be the case, if anything, their use increased, with the children deliberately seeking out the mirrors on occasion.

This led me to consider the possibility that the children's interactions with the mirrors were of some functional significance. Deaf adults, who had signed as children, reported that they had enjoyed signing to themselves in the mirror, suggesting a language function.

Child's Knowledge of Mirror Images

Reacting to mirror images can be problematic as evidenced by tracking studies etc, or less formally, the problems encountered when putting on make up, or trying to cut ones own hair. The major feature of a mirror image is lateral inversion, with preservation of vertical information. The children appeared to be quite sophisticated in their appreciation of mirror images. They appeared to have no problem in interpreting signed utterances in the mirror, when these came from other people. They would also follow conversations between two people, one being a mirror image, the other real. The point here is that the signing would be by an apparently left handed person.

Signing follows handedness, in that one handed signs are made by the dominant hand and two handed signs with the dominant hand taking the lead. Therefore, the deaf person has to be able to interpret a signed utterance irrespective of the handedness of the sender. At least two of the deaf instructors were left handed, and therefore, the children had experience of left handed signers.

The children were able to track moving objects in the mirror accurately and could also reach out for, or strike objects (or persons), with the mirror image being used for hand eye co-ordination. However some tracking errors were made. These were a consequence of the tracked object or person being obscured and then reappearing. The typical error was to anticipate reappearance at the point where the person or object had disappeared. These occasions invariabley elicited checking between the mirror image and the real object.

That these checking moves by the children led to learning is suggested by the children's use of the mirror to observe otherwise obscured events. For example, one boy was following an interaction between one of the instructors and one of the other children as they walked across the room. As the instructor obscured the child, and consequentially the interaction, the observing child immediately turned to the mirror and looked at such an angle so as to be able to continue to observe the event. This suggests quite a high level of intuitive knowledge of the optical properties of mirrors for a 3/4 year old child.

Mirror Images and Sign Language

All of this begs the question why do the children apparently invest so much learning into the mirror. It has been suggested that the experience of deafness is a visual experience (Erting, 1985). The mirror provides visual experiences which are novel (inversions) useful (environmental monitoring) and rewarding (feedback, contingencies). These three might be sufficient to explain the children's interest in them, but would apply equally to hearing children. No evidence that hearing children do engage in the same kind of behaviour has been found. An inspection of video tapes recorded in a nursery for hearing children, through similar observation screens did not reveal any mirror interactions as described here. Perhaps the unique aspect of mirror images in relation to deaf children is the relationship they bear to sign language.

Efficient use of sign language requires an appreciation of spatial relations, both in the environment and as they pertain to observers from different perspectives, i.e. the treatment of space, and time, which is also marked spatially, is relativistic in Sign. In discussing the development of ASL from Signed English input (Livingstone, 1983) argues that certain structures cannot emerge until the child has acquired sufficient cognitive skills to deal with the spatial structures of the language.

Space is used in four ways in sign language:-
1) it is the medium in which it is transmitted
2) it is used grammatically e.g. to mark tense, or more general aspects of time, pronominal referencing.
3) it is used to represent itself.
4) to compress information (see Chapter 4).
Many of these spatial grammatical devices require that the participants in a conversation can construct a structure between them and then refer to it as a set of locations which is spatially independent of the person who constructed it (see figure 8.1)

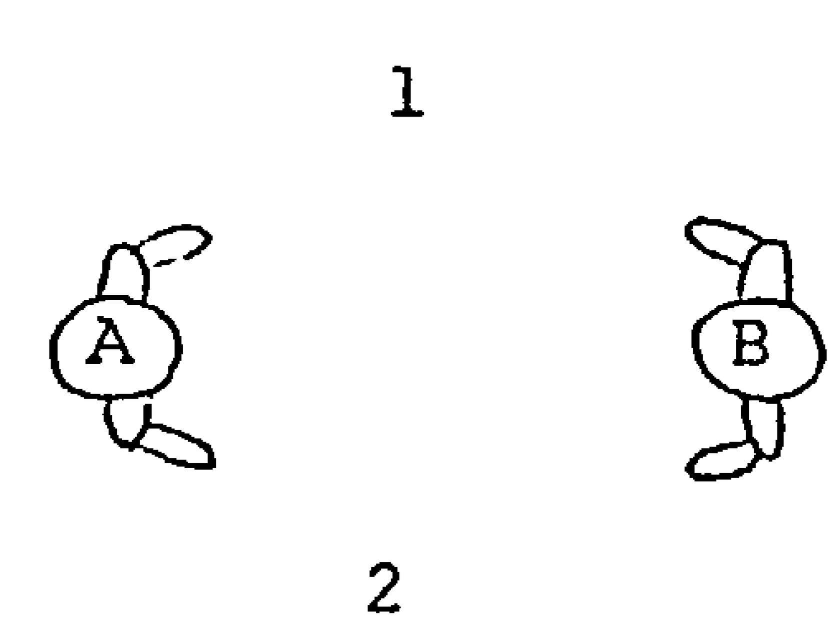

Fig. 8.1: An Example of Placement

In the above figure A & B are participants in a conversation and 1 & 2 represent two events or persons who are being talked about. Let us assume that B introduces a person into the conversion. B gives the person a location in space (1) by signing the persons name and then pointing to a location. Subsequent points to that location refer to that person. Location 1 is to the right of B. Now person B introduces a second person into the conversation who also requires a location for subsequent reference. This is location 2 on B's left. Person A now makes a comment about person 1. To refer to this person A must point to left i.e. the absolute location of 1 in space not the relative location (to the right of the person talking about 1). Similarly with location 2. This is precisely the situation encountered in a mirror image.

This facility is not confined to pronominal referencing but also applies to spatial descriptions. For example a scene containing a social element, such as a person, is described as though the person was experiencing it, not as though they were looking at it. Hearing people learning sign have great difficulty in learning to use placement correctly. Much of the difficulty appears to stem from an inability to treat aspects of space isotonicaly, or perhaps to be unable to divest objects or persons of chirality[1]. In fact the hearing person encountering placement is in the position of the child performing Piaget's three mountains experiment, only in this case the correct solution is to be egocentric!

The production of oral language, under normal circumstances, is accompanied by simultaneous feedback, such that the producer hears exactly what the receiver hears. This feedback allows the producer to control his speech, by, for example, correcting pronunciation errors. If feedback is prevented, say by masking

1. Handedness, describes a variable with two values; left and right. Chirality, describes the same kind of variable, i.e. one with two values. It is this neutral aspect of handedness which I wish to describe by using chirality as opposed to handedness.

with white noise, the person's speech becomes louder as they try to compensate. If compensation is not possible, then intonation and some pronunciation becomes disrupted and sentences become shorter. The speech of people using personal stereos is an everyday example. In the case of sign language, feedback is different. Because sign language involves the face and body as well as the hands feedback is kinaesthetic, whereas reception by the recipient is via the visual channel. The producer may receive some feedback visually, if they look at their hands, but what they see will be very different from that which the receiver sees. A mirror allows feedback which is much closer to the view of recipient. Although not identical, due to the lateral inversion, it could be a useful device for allowing the relationship between kinaesthetic sensation and the visual form of the total sign to be learned, such that necessary corrections can be made on the basis of kinaesthetic information alone.

Hence, the efficient use of sign language requires three skills which have a direct relationship to mirror images, in that they require an appreciation of lateral inversion; understanding opposite handed signers, pronominal referencing, and placement.

Egocentric Speech and Imaginal Dialogue

All young children talk to themselves a phenomenon termed 'egocentric speech'. However, the meaning of this term varies according to the developmental theorist using it. The variation in meaning arises from the functions ascribed to it and its postulated developmental roots. Vygotsky (1962) argues that between the ages of 2 and 7 speech performs two functions; 1) an external function of communicating with others i.e. social speech and 2) an internal function of monitoring and directing thought. Initially the child is unable to distinguish these functions and both take the form of overt utterances, which the child assumes will be understood by others; which is egocentric speech. As the internal and external functions separate, egocentric speech becomes increasingly symbolic and less intelligible to others, eventually being internalised, at around age 7, as verbal thought. Vygotsky bases his arguments on two lines of evidence; firstly the grammatical structure of egocentric speech becomes increasingly like that of inner speech, sometimes described as predicate only speech. Secondly, experimental evidence concerning the conditions under which egocentric speech is present. The social origin, and the assumption by the child that his speech is understood, is demonstrated by a decrease in egocentric speech in situations where the child is either not able to be understood, e.g. in the presence of deaf or foreign language children, or when the child is alone. Egocentric speech is also found to decline where the child is unable to hear himself or others.

Piaget initially viewed egocentric speech as a running commentary on the child's behaviour, a monologue, which does not perform the adult function of communicating ideas to others. At around the age of 7 egocentric speech is replaced by socialised speech which does performs the adult function of communicating to others. Some commentators (e.g. Gross, 1987; Dobson et al, 1981) now argue that Piaget agrees with the views of Vygotsky, that egocentric speech serves the function of planning and directing behaviour.

Some overt speech, both in children and adults, has a grammatical structure which is identical with that of social speech, yet is not directed to some other person. This has been termed imaginal dialogue (Meek, 1985), on the basis that this is speech which is directed towards to an imaginal other. Amongst the functions which Meek discusses, the relevant one here is the role of imaginal dialogue in play. Imaginary friends are not uncommon, and these are spoken to as though they were real. Symbolic play is often signaled and disambiguated for the observer by the language the child uses. The main point here is that imaginal dialogue differs in structure to egocentric speech and also in function, in that it is an end product rather than a means to an end.

Deaf Children and Egocentric Speech

Given the emphasis on the relationship between language and thought in much of the previous work on the deaf there is little if any mention of egocentric speech. I have not been able to find any empirical reports of egocentric speech in deaf children for either oral or sign language. This is especially surprising in the case of Lewis (1968) as this work has the specific aim of investigating the role of language, or lack of it, on the development of internal controls on social and emotional aspects of behaviour, e.g. perceptions of and attitudes towards self and others, impulse control, etc.. He uses the term orectic behaviour to describe this behaviour generally. Given that his theoretical base is that of Luria (e.g. 1966), which posits language as a second signal system, allowing just such an internal control, for both cognitive and orectic behaviour. Egocentric speech, which is an overt and developing manifestation of such internal control would seem worthy of investigation in this respect. Denmark et al (1985) reporting on emotional disturbance in the deaf, argue that early manual communication is protective. If they are correct then, it could be that what this early input of sign language gives the child is the means to internally represent and control his behaviour. Egocentric sign language would be indicative of this. All this presupposes that egocentric speech is indeed a manifestation of linguistic control of behaviour if not thought, and that such processes and functions are equivalent in the deaf and hearing and with oral and sign language. However, irrespective of considerations regarding internal self control, if egocentric speech is seen as nothing but a practice of developing linguistic skills, then to those who argue that sign and oral language are functional equivalents, which develop in analogous ways, then a demonstration of egocentric sign language, or at least sign language used for the self, would strengthen their arguments.

Evidence for Linguistic Basis to Mirror Interactions

Initial interest was focused on examples of the children signing to themselves in the mirror. These examples are incontrovertibly linguistic in nature, in that they are composed of connected discourse in sign which is meaningful to an outside observer. However, there are a large number of interactions which are not overtly linguistic, i.e. are not composed of recognisable signs made with the hands. However, these interactions do involve face and body postures which could accompany signs. Given that the children are often using their hands for the current game/activity it is possible that these face and body postures are the overt part of an imagined utterance. If this is the case then these interactions also have a linguistic base and would have the same characteristics as overt sign sequences. One characteristic of dialogue is turn taking and such behaviour should be evident if the children are behaving linguistically.

Other Uses of the Mirror

Not all the mirror interactions were linguistic nature. In line with Myklebusts 'organismic shift' hypothesis, the deaf child has to monitor his/her environment purely visually, whereas the hearing person can also use the auditory channel. It was noticed that this constant visual monitoring of the environment could prove disruptive to the children as their attention was constantly being drawn away from the on going activity. Two situations were observed where the children showed more sustained periods of attention, in the sense that they were not so likely to be distracted by their environmental monitoring. One was in the presence of adults and the other, when play was in the proximity of the mirror. In cases where the play house was positioned against the mirror, lack of environmental distractors could reasonably account for this. The play house, by its nature, restricts the amount of space in which the child is operating. However, in the cases where interactions took place around the sand-pit, or at one of the table activities, the amount of space in which the child is operating is identical to any free play situation.

Control of Attention

There are two possible reasons why the mirror apparently increases attention to the on going activity. 1) The contingent nature of the interactions is of itself sustaining 2) the mirror increases the ease of environmental monitoring. The large surface of the mirror makes it possible to observe a large part of the room. This means that the children have immediate access to events occurring behind them as well as being able to monitor their own activity. That the children were monitoring the environment, as well as themselves, is evidenced by the fact that the children would often choose to look at the result of their action in the mirror rather than at the real object when each was equally easy, or indeed it meant an extra movement to view the activity in the mirror. That they used the mirror to scan the environment is evidenced by the fact that the children would sometimes check the mirror image with the real world event. This activity seemed on occasion to be initiated by behaviour of a person or object in the mirror which was surprising to the child as evidenced by a) a change of facial expression and/or b) an error in locating the real world object.

In the absence of systematic data, all such discussion is speculative. The above considerations alone are enough to warrant a closer examination of these interactions. The novelty of these interactions, may give rise to some misgivings about the validity and utility of such an investigation. I have argued elsewhere (Chapter 4) that an understanding of the deaf requires data which is derived from observations of the deaf, such that any unique adaptations may emerge. Not to examine these interactions, just because identical observations cannot be made for the hearing, would be a contradiction. The validity or utility of such an investigation can be determined by the outcome; by the presence or absence of discernible patterns or structure in the data. Therefore, an observational study of the children's interactions with the mirror was carried out and is reported below.

Aims and Objectives

The aim of the present analysis is to determine the developmental and or functional significance of the children's interactions with the mirror by examining:-

1) The type of interactions, e.g. linguistic, environmental monitoring,etc.
2) The structure of interactions
3) The relative distribution of linguistic and non-linguistic interactions
4) The effect of social variables, e.g. presence or absence of others on interactions.
5) The effect of symbolic play on interactions
6) The effect of age on 1-5 above.

METHOD

Subjects

Two groups of children attending the departmental nursery on separate afternoons acted as subjects. The older group (N=6) had an age range of 46 to 60 months, with a mean of 52.66 months, and the younger group (N=6) an age range of 37 to 48 months with a mean of 42.33 months.

Data Source

Video tapes of nursery sessions over a consecutive four week period, which had been recorded for another purpose, were examined for mirror interactions. The recordings were made using, a tripod camera, through the observation screen. At this stage, the children were unaware that there were people present behind the screen and that they could be observed or filmed through it.

Although the groups attended on separate afternoons, the layout of the nursery was identical for both sessions. All interactions during the four week period were coded according to the scheme described below.

Coding Scheme and Rationale

A mirror interaction is taken to have occurred when the child has engaged in some behaviour in which the focus of attention is an image reflected in the mirror. The image may be social (i.e. self, other(s), or non social i.e. some aspect of the environment, toy, etc). Behaviours directed at the mirror per se do not count as interactions, e.g. hair brushing, teeth cleaning, adjusting clothing. However these events may lead to subsequent behaviours which are mirror interactions.

The scheme was designed to allow an examination of both the structure and the content of the interaction as it occurred in time. Informal observation suggested that the interactions were deliberate acts by the child. The first set of categories allows a test of this. The focus[1] categories indicate to whom or what attention is directed, at the start of an interaction i.e. the stimulus, and the location categories, where the stimulus is situated relative to the child. Whether the child was alone or with others, and whether the child was engaged in symbolic play or not was also recorded. This gives a complete description of the initiation and context of an interaction.

The decision to dichotomise play as symbolic/non-symbolic was twofold. Firstly, the coding scheme, without play categories, is already complex. Secondly, symbolic play is the type of play, which in the hearing has been related to language (e.g. McCune-Nicholic, 1981). She defines symbolic play as

> "The juxtaposition of a real action and an intended fantasy provides the underlying structure of symbolic play... In symbolic play the child transforms activities from their real objectives and objects from their real counterparts. This transformational quality is the defining attribute of symbolic play (Fein, 1975). (p785/6)"

From this definition it is clear that the major problem which confronts the observer is deciding whether there is an "intended fantasy" or not. For example, a child sweeping the floor with a toy dustpan and brush may or may not be engaged in symbolic play. If the child is sweeping the floor because Mum says dirty floors should be swept then this is not symbolic play, even though the child is using toy props and not real (adult) implements. If, however, the child is pretending, either to sweep up imaginary dirt, or to be some adult engaged in sweeping the floor, then this is symbolic play even if there is real dirt and or even if the child had been using adult implements. To infer pretence, the observer must rely on cues in the child's behaviour. The pretence may be signalled by language. Some children adopt a stereotyped gait and body postures when they are pretending. Dressing up, treating inanimate objects as animate (e.g. dolls), the non literal use of objects, e.g. using a broom as a horse, are all indicative of pretence. Also symbolic play is characterised by being organised and thematic.

	intention
incidental	the child's attention is attracted by the mirror image
deliberate	turns or otherwise indicates intent to look/comment at self or other
not known	already engaged in interaction at start of recording
continuation	previous event a mirror interaction

focus$_1$	
self	sees self
other	sees other person
event	sees event/group activity
	location
front	all locations relative to child.
behind	Multiple entries indicate diagonals. Location is of the stimulus event
left	
right	

Content of Interactions

Interest in the children's interactions with the mirror was initially confined to instances of clearly discernible sign utterances. However, closer examination of the tapes showed that these episodes formed only a proportion of the children's interactions. The present analysis includes all instances of mirror interactions. Some interactions although not clearly sign utterances apparently involved 'turn taking'. Some evidence for this was apparent in the behaviour of the deaf instructors during these interactions. The deaf instructors waited until the child was at a 'turn taking' point before attempting to gain the child's attention, i.e a competent language user behaved as if the interaction with the mirror was linguistic in this sense. Attempts to interrupt the child at points other than these would fail to gain the child's attention until such a point had been reached. It is this type of behaviour which the converse category records.

interaction type	
watch	continuous looks
converse	interrupted looks. turn taking but not overtly verbal
comment	single sign or facial expression
dialogue	connected discourse
initiate	attracting attention of other
explore	checking image to real world

monitor	checking glances
number of turns	a count of the number of apparent turns in the converse and dialogue categories

The $focus_2$ categories indicate to whom or what the interaction is directed. This may or may not be the same as in $focus_1$. The major difference between the two sets of focus categories is that the recipient of the interaction is described in more detail.

$focus_2$	
self per se	
self as actor	own activity not self per se e.g. watching sand-pie come out of the bucket.
self as other	
child	
adult	
environment	some non-social aspect of the situation
imaginary	directed to space as well as mirror

These categories parallel the location categories of the initiating event, in that they are an attempt to record the degree to which the mirror was necessary for the event to take place.

direction	
Necessary	either considerable physical movement required to gain information e.g. event occurring directly behind S.
Peripheral	Event could have been seen out of side of eye i.e. some element of choice in using mirror
Optional	deliberate choice to use mirror i.e. event could easily have been observed or interacted with, without use of mirror e.g. looking at an object S is holding/playing with

Termination of Interaction

The final categories are concerned with what terminates events. If the mirror increases attentional control then we might expect to see a low frequency of distractions for example. Also recorded is the time elapsed, in seconds, from the beginning of the interaction.

	type of end event
distracted	change in focus of attention S passive
interrupted	active distraction of child by another person
switch to real	attention is redirected to real person or event
another mirror	new focus of attention, but still a mirror image
return to activity	

All categories except number of turns and duration are nominal.

The above coding scheme exhaustively coded the data. The data was coded using a Bull AP-L lap top computer, and SMART spreadsheet. Frequency counts, percentages, and transitional probabilities were calculated using the softwares resident statistical provisions. Chi-square and Mann-Whitney analyses were calculated on an Amstrad PCW using the AMSTAT package.

RESULTS

Distribution of Interactions

In a four week period 125 interactions were recorded for the older group and 112 interactions for the younger group. The percentage of interactions falling in each category for each age group is tabulated below (Table 8.1). Chi-square values are for tests of independence of distribution amongst categories with age. All tests are two tailed. Table 8.1a gives chi-square values for each group of categories for each age.

Re-coding after an interval of one month gave 90.4% agreement between the two data spreadsheets. This was assessed by a simple cell by cell comparison of the two data sets, by the

	Old	Young
Intention		
Incidental	9.6	17.85
Deliberate	69.6	52.85
Continuation	20.0	29.46
	X2=7.88; df 2; p<.05	
Focus1		
Self	79.2	68.75
Other	19.2	28.57
Event	1.6	2.68
	X2=3.3; n.s.	
Content		
Watch	48.8	64.28
Converse	12.8	9.82
Explore	1.6	1.78
Comment	32.14	19.64
Dialogue	8.0	3.57
	X2=6.98; n.s.	
Focus2		
Self	29.6	23.21
Self as Other	20.0	14.28
Self as Actor	24.0	33.04
Total Self	73.6	70.53
Child	4.8	12.5
Adult	16.8	16.07
Imaginary	4.0	0
Total Other	25.6	28.57
Environment	0.8	1.78
	X2=12.82; df 6; p<.05	
Termination		
Distracted	4.0	8.04
Interrupted	8.8	4.46
Switch to Real	23.2	25.00
Another Mirror	20.0	29.46
Return to Activity	43.2	33.04
	X2=7.1; n.s.	

Table 8.1 Percentage of Interactions in Each Category.

Group	Old X2	Young X2	df
Intention	77.73	21.13	2
Focus1	124.14	74.48	2
Type	90.08	150.67	4
Focus2	65.23	62.00	6
Termination	58.58	38.5	4

p<.00001 for all cases

Table 8.1a. Chi-square Values and Significance Levels for Distribution Across Category Groups computer. The major difference between the two sets of coding was that the second set recorded more interactions. This was probably as a result of increased familiarity with the instrument and the material.

Intention

As can be seen from table 8.1, the distributions for the two groups follow a similar pattern, both being significantly different from chance. The majority of interactions are deliberate, for both groups. However, the relative frequencies differ for the groups, with the younger group having nearly twice as many interactions which are incidental. The chi-square analysis shows that the distribution of events amongst the categories is age dependant. These data tend to support the view that mirror interactions are intentional behaviours and further, that deliberate use of the mirror increases with age, suggesting that learning is taking place. Further confirmation of this view comes from examining the first interaction of each episode. For the young group 75% of episodes began with an incidental interaction as opposed to 38.89% for the older group.

Focus and Intention

The distribution of interactions amongst $focus_1$ categories follows the same pattern for both groups, with self being the most frequent initiating focus. Chi-square analysis shows that distributions differ from chance for both groups and that the distribution of interactions amongst categories is independent of age.

The transitional probabilities for intention and focus; i.e. given an intention what is the probability of a given focus, are shown in Table 8.2.

	Focus					
Intention	Self		Other		Event	
	Old	Young	Old	Young	Old	Young
Incidental	.67	.75	.33	.2	0	.05
Deliberate	.91	.81	.08	.19	.01	0
Continuation	.48	.64	.52	.36	.04	.06

Table 8.2 Transitional Probabilities From Intention to Focus1

Inspection of the data shows that for the younger group self is the most probable focus irrespective of intention, whereas for the older group self is most probable following incidental and deliberate categories and other is most probable following a continuation. For both groups self following deliberate is highly probable, occurring in 91% and 81% of cases. For both groups social stimuli account for nearly all cases.

Content of Interactions

The distribution of interactions across event types again follows the same pattern for the two groups and is significantly different from chance in both cases. Although the relative frequencies vary between the groups, a chi-square analysis shows this to be independent of age. The predominant category is watch for both groups, with the younger group having the higher percentage (64.28% v 48.8%). The second largest category for both groups is comment, with the older group having the higher percentage (32.14% v 19.64%).

This data could indicate a trend from non-linguistic to linguistic interaction as age increases. If the cells are collapsed to give a linguistic/non-linguistic distribution for both age groups, a chi-square analysis of the resultant contingency table (table 8.3) shows the distribution to be age related (X^2=5.94; df 1; p<.02). The younger group has a higher

	Old	Young
Linguistic	49.6	33.9
Non-linguistic	50.4	66.1

Table 8.3 Percentage of Interactions in Linguistic and Non-linguistic Categories for each Group

proportion of non-linguistic interactions, whereas for the older group, there is little difference in the proportions of linguistic and non-linguistic interactions. These data support the view that use of linguistic categories increases with age.

Duration of Interactions

The above considered only frequency of interactions. The amount of time spent in any one kind of interaction may also vary between linguistic and non-linguistic interactions and between age groups. Table 8.4 gives the distribution of interaction types with respect to time (in seconds). These data show that the proportion of time spent in linguistic and non-linguistic interactions is reversed for the two groups, the

	Old					Young				
Type	Dur.	% total	N	avg.	sd	Dur.	% total	N	avg.	sd
Non-linguistic										
Watch	141	34.5	61	2.3	2.3	262	62.4	72	3.6	2.9
Explore	7	1.7	2	3.5		5	1.2	2	2.5	
Total	148	36.2	63	2.4		267	63.6	74	3.6	
Linguistic										
Converse	87	21.3	16	5.4	3.3	88	20.9	11	8.0	4.7
Comment	38	9.3	36	1.1	.3	33	7.9	23	1.4	.6
Dialogue	136	33.3	10	13.6	14.4	32	7.6	4	8.0	3.4
Total	261	63.8	62	4.2		153	36.4	38	4.0	

Table 8.4 Distribution of Interactions with Respect to Time (seconds)

younger group spending nearly 2/3 of the time engaged in non-linguistic behaviours, the older group spending nearly 2/3 of the time in linguistic behaviours. This difference between the groups is almost entirely accounted for by the categories watch (non-linguistic) and dialogue (linguistic).

Owing to the marked skewness of the distributions Mann-Whitney was used to test for the significance of the difference between age groups in the time spent on types of interaction. These showed a significant difference between the two age groups for the watch category ($U=1443$; $p< .001$, t-tailed ties corrected) and the comment category ($U=276$; $p<.01$, t-tailed, ties corrected). The amount of time each group spent in the converse and dialogue categories was not significantly different.

Considering frequency and duration together, inspection of the raw data shows that for the watch category 55.75% of the interactions had a duration greater than one second for the older group, compared to 75% for the younger group. Hence not only is frequency of watch greater for the younger group, but also the duration. For the comment category the situation is somewhat different. For the older group 8.33% of interactions had a duration greater than one second compared to 39% for the younger group. Hence although the two groups spend a similar proportion of time engaged in comment the older group has a higher frequency of shorter duration interactions.

The non significant differences for the dialogue and converse categories indicate that although a greater proportion of time is spent engaged in dialogue by the older group, this is due entirely to higher frequency, the duration of a dialogue being similar for both groups.

The converse and dialogue categories are characterised by turn taking. Consistent with the above data there was little difference between the groups in the average number of turns per interaction (young $\bar{x}$=3.75 (sd.3.362) range 1-19, older $\bar{x}$=3.272 (sd. 5.487) range 1-40). Some caution is needed here as the distributions were markedly skewed, as indicated by the ranges. The duration of a turn was also consistent between the groups (young $\bar{x}$=1.875(sd.0.275) older $\bar{x}$=1.721(sd.0.334) Bellugi & Fischer (1972) in comparing sign and spoken language show that in adult signers signs are produced at the rate of 2 to 3 per second and that propositions are produced on average at the rate of 1 per 1 to 2 seconds. That the children have similar temporal patterns gives support to the view that the converse category is linguistically based.

It was noted earlier that the younger group had a high proportion of comment interactions over 1 second. It could be that these longer interactions in this category reflect a transition in linguistic development, as the temporal pattern was consistent with a 2 turn interaction.

Interaction Focus

The second set of data labelled focus in table 8.1 is the focus of the interaction per se as opposed to the focus of the initiating event. The sub totals for self and other give an indication of the extent to which interaction focus differs from initiation focus.

The distribution of interactions across categories differs for the two groups, both being significantly different from chance. A chi-square analysis shows this distribution to be age dependant. Although the relative frequencies of all self and all other categories is the same for both groups, for the older group self is the most frequent category, whereas for the younger group self as actor is the most frequent. This distribution perhaps reflects the relative frequencies of events in the linguistic and non-linguistic categories. Table 8.5 gives the transitional probabilities of interaction type and interaction focus.

	Focus						
Old Deaf	**Self**	**Self as other**	**Self as actor**	**child**	**adult**	**imag.**	**environ.**
Watch	.18	0	.49	.05	.26	0	.02
Converse	.37	.44	0	.06	.13	0	0
Explore	0	0	0	.5	.5	0	0
Comment	.55	.39	0	0	.05	0	0
Dialogue	0	.8	0	0	0	.2	0
Young Deaf							
Watch	.11	0	.5	.15	.24	0	0
Converse	.18	.73	0	.09	0	0	0
Explore	0	0	0	0	0	0	1
Comment	.66	.17	.04	.08	.04	0	0
Dialogue	0	1	0	0	0	0	0

Table 8.5 Transitional Probabilities of $Focus_2$ Following Event

The major differences between the two groups are in the transitional probabilities associated with the converse and comment categories to the self categories. The high transitional probability for converse to self as other, for both groups, again suggests a linguistic base for this category. One interesting point is that Dialogue is never addressed to

Self, in either group, in contrast to the other linguistic categories.

Termination

The distribution of events between termination categories was significantly different from chance for both groups and independent of age (X^2=7.1; n.s) suggesting that termination is a function of interaction type. The low frequency of distraction and high frequency of return to activity gives support to the suggestion that attentional control is increased in this situation.

Table 8.6 shows the transitional probabilities from event type to termination. The high transitional probabilities for the return to activity category reinforce the frequency data with respect to increased attentional control. This is especially evident for the linguistic categories. The very high transitional probability associated with dialogue category for the older group raises the possibility of the linguistic control of attention.

	Distract		Interrupt		Switch to Real		Another Mirror		Return to Activity	
	O	Y	O	Y	O	Y	O	Y	O	Y
Watch	.06	.08	.08	.03	.38	.32	.23	.26	.24	.3
Converse	.06	.18	.19	.09	.06	.09	.19	.18	.5	.45
Explore		.5			.5				.5	.5
Comment			.08		.05	.16	.22	.5	.64	.3
Dialogue		.25		.25	.2				.8	.5

Table 8.6 Transitional Probabilities Interaction Type to Termination

Factors Affecting Interactions

The preceding analysis indicated that the two groups differed in the time distribution between linguistic and non-linguistic interactions and also in the frequency distributions of interaction focus. Both of these results may be a function of the type of play they were involved in at the time of the interaction and/or the presence of others, as both of these have been shown to be related to linguistic behaviour.

Note on Treatment of Data in Remaining Sections

It will be recalled that the data was derived from video recordings which had not been made specifically for the purpose of this study. As a result of this the number of observations in some of the following conditions is such that analysis is compromised. The decision to continue with the analyses in spite of this was taken on the basis of the uniqueness of the observations and the desire to determine if future investigations of these mirror interactions might provide useful data.

The following example is typical of the data sets which will be reported on pages 150-154. The small number of events observed when the children are alone and the relatively large numbers of categories amongst which the observations are distributed makes statistical treatment of the data problematic. Inspection of individual children's data for the 'with others' category shows a good deal of consistency in the data, which is not evident in the 'alone' data. Table 8.7a shows the distribution of interactions amongst interaction types expressed as a percentage of each child's interactions.

	Alone					Others				
	W	E	Cv	C	D	W	E	Cv	C	D
Old Deaf										
S1	16.6		83.3			59.0			36.36	4.54
S2						52.38	4.16	9.52	38.09	0
S3	62.5		12.5	12.5	12.5	40.0	4.0	12.0	28.0	20.0
S4	25.0		25.0	50.0		50.0		11.11	29.62	7.4
S5						50.0			50.0	
Young Deaf										
S6						64.7	2.9	8.8	26.4	
S7	83.3	8.3	8.3			50.0			50.0	
S8				100		66.6		16.6	7.14	9.52
S9	100					75.0			25.0	
S10						54.54			45.45	

Key: W=watch; E=environment; Cv=Converse; C=Comment; D=Dialogue

Table 8.7a Percentage of Interactions in Each Category for Each Child.

The table also shows more consistency in the data of the older group, than in that of the younger group. In any event it is the relative distribution of linguistic behaviour between the two situations which is pertinent. If one considers total Linguistic versus total non-linguistic interactions in the presence of others then a Wilcoxon test shows that the young group have significantly more non-linguistic interactions ($T=0$; $N=5$; $p<.05$, t-tailed), whilst there is no significant difference for the older group. Between groups comparisons using Mann-Whitney U tests show no significant between groups differences for either linguistic or non-linguistic interactions. It was not felt appropriate to compare the data between conditions (alone v presence of others) by this method. Also there is a problem with using multiple comparisons, in what is essentially a multivariate design.

Pooling individual subject's data and using Chi-square analysis gives comparable results for the data just analysed (see below). Whilst recognising that this use of chi-square with repeated measures is not correct, the data for this section and that relating to symbolic play will be "summarised" in this way. The intention is to provide a description of the data, which is indicative of trends, and hence may the indicate the usefulness or otherwise of further investigations, and not to claim the findings as substantive.

Presence of Others

The presence of others has been shown to affect the presence of egocentric speech (Vygotsky). Hence if the children are engaged in egocentric speech, then we might expect to find a differential distribution between linguistic and non-linguistic categories in the presence or absence of others. 22.05% of the older groups interactions and 15.93% of the younger groups interactions occurred when the child was alone. Immediately obvious here is the high percentage of interactions which occurred in the presence of others. It will be recalled that the data was collected from video tapes made for another purpose. As that purpose was to examine interactions per se the camera was inevitably focused on groups, rather than single children. Therefore no significance can be attached to the distribution. In any event it is the relative distribution of linguistic behaviour between the two situations which is pertinent.

The distributions of interaction types for being alone or with others is given in table 8.7 for both groups. The presence of others makes no significant difference to the distribution of interaction types either within or between groups. Therefore the distribution is not age related.

	old				young			
	alone		other		alone		others	
	f	%	f	%	f	%	f	%
Watch	13	48.2	48	49.0	12	66.6	60	63.8
Explore	0	0	2	2.04	1	5.6	1	1.1
Total	13	48.2	50	51.04	13	72.12	61	64.9
Converse	4	14.8	12	12.2	1	5.5	10	10.6
Comment	8	29.6	28	28.6	4	22.2	18	19.1
Dialogue	2	7.4	8	8.3	0	0	4	4.2
Total	14	51.85	48	49.1	5	27.7	32	35.1

Table 8.7 Distribution of Interaction Types When Child is Alone or With Others for Young and Old Deaf

Collapsing cells and considering linguistic versus non-linguistic categories again shows no significant differences either within or between groups, although a trend is evident in the comparison between the old and young groups in the presence of others, where the chi-square just fails to reach significance (X^2=3.584; df 1; p=.0552), the younger group having a higher proportion of non-linguistic interactions in the presence of others. The older group have roughly equal proportions of linguistic and non-linguistic events in the presence of the others.

Presence of Others and Event Focus$_2$

The presence of others might be expected to effect the focus of the interaction, if for no other reason than more choice is available to the child. The distribution of interactions across focus$_2$ categories is given in table 8.8.

	old		young	
	alone	other	alone	other
Self	17.85	32.32	33.33	21.05
Self as Other	35.71	15.15	5.56	15.78
Self as Actor	17.85	25.25	22.22	34.74
Total	71.74	72.57	61.11	71.57
Child	3.57	5.05	22.22	10.53
Adult	10.71	18.18	11.11	16.84
Environment	3.57	1.0	5.56	1.05
Imaginary	7.14	3.03	0	0
Total	28.26	27.43	38.89	28.43

Table 8.8 Percentage of Interactions in each Category According to Presence of Others for Young and Old Groups.

Chi-square analyses show that the distributions do not differ significantly either within or between groups. The alone/not alone classification was determined by the state of affairs at the beginning of the interaction. That this changed during the course of the interaction is indicated by the presence of entries in the child and adult categories for the alone distributions. Of more interest is that the presence of others does not reduce interactions which are directed to the self categories. This is the case for both groups. Inspection of the table suggests that the presence of others may affect distribution of interactions within the self categories. For the older group the distribution of interactions differs significantly depending on the presence or absence of others (X^2=6.835; df 2; p<.05). This difference is almost entirely accounted for by the categories self and self as other, self being more frequent in the presence of others, self as other being more frequent when the child is alone. The difference in the distributions for the old and young groups when alone just failed to reach significance (X^2=5.4; df 2 ;n.s.). The most noticeable difference here is the low frequency of interactions to self as other for the young group compared to the old group. There are no other significant differences either within or between groups.

Play and Interaction Type

A reciprocal relationship has been suggested between the development of symbolic play and language. Therefore, we might expect to find both type of play and age having an effect on the distribution of interactions. 24% of the older children's and 38% of the younger children's interactions were observed during symbolic play. The same caution apply here, as to the previous analyses, about attaching any significance to the relative amounts of symbolic and other play observed.

The distribution of interactions across types for symbolic and non-symbolic play is given in table 8.9 for both groups. The distributions do not differ significantly either within or between groups.

Considering total linguistic and total non-linguistic interactions, Chi-square analyses show that the distribution of linguistic interactions across symbolic and other types of play differs significantly from chance for the older group (X^2=3.75; df 1; p<.05)but not the younger group. The distribution is age dependant for symbolic play (X^2=5.72; df 1; p<.02) but not for other types of play. Hence linguistic interactions increase with age during symbolic play.

	old		young	
	symbolic	other	symbolic	other
Watch	30	54.74	57.14	69.57
Explore	3.33	1.05	4.76	0
Total	33.33	55.79	61.9	69.57
Converse	10	13.68	9.52	10.14
Comment	40.0	25.26	28.57	14.49
Dialogue	16.67	5.88	0	5.8
Total	66.67	44.82	38.09	30.43

Table 8.9 Percentage of Interaction Types According to Type of Play for Old and Young Groups

Type of Play and Event Focus$_2$

Table 8.10 contains the distribution of interactions across focus$_2$ categories for symbolic and other types of play. For the older group self is less frequent during symbolic play than other types where it is the most frequent. During symbolic play self as other is most frequent. For the younger group there is no difference in the distributions for the three self categories. The major differences for the young group are in the relative frequencies of interactions to child and adult, child interactions being more frequent during symbolic play.

	old		young	
	symbolic	other	symbolic	other
Self	10.0	35.79	25.58	21.754
Self as Other	33.33	28.42	11.63	15.94
Self as Actor	23.33	28.42	30.32	34.78
Child	3.33	5.26	23.26	5.8
Adult	16.66	16.84	4.65	23.19
Environment	0	1.05	4.65	0
Imaginary	13.33	1.05	0	0

Table 8.10 Percentage of Interaction Focus According to Type of Play.

These distributions between symbolic and other types of play differ significantly for both the older group (X^2=14.97; df 6;

p<.05) and the younger group (X^2=16.06; df 5; p<.05). Also they are age dependant for symbolic play (X^2= 21.04; df 6; p<.01) but not other types of play (X^2=10.33, n.s.) .

DISCUSSION

Summary of Results

The results show that the children make deliberate use of the mirror and that deliberate use of the mirror increases with age. Interactions are structured, in that distribution of interactions amongst categories is significantly different from chance. Overall, the distribution of interactions according to type is not age related. However, when total linguistic interactions are compared with total non-linguistic interactions, the distribution of interactions is age related with the older group having equal frequencies of linguistic and non-linguistic interactions, whilst the younger group has a frequency of non-linguistic interactions nearly twice that of linguistic interactions. The termination of the interactions is characterised by the low frequency of distraction and the high frequency of return to activity. This indicates that the mirror functions in some way to aid attentional control. This is reinforced by the transitional probabilities from interaction type to terminating event. High transitional probabilities for the linguistic categories for both groups raise the possibility of linguistic control of attention.

The presence of others did not affect the distributions of interaction types between or within groups overall, although an age related trend in distribution between linguistic and non-linguistic categories was evident. Overall the $focus_2$ of interactions did not differ either within or between groups with respect to the presence of others. However, the presence of others did significantly affect the distribution of interaction types across the three self categories for the older group. Irrespective of the presence of others a high percentage of all interactions were addressed to the self categories for both groups.

Overall, type of play did not affect the distribution of interaction types either within or between groups. However, type of play affected the distribution of linguistic and nonlinguistic interactions for the older group, but not the younger group. The distribution of linguistic and non-linguistic interactions is age dependant for symbolic play, but not other types of play, with linguistic interactions increasing with age. The distribution of interactions across $focus_2$ categories differed significantly from chance between symbolic and other types of play for both groups. Also the distribution for symbolic play is age related but not for other types of play.

The Linguistic Basis of Interactions

Whilst the dialogue category can be seen to be linguistic, in that it is composed of formal signs this is not the case for the converse category and to a lesser extent the comment category. The comment category included single formal signs, single gestures and single facial expressions. Converse included combinations of gestures and facial expressions which showed turn taking characteristics. The formal signs pose no problem, however, in a sign language environment assigning linguistic status, or otherwise, to gestures and facial expressions is problematic. Facial expression and use of the body is a part of sign language. Gestures could well be 'mumbled' signs or even signs not recognised by the observer. In the preceding analyses I have given both these categories linguistic status. My initial reason was, as already stated, the turn taking character of the converse category and the behaviour of deaf adults towards children engaging in such behaviour. In the event, I would argue that the data gives support to my contention that these interactions are linguistic. The temporal characteristics are indicative. The linguistic categories are mainly addressed to self and self as other for both groups but are also addressed to adult and child. That age related changes were found in the frequency of these categories, with age increasing their frequency, is also indicative.

Functions of Linguistic Interactions

Two possible functions have been suggested for overt linguistic behaviour, not directed specifically to real others; 1) egocentric speech, as a means of planning and directing on going behaviour or as a running commentary on behaviour and 2) imaginal dialogue as an adjunct to symbolic play.

Language for Self

Approximately 70% of interactions involved self categories, slightly over half of which were linguistic with comment being the predominant category. In other words 33% of the younger groups and 43% of the older groups interactions were self addressed and linguistic. By contrast 2% of the young group's and 4% of the older groups interactions were linguistic and addressed to others. In addition a high proportion of interactions were intentionally addressed to self, 91% and 81% for old and young groups respectively. Is this, in concert with the other analyses sufficient to show evidence for either or both egocentric speech and imaginal dialogue? My intuitive feelings, both on observing the behaviour for the first time and after spending many hours viewing the tapes, is that these interactions are integral and functional aspects of the child's behaviour. However, it is incumbent upon the data to show formal support for such intuitions. One of my intuitive reasons was that I reacted to the linguistic interactions as though they were messages, i.e. I attempted to interpret them. The deaf adults behaved in a similar way. When shown tapes of dialogue interactions, the deaf adults agreed that they were examples of sign language, but had difficulty in interpreting some of them, which surprised the adults. Their comments were that the child was missing things out, it was as if they were seeing only half a conversation and that some of the signs were partial or mis-formed. These comments were also made regarding samples of converse interactions. The dialogue category included only examples of formal signing which were recognisable to a relatively unskilled signer and therefore, it not surprising that the deaf adults agreed with the observation. Of more relevance to the point in question is that the adults did not find the language used wholly intelligible in all cases.

Imaginal Dialogue

The reactions of the deaf adults, then, lends some support for both egocentric speech and imaginal dialogue. One of the $focus_2$ categories was imaginary. This was defined as interactions directed at space as well as the mirror. This category was used by only one child aged 57 months. There were five of these interactions, all dialogue including as many as nineteen turns, distributed between the child's mirror image and a single definite location in space. Four of these interactions occurred during symbolic play and were clearly a part of that play. Had a hearing child, using oral language been observed similarly engaged there would be no hesitation in stating that the child was engaged in an imaginal dialogue. I can see no reason why the deaf child's sign language behaviour should be treated differently. In addition the majority of all other instances of dialogue were addressed to self as other and for the older group linguistic interactions in general were more prevalent during symbolic play. On this basis I would conclude that deaf children in a sign language environment engage in imaginal dialogue.

Egocentric speech

Some characteristics of egocentric speech have already been noted, with respect to the dialogue and converse categories; abbreviated form, low intelligibility, and not being addressed to another person. In the case of the converse category it could be the case that these interactions are not intended to convey meaning. Whilst this may be true for some instances, the similarity of temporal patterns between converse and dialogue, the addressing of these interactions to self as other as well as other people, and the reactions of competent language users all suggest a linguistic intent. By and large instances of converse interactions occurred when the child's hands were occupied with the on going activity, which would effectively preclude the formation of signs, although not necessarily prevent a gesture being made. In this sense these interactions represent a physically abbreviated form of language, if not the grammatically abbreviated form associated with egocentric speech.

Contrary to what would be expected, if these linguistic interactions are examples of egocentric signing, the presence of others did not increase linguistic interactions, although a trend was evident for the older group. However, presence of others is not the only factor which affects egocentric speech; if a child cannot hear himself then egocentric speech declines. The feedback possibilities of the mirror were raised in the introduction. The mirror not only provides feedback to the signing child, but increases it, by giving the child a perspective on his own signing which he has no other way of obtaining. If the interactions are in fact instances of egocentric signing, it is possible that this unique access to feedback maintains the level of production in the absence of others, leading to the observed results.

Evidence that these interactions are involved in the planning and or control of behaviour would strengthen the case for egocentric signing. The content of some interactions is clearly of this nature. These include the child telling themselves to be careful, choosing which colour paint to use next 'out loud', signing to the mirror image of self that whatever the sand represents is hot, indicating to the mirror image of self where the sand-pie is going to be put, asking a question of the mirror image of self and answering it, etc.. More formal evidence is found in the transitional probabilities from type of interaction to terminating event. Vygotsky's (1962) formulation of egocentric speech and Luria's (e.g. 1981) views on language as a second signaling system have in common the idea that language can function to bring behaviour under conscious control, by freeing the person from the perceptual pull of the immediate context. All types of interaction are resistant to distraction, but an additional feature of the linguistic categories is the high probabilities associated with return to activity. This suggests that the interactions are embedded in the on going activity. Further confirmation of this comes from examining the raw data for temporal contiguity between interactions. There are few single interactions, the majority occurring in clusters during short intervals, 5 in 10 to 15 seconds is not uncommon, with longer periods, between clusters. I feel that there is sufficient weight of evidence to support the view that at least some of the linguistic mirror interactions are examples of egocentric signing, which functions to direct on going behaviour.

Other Linguistic Functions

One final point is that not all linguistic interactions were addressed to aspects of self. As was noted earlier a small proportion of interactions are directed to others, i.e. the mirror is used for direct inter-personal communication. This use of the mirror was not confined to the children; the deaf instructors communicated both with the children and between themselves via the mirror. There seems to be no other reason for this other than the mirror is there and it allows eye contact with someone who's back is turned.

Other Functions of Mirror Interactions

Not all mirror interactions were linguistic. Overall, half the mirror interactions were in non-linguistic categories mainly watch. Descriptions of oral deaf pre-schoolers play indicate that they spend more time in onlooker behaviour than hearing children (e.g. Higgenbotham & Baker, 1981), are easily distracted and attend to themselves more (e.g. Gorrell, 1972). The data reported here could be indicative of just that; the watch interactions being instances of distractions, with self addressed interactions being instances of self attendance and interactions addressed to others being examples of onlooker behaviour. I do not dispute that this description may be true of some interactions, but would argue that aspects of the data make this description inadequate for all cases.

A distractor is, by definition, some event which causes the person to unintentionally switch his attention from an on going activity to itself. Where an interaction has an entry in both the watch and incidental categories then this is almost certainly a case of distraction. A watch which has an entry in the deliberate category cannot be seen as a distraction.

Methodological Note

The mirror provided a window through which we could observe the secret world of these deaf children. Through it a world much richer in language and imagination, than might be predicted from previous work, is observed. This chapter is an example of direct observations of the deaf demonstrating unique adaptations.

CHAPTER 9: Problem Solving Processes in Deaf Pre-school Children for Lure Retrieval Problems

INTRODUCTION

The study of problem solving in deaf and hearing 6 year olds, reported in Chapter 5, suggested that for the deaf group social interaction was as important as language per se in the problem solving setting. Whilst in absolute terms, number of spontaneous solutions, there was little difference between the groups in their ability to solve the problems set there were differences between the groups in their ability to make use of information discovered or supplied during the course of problem solving. Various analyses suggested that this was a function of the way the different groups interacted with elements of the problem solving environment, including E. A Markov chain analysis demonstrated a well developed unitary process for the deaf group, which was not the case for the hearing group. This unitary process, suggested that the deaf child's problem solving strategy was directed towards some consistent factor in the problem solving environment. It was suggested that E might be this constant factor and that the process in which the deaf children were engaged was the application of strategies developed to solve the problem of communication.

Experimenter effect is well documented (e.g. Rosenthal & Jacobson, 1966). Vernon (1967) has reported that the more experienced an E is in working with deaf children, the less likely they are to find differences in behaviour between deaf and hearing groups. In both cases the experimenter used the language code appropriate to the hearing status of the child i.e sign or oral English, therefore any effect could not reasonably be ascribed to language per se. Brasel & Quigley (1977) cite evidence which indicates that the improved achievement of the deaf children of deaf parents, is apparent irrespective of the language code used by the parents. It is argued that social and emotional factors are important; that in a deaf family, deafness is accepted and understood and, therefore parent - child interactions are not disrupted by the trauma of discovering that one has a handicapped child. Work by Mogford et al (1980) with pre-verbal deaf children has suggested that the interactions between deaf mothers and their babies are qualitatively different from those of hearing mothers with deaf babies, in a number of contexts. Further it is suggested that the effects of this are not purely social and emotional, but may also have cognitive implications . The major difference between the two groups of mothers seems to be in the way deaf mothers develop contingencies in their deaf children by directing and controlling their attention.

The problem of 'divided attention' has been raised by many writers (e.g. Wood et al.,1986). Divided attention in this context means that by virtue of his deafness the deaf child cannot look at and talk about a referent at the same time. This is true whatever language code the child and caretaker use as reception must be visual. What the deaf mother appears to be able to do is to make clear to the child the intended referent and the manner in which the message relates to that referent.

Observations in the nursery suggested (but were not formally tested) that the deaf children were aware of, and showed a preference for those adults who were themselves deaf. If, as suggested above, the deaf person can act contingently with the deaf child in a manner which the hearing cannot, then this is not altogether surprising. However, it does imply that any special qualities in interactions with deaf children are not confined to mother-child interactions but are general to deaf-deaf interactions.

If this is indeed the case then it is possible that in the previous study the hearing Es lack of this special quality was eliciting the behaviours found, either to compensate for Es lack of contingency or in "an effort after meaning" by the child, or perhaps even both. The most obvious test of this is to repeat the experiment using a deaf experimenter with the deaf children. If the hearing status of E is a causal factor, then the behaviour of children in a deaf environment should differ from the behaviour observed in a hearing environment.

A strict replication proved impossible as there were no deaf children of the correct age and with a similar language history available. Chulliat & Oleron (1955) reporting Rey's 1935 hearing data indicated that problems were suitable for nursery age children and therefore it was decided to use children attending the departmental nursery as Ss. A second group of nursery aged hearing children was not tested for two reasons. Firstly, the focus of this study was the difference in the behaviour of the deaf groups with Es of different hearing status. Hence, the relevant comparison was deaf/deaf not hearing/deaf. Secondly, the 1935 and 1955 data showed that performance on the tasks increased with age. Although no data for nursery age deaf children was reported there was no reason to suppose that their behaviour would differ from that of the hearing in this respect, i.e. that the problems would be easier for the younger deaf children. Therefore, it was expected to find an age related decrease in absolute performance.

In view of the more limited attention span of the younger children, only two problems were given the cage and the slider. These two problems were chosen as they showed the least and most difference in behaviour between the groups and are also the easiest and most difficult problems.

Aims

The aim of this study is to examine the influence of hearing status of E on the problem solving behaviour of deaf children.

METHOD

Subjects and Experimenter

Six pre-school deaf children attending the departmental nursery acted as subjects. Ages were in the range 26 to 56months, mean age 38.8 months. A deaf Instructor, well known to the children, acted as experimenter. All communication was in BSL.

Apparatus

The Cage and Bottle problems, described in Chapter 5, were used. Drawings are in appendix 5

Procedure

All the children were tested individually, in a small 'booth' situated in the playroom, directly in front of the observation screen. The booth was a play house, with the windows blocked, to prevent other children looking in. The sessions were recorded through the observation screen and the children were not aware that they were being filmed through the screen, although they were aware that the video cameras permanently mounted in the playroom were used to film them. In all other respects the method was as described in Chapter 5.

RESULTS

Method Analyses

The video tapes were transcribed as a series of discreet behavioural acts, and these transcripts were used for all analyses.

Cage Problem

The data were scored according to the coding scheme described in Chapter 5. The data are shown in table 9.1., along with the totals for the older deaf group.

The young deaf children made twice as many attempts on average (mean 6.67) than the older group (mean 3.14)and were less likely to choose the appropriate tool at the first attempt.

Despite this 3/6 of the younger children, compared to 2/7 of the older deaf children, solved the problem without suggestion from E, the remaining children in both groups solving the problem after a suggestion from E. None of the younger children used the turn-table to assist in recovering the sweet.

Subject	A	AT	T	S	SE	TT
D1	2	0	+	+		-
D2	9	0	-	-	+	-
D3	9	0	-	+		-
D4	4	0	-	-	+	-
D5	6	1	-	-	+	-
D6	10	1	+	+		-
Total	40	2	2	3	3	0
Old Deaf(N=7)	22	6	5	2	5	2

Table 9.1 Method Scores for Cage Problem: Young Deaf (N=6)

Slider Problem

The transcripts were scored according to the coding scheme described in Chapter 5. The data are tabulated below, along with the totals for both the deaf and hearing older children (table 9.2). Data from S's D2 and D4 were lost due to a recording error.

Subjects	A	I	T	S	PS	NS	E
D1	3	-	0	-	+	1	
D3	8	-	2	-	+	1	
D5	3	-	0	+			
D6	1	-	0	+			
Total	15	0	2	2	2	2	
Old Deaf(N=7)	63	7	26	0	3	4	6
Old Hear(N=8)	52	1	3	1	7	20	2

Table 9.2 Method Scores for Slider Problem: Young Deaf (N=4)

These data show that the young deaf behave more like the older hearing group than the older deaf group. The young deaf make fewer attempts in all (mean=3.75) than either the older deaf (mean=9) or the older hearing (mean=6.5). None of the young deaf try impetus as a solution compared to all of the older deaf group. Only one of the young deaf group failed to discover the throat immediately compared to 6 of the older deaf group. 2 of the young deaf group solved the problem without suggestions from E and 2 offered partial solution. Both of these children used this information to discover the correct solution after only 1 further attempt. The older subjects (1 deaf and 5 hearing) who offered partial solutions needed 4 further attempts on average to discover the correct solution.

Hence the younger deaf differ from the older group in requiring fewer attempts to solve the problem, and in being more able to use information discovered in the course of problem solving to arrive at a correct solution. Like the older hearing group, the young deaf do not try impetus as a solution, but actively search the apparatus and discover the throat.

In some respects the data of the young deaf group are better than those of the hearing group in that the younger deaf are more efficient when numbers of attempts are considered. However the small sample makes such an assertion speculative, but the data would appear to warrant a larger scale study.

Behavioural Analyses

The preceding analyses suggested that the problem solving behaviour of the older and younger deaf groups differed. The behaviour of the two older groups was found to differ on a number of behavioural measures and that some of these could be systematically related to successful problem solving behaviours. Hence we might expect differences in the behaviour of the older and younger deaf groups to be reflected here also. Table 9.3 shows the mean number of behaviours transcribed for all three groups for the Cage and Slider problems.

The number of behaviours elicited by the Cage problem from the young deaf is similar to the old deaf group, both of which differ from the old hearing group. For the Slider problem, however, the young deaf are similar to the old hearing group in the number of behaviours elicited, both of these groups recording half as many behaviours as the old deaf group. This reduction in numbers of behaviours for the young group is due to the fact that they did not demonstrate the perseverance in the pursuit of ineffectual methods which were apparent in the older deaf group and the deaf S's of Chulliat & Oleron.

	Cage	Slider
Old Deaf	75.14	68.35
Old Hearing	30.48	33.13
Young Deaf	62.12	28.0

Table 9.3 Mean Number of Behaviours

For the older deaf children, the frequency with which the children looked at E was noted, and comparisons made with the older hearing children. Table 9.4 shows the percentage of total behaviours which were looks to E, for all three groups, for the Cage and Slider Problems.

	Cage	Slider
Old Deaf	23.76	16.15
Old Hearing	12.95	14.28
Young Deaf	20.11	25.00

Table 9.4 Percentage of Behaviours Which Were Looks to Experimenter

The data for the young deaf are not strictly comparable as it was almost impossible to exclude looks to E which were not concerned with direct communication. This was due to E making use of looks directed towards her for communication i.e. waiting for the child to volunteer eye contact rather than attracting the child's attention when E wanted to communicate.

The distribution of visual behaviour preceding a tool change was categorised according to the scheme described in Chapter 5. These data are shown in table 9.5 and graphically in Fig. 9.1 where data for the two older groups is included for comparison.

Inspection of the table shows that there is little change in the distribution of behaviour between categories for the young deaf group. From Figure 9.1 it can be seen that there is little difference in the distribution of behaviours preceding a tool change for the two deaf groups, with E being the predominant

	Cage	Slider
E	67.5	60.0
A	5.0	6.66
T	17.5	26.6
U	10.0	6.66

Table 9.5 Distribution of Events Preceding a Tool Change (Young Deaf)

category for both problems. Table 9.6 gives the distribution of behaviours preceding the choice of the final (successful) tool. This is shown graphically in Fig. 9.2, with data from the older deaf and older hearing group for comparison.

	Cage	Slider
E	50	25
A	0	0
T	33.3	75
U	16.7	0

Table 9.6 Distribution of Events Preceding Choice of Successful Tool (Young Deaf)

Inspection of table 9.6 shows that when only the final choice of tool is considered the young deaf group show a shift in behaviour between problems; E being the most frequent preceding event for the cage problem, T the most frequent for the slider problem. Figure 9.2 shows that the behaviour of the young deaf group differs from both the older groups, but is more like that of the hearing group than the older deaf group with success being related to a category other than E (T) in 3/4 subjects. As with the hearing group the younger deaf are able to make use of information gained during the course of problem solving.

Matrix Analyses

4 (preceding category) x 4 (succeeding category) frequency matrices were constructed for each problem as described

Figure 9.1/2 Distribution of Visual Behaviours Preceding Tool Change

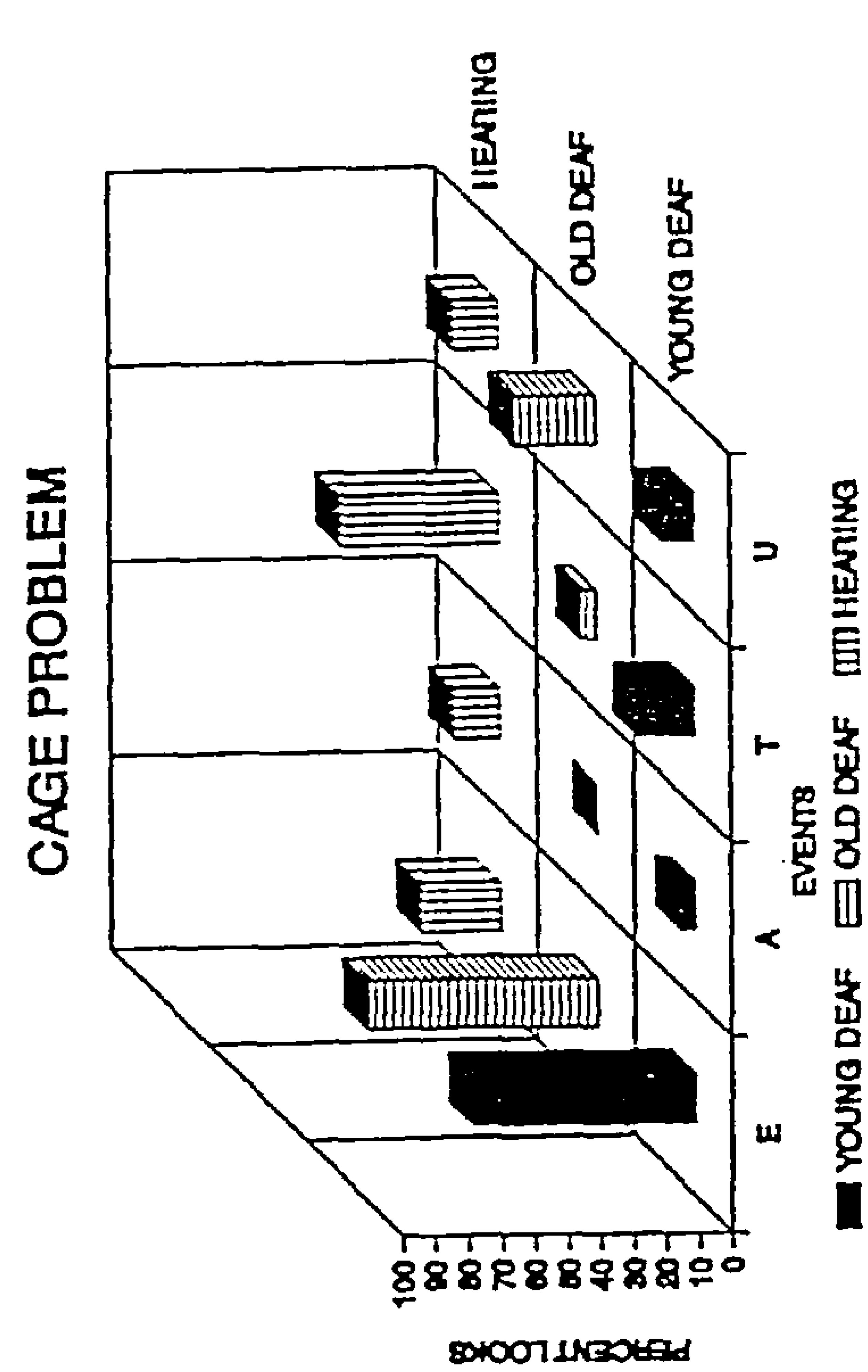

Fig. 9.1 Distribution of Events Preceding Tool Change (Young Deaf)

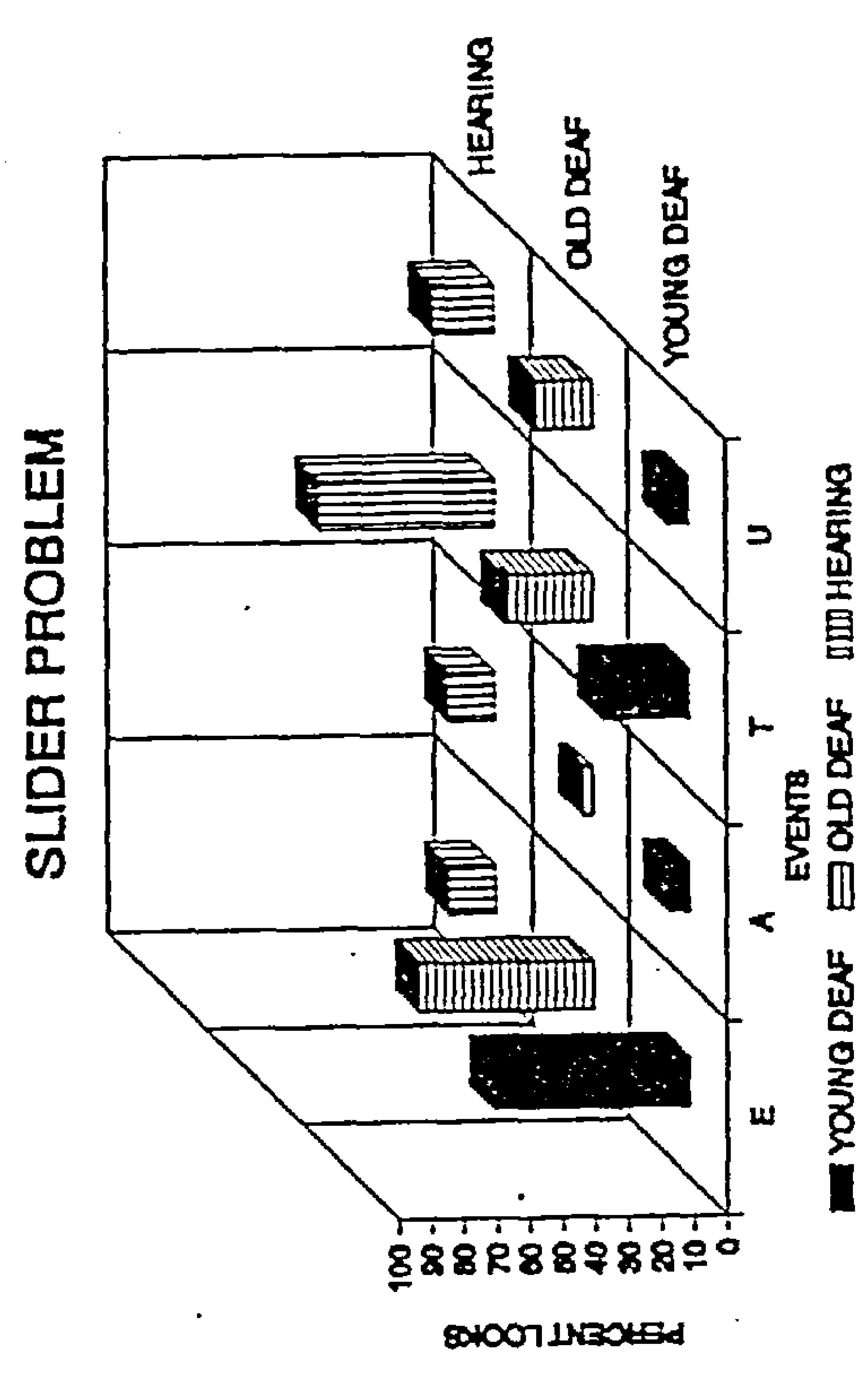

Fig. 9.1b Distribution of Events Preceding Tool Change (Young Deaf)

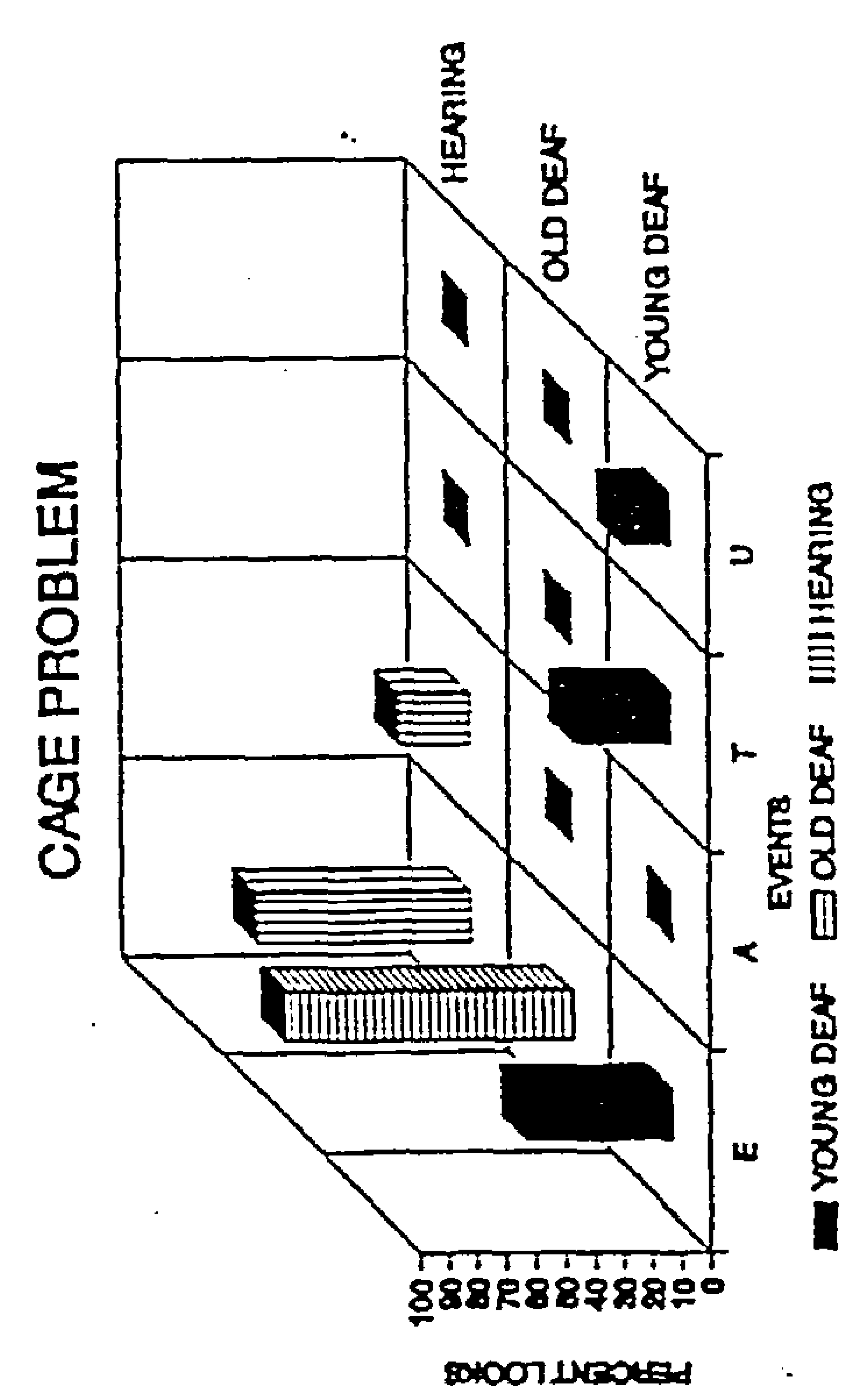

Fig 9.2a Distribution of Events Preceding Sucessful Tool Choice (Young Deaf)

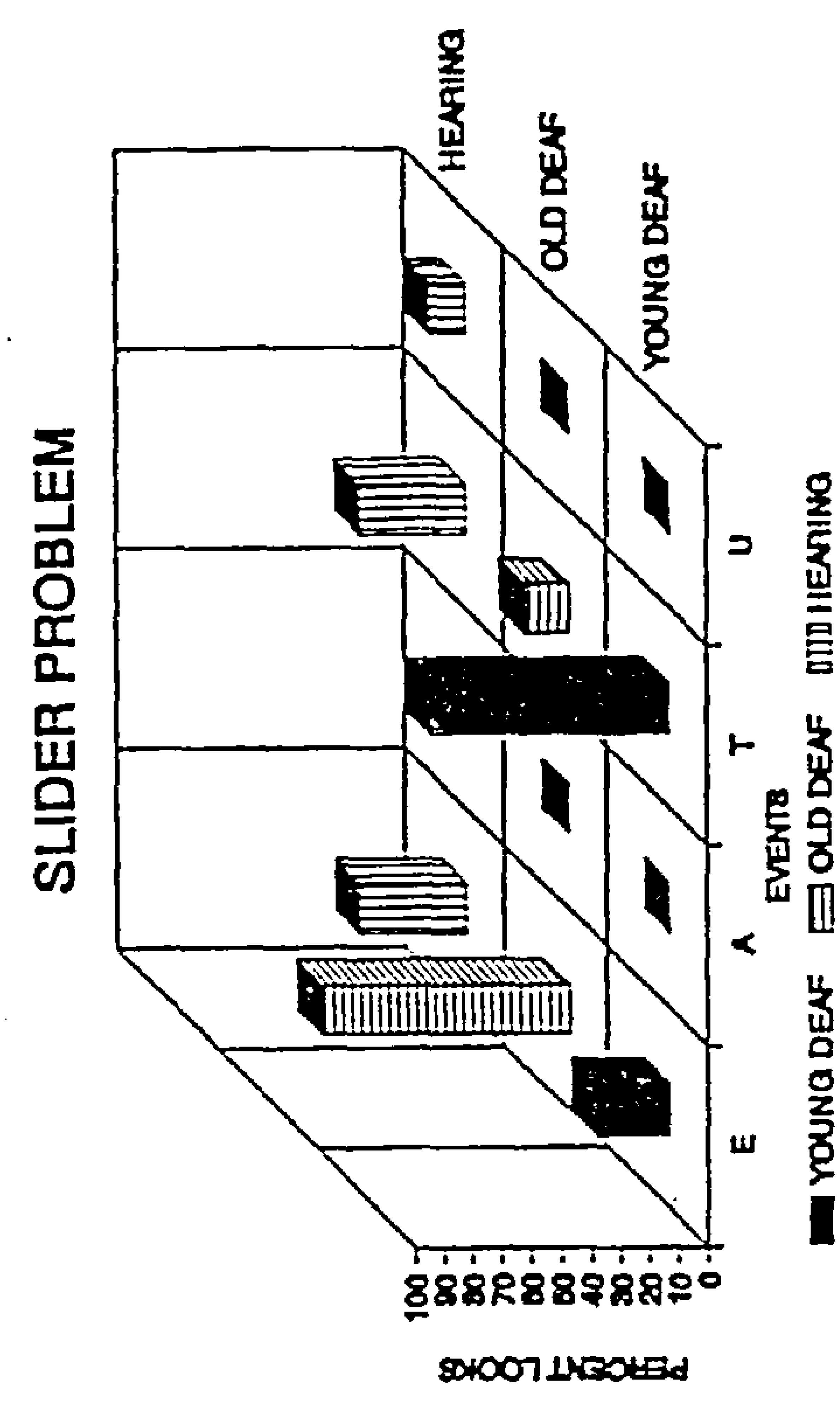

Fig 9.2b Distribution of Events Preceding Sucessful Choice of Tool (Young Deaf)

in Chapter 5. These can be found in appendix 9.

Dominance

Dominance matrices (appendix 9) were calculated for both problems (see Chapter 5). Table 9.7 gives the rank order dominance for each category, for each problem. Data for the two older groups is given for comparison.

	Cage			Slider		
	Old D	Young D	Old H	Old D	Young D	Old H
E	1	1	1.5	1	1	1
A	4	3	4	3	3	4
T	2.5	2	1.5	3	3	2
U	2.5	4	3	3	3	3

Table 9.7 Rank Order Dominance of Events Preceding a Tool Change

These data show little difference between any of the groups, with E being the dominant category for both problems, and for the Slider Problem the dominant category not being predictive of success.

Markov Chain Analysis

The young deaf group have shown similarities in behaviour with both the older groups. Like the hearing group they show the ability to make use of information gained in the course of problem solving, and less consistency in behaviour between problems. The hearing group required a different Markov model for each problem, the state of the process immediately preceding the problems being at chance. By contrast the behaviour of the older deaf group was predicted by a single model for all three problems, the state of the process immediately preceding the first problem being in a state other than chance. If the single Markov model is purely a function of differential hearing status of E and S then we should expect the behaviour of the young deaf group to parallel that of the hearing group and find two Markov models necessary to predict their behaviour.

Transitional probability matrices were derived from the frequency matrices used for the dominance analysis as described in Chapter 5. The operations performed on these matrices are also as described in Chapter 5. The result of these operations show that a single Markov model is sufficient to predict the behaviour of the young deaf group for both

	E	A	T	U
Slider Problem				
Observed slider vector	.64	.09	.18	.09
Observed cage vector x [C]^{2}	.625	.084	.179	.136
Equilibrium vector [S]^{32}	.61	.084	.169	.084
Chance vector x [S]	.857	.035	.07	.035
Cage Problem				
Observed cage vector	.65	.062	.187	.130
Slider equilibrium vector x [C]	.62	.072	.166	.084
Equilibrium vector [C]^{32}	.646	.075	.171	.086
Chance vector x [C]	.487	.137	.185	.187

N.B. [] denotes a matrix. S - Slider; C - Cage

Table 9.8 Predicted and Observed Probability Vectors for Cage and Slider Problems (Young Deaf)

problems (see table 9.8). As for the older deaf group the state of the process immediately preceding the first observation is not at chance level. These data indicate that the Markov model which describes the visual behaviour of the young deaf is similar to that of the old deaf.

Given that both deaf groups are similar and different from the hearing group, then the process described by the Markov model could be a function of deafness per se., and not a consequence of the relative hearing status of E. To test this possibility the Slider matrix of the young deaf group was premultiplied by the equilibrium vector for the Slider problem from the old deaf group. The following results were obtained:-

	E	A	T	U		E	A	T	U
Predicted prob vector	.614	0	.048	.027	f	6.7	0	.5	.3
Observed prob vector	.65	.062	.187	.130	f	7	1	2	1

Also given (to the right) are the predicted and observed

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frequencies for each category. As can be seen there is a close agreement between the predicted and observed data. Whilst the small samples involved urge caution, these data are certainly indicative of a commonality of process across the two deaf groups[1].

DISCUSSION

Summary of Results.

Overall the results indicate that the problem solving behaviour of deaf children differs when E is a deaf BSL user as opposed to a hearing signer. For the cage problem three of the young deaf children solved the problem un-aided and three after a suggestion from E. As Chulliat and Oleron's data for hearing children of this age showed a decrement in performance compared to six year olds, then this represents a better performance than either of the two older groups where only 2/8 hearing and 2/7 older deaf children solved the problem un-aided. This pattern of results was also found for the slider problem. Two of the young deaf group solved the problem un-aided and two offered partial solutions. These two children discovered the correct solution after only one further attempt compared to an average of four attempts needed by the older children both deaf and hearing. It is also worth noting that the young deaf group's results were better than those cited by Chulliat and Oleron (1955) for hearing five year olds. From these data it is apparent that the young deaf are better able than the older deaf to make use of information gained in the course of problem solving.

The behavioural analyses showed that the number of behaviours elicited by the Cage problem was comparable for the old and young deaf groups. For the Slider problem, however, the number of behaviours elicited from the young group was half that of the old deaf group, and comparable to the hearing group. The

1. This observation can be tested further by varying the permutations of vectors and matrices which are multiplied. These can be found in appendix 9

percentage of behaviours which were looks to E were not strictly comparable, due to E using these as an opportunity to communicate.

The distribution of visual behaviours preceding a tool change did not differ between the old and young deaf groups for either problem. When visual behaviour preceding successful choice of tool is considered, the distributions for the young deaf group differed from both the old deaf and old hearing groups for both problems.

The matrix analyses showed that the rank order dominance of the events preceding a tool change did not differ between the three groups, for either problem, E being the dominant category.

The Markov chain analysis showed that a single model was sufficient to predict the behaviour of the young deaf group for both problems, and that the state of the process immediately preceding the first problem was in state other than chance. In this respect the old and young deaf groups do not differ from each other, but both differ from the hearing group.

Interpretation of Results

The main feature of these data is the better performance of the young deaf group than either of the two older groups, in terms of un-aided solutions. For the Slider problem Chulliat & Oleron do not record a spontaneous solution by a deaf child until age 9 and by a hearing child until age 5. Of the hearing 5 year olds only 6/22 (27%) discovered a solution, either spontaneously or after a suggestion. Of the remaining children 2 showed no understanding of the problem at all and 14 had to be told the solution but could generalise the response, i.e. use a combination of bars up to 12cms. In view of this the data reported here represent at least an 18 month advantage for the young deaf group over the hearing 5 year olds. One reason the problems were chosen was that they were visual concrete problems and therefore should not disadvantage the deaf. If the concrete visual nature of the problems alone, accounts for the enhanced performance observed here, then it should have also been evident in the data of the older group. The two factors which distinguish this study from that of Chulliat & Oleron with respect to deaf S's are (i) that the experimenter was also deaf and (ii) that the children had sign language experience from an early age.

Influence of Deaf Experimenter

In Chapter 6 it was noted that changing the hearing status of the experimenter also changed the language which was being used, even though both experimenters used manual methods to communicate. Hence, the difference between the older and younger deaf groups was the presence of a deaf experimenter whose language was BSL, i.e. the <u>total socio-linguistic environment of the groups differed.</u> This means that the different pattern of results for the two groups could be due either to the presence of a deaf experimenter or to the different language. Chosing between these two possibilities is impossible with the design used here. To decide between these possibilities would require a design in which language and hearing status were not confounded, for example, comparison of data from groups where the experimenters were a hearing BSL user (e.g. the hearing child of deaf parents) and a deaf BSL user.

To decide on the effects of the language used is more problematic. If language and thought interact then it is entirely possible that the type of language and type of problem interact, in so far as their coding capabilities are more or less efficient for different kinds of information. Indeed, I will report data which indicates that the spatial nature of BSL makes it an efficient medium for coding spatial information, in the same way as it is argued that speech based codes are efficient at coding order information.

Given that it is not possible to separate hearing and linguistic status in the present study, the ensuing discussion will examine the differences in the way which the deaf and hearing E's used their "signed language" in communicating with the children.

It was noted that classifying 'Looks to E' independent of a communicative act was difficult for the young group as the deaf E used volunteered eye contact to communicate with the children rather than attract their attention. In other words the deaf E's communicative acts were contingent on the child's behaviour to a greater extent than the hearing E.

Another noticeable difference between the two Es was the use of the problem space in relation to sign. The hearing E made the vast majority her signs in the conventional signing space, i.e. a space extending from the waist to the top of the head. The deaf E signed within the problem space, i.e. in proximity, to or over the apparatus for problem relevant information and in problem neutral space for other information, such as praise or questions. There are two possible reasons why the deaf Es place of signing could have led to the observed results. The first is that because the problems are visuo-spatial in nature and because sign is visuo-spatial, by signing over the problem space, the deaf E in some way 'told' S the solution. There are four arguments against this. Firstly, there was less difference in the signs used by the two Es than where they used. Therefore, any advantage from the signs themselves would apply to both groups. Secondly, Chulliat & Oleron mimed the instructions to their deaf S's. Presumably, mime would contain as many clues as sign language to the solution. Thirdly, even though the hearing E gave oral instructions to the hearing group, these were accompanied by gestures, which were mimetic of the actions required and in some cases (as the deaf E pointed out) signs. Finally, the behaviour of the subjects indicated that they were discovering a solution, rather than putting into practice an already known solution.

The second reason place of signing may be important is that it clearly indicates to what the information being given relates, i.e. it overcomes the problem of divided attention. By signing over the problem space the deaf E made it possible for the child to both look at the signs and the referent. A related point is the synchronicity evident in the visual behaviour of the deaf dyads. If during face to face signing some aspect of the apparatus was referred to both E and S would look at the referent, S apparently following E's eyeline. They would then resume face to face signing apparently simultaneously. Stepping through the video frame by frame, a resolution of 1/25th of a second, it was not possible to determine who initiated the return to communication. With the hearing E the hearing Ss spent little time looking at E while instructions or information was being given. Instead they looked at the apparatus, and when an intended referent was not clear to them they would seek clarification, for example, by pointing at something and querying its correctness. In other words for the hearing Ss attention was divided between the aural and visual channels. If this argument is correct then, the advantage which the young deaf group have over the old deaf group is a more certain knowledge of what the nature of the problem is. However, this alone does not explain the enhanced performance of the young group over the hearing children.

One analysis which did show equivalence between the two deaf groups was the Markov chain analysis. It was also indicated that a single model may be sufficient to describe the visual behaviour of both the old and young deaf. In other words the underlying process is a function of deafness per se.

If we assume for the moment that this process is one which relates to communication (Meadow, 1980), then the implication is that in the presence of a deaf E this strategy is successful. Is this because the deaf E shares the same process? Is it this process which leads to the qualitatively different interactions observed between deaf mothers and their deaf infants? Is this process the observable consequence of 'divided attention'? If so the implication is that 2/3 of attention is given to social stimuli and 1/3 to non social stimuli. These are empirical questions which could be addressed by future work. The answers to these questions would seem to have important educational implications.

Methodological Note

The methods used here and in Chapter 5 have demonstrated that different process can lead to similar outcomes; deaf/hearing comparisons for spontaneous solutions, and that similar processes can lead to different outcomes, depending on context; deaf/deaf comparisons.

CHAPTER 10: A Comparison of Deaf and Hearing 6 Year Olds Solving the Tower-of -Hanoi Problem.

INTRODUCTION

In two previous studies (Chapters 5 and 9), problem solving was examined using concrete, visuo-spatial problems. The study reported here uses a visually presented, well defined, abstract problem which is a variant of the Tower-of-Hanoi problem described by Klahr & Robinson (1981).

Abstract Functioning in the Deaf

As with most areas of cognitive functioning in the deaf, abstract ability has been examined mainly as an aspect of a discrete function, such as concept formation, and as a means of examining the relationship between language and thought. The central issue in all reviews (Myklebust, 1964; Furth, 1964; 1966; 1971; Meadow, 1980; Rosenstein, 1961) is the role of language in abstract functioning, and whether a language deficiency impairs that functioning. In general, the cognitive processes of deaf children are characterised as being more concrete and less abstract, especially where verbal symbolic skills are considered to be an aid to abstraction (e.g. Myklebust, 1964; Oleron, 1953; Furth, 1961). For example, on tasks involving classification, the deaf and hearing score at equivalent levels, but when more abstract processing is required, such as in a task requiring analogies (e.g. Templin, 1950) or a transfer task (e.g. Furth, 1963), then the deaf score less well. Rosenstein (1961), commenting on Wright's study (1955) of the abstract reasoning of deaf college students writes;

> ".... that the deaf students exhibited inferior performance. He concludes that the more abstract the task, the greater will be the discrepancy between the deaf and the hearing; and, (interestingly enough), that this discrepancy occurs irrespective of whether the stimuli are verbal or non-verbal in nature." (p281).

More complex abstract tasks, such as logical reasoning, have been examined by Furth (e.g. 1964) Suppes (1974) argues that most tasks of logical reasoning given to the deaf are extremely elementary. He suggests that this is due to the efforts to make such tasks non-verbal and that more complex kinds of reasoning, such as can be give to 6/7 year olds, are difficult to test outside a verbal context. He suggests that these more complex aspects of abstract functioning, such as inference should be tested within a sign language context. He goes on to say;

> "These more developed forms of inference are not primarily auditory in nature but visual; for example, there is very little development of mathematical proofs in purely auditory fashion." (p159).

This suggests the possibility of examining more complex abstract functioning than can be accessed by classification tasks, by the use of a problem which is amenable to visual inferencing. Such a task is the Tower-of-Hanoi.

Task Characteristics

The Tower-of-Hanoi (TOH) involves moving a stack of n disks, which decrease in size, from one of three pegs to another, subject to two rules; 1) that only one disk can be moved at a time and 2) that a large disk may never be placed on a small disk. For a stack of n disks the minimum number of moves in which this can be accomplished is given by the algorithm 2^n-1. The problem is well defined, in that initial and goal states are fully given, as are operators and operator restrictions (i.e. rules). Despite the inherent definition of the problem, the path to the goal is not immediately obvious and for any problem requiring three or more moves, sub-goals are necessary, which may have a negative goal gradient. For example, the missionaries and cannibals problem, which has similar task characteristics, requires the movement of three missionaries and three cannibals across a river. Only two people can cross the river at any one time, and cannibals must never outnumber missionaries. The solution to the problem requires that people are taken back across the river to the starting point, in other words it requires sub-goals and associated moves which appear contrary to the end-goal. These are moves with a negative goal gradient. Hence the solution of this kind of problem requires a means-end analysis, the identification of sub-goals and the operations necessary for transforming the problem from its initial state, to the goal state. This implies that the problem solver creates a mental representation of the problem which is used to enable the formulation of a plan for the execution of moves.

The extent to which language is useful or necessary for this problem is a moot point. Piloting a three disc version with older children and adults, indicated that there were some who could solve the problem in the minimum number of moves and give a concurrent verbal protocol. Others, including the author, could not solve the problem and give a concurrent verbal protocol. Findings from cross modality interference studies suggests that those such as the author, are solving the problem verbally, hence a concurrent verbal task interferes with the solution of the TOH task, whereas those who can give a concurrent verbal protocol are solving the problem visually, hence there is no interference.

Previous Work with Children and Tower-of-Hanoi

There are very few studies which use the TOH with young children. Piaget (1976) used 2-, 3- and 4-disk versions with hearing children between the ages of 5 and 12 and concluded that most 5 to 6 year olds could only solve a 2-disk tower with difficulty and a 3-disk tower was impossible for them. He argued that the method used was trial and error and that the children were not conscious of the logical links involved.

Klahr & Robinson (1981) point out that a 2-disk tower requires only three moves, and that children much younger than 5 or 6 were capable of solving three step problems in everyday contexts. They used a modified 3-disk version of the TOH with hearing children between the ages of 4 and 6 years. The task uses three stacking cups, instead of the usual disks. To reduce memory load, the task has two sets of pegs on which are represented the goal state and the initial state. The size rule is reversed, i.e. a small cup cannot be placed on a big cup. The apparatus is such that it is difficult to violate this rule, but if it is violated, the resultant stack falls off the peg.

There are 27 possible configurations, or states, of the 3 cups. As every state can be reached from every other state it is possible to devise a set of problems in which the number of moves required for solution varies from 1 to 7. Normally, the initial and goal states of the TOH are stacks or towers. Producing the problems by the method just outlined gives some problems where the initial and goal states are flat, i.e. a cup on each peg. Klahr & Robinson, presented the children with blocks of problems half being tower-ending and half flat-ending, each successive block requiring one more move for completion. The children's set of cups represented the goal state and the Es cups the initial state. The children had to tell E how he would have to move his cups to make them look like the child's, although the cups were never actually moved. This verbal protocol, in the absence of visual confirmation of the results of moves, was taken as evidence that the children were planning the solution, rather than discovering it by trial and error.

The children were assigned a planning level, which corresponded to the maximum number of moves for which they could produce minimal path solutions for all tower-ending or flat-ending problems in a block. For tower-ending problems approximately half the 4 year olds could solve 3 move problems and over half the 6 year olds gave minimal path solutions for 6 move problems. Flat-ending problems were much more difficult, with planning levels being well below those for tower-ending problems. However, it remains that this modified version of the TOH demonstrates that 6 year olds can plan up to 6 moves ahead using mental representations of future states and the effects of transformations.

I have not been able to find any study which uses the TOH with deaf children. However, it appears to offer a way of investigating the problem solving capabilities of deaf children in an abstract domain. A second aspect of the task is that it requires a sequence of moves. Sequencing ability in the deaf is generally thought to be poor (see next Chapter). In view of this it was decided to examine the capability of manually educated deaf children for this task. Some procedural changes were deemed necessary which took account of the differential language status of E and S. The first of these was that the children would solve the problems by executing the moves themselves, rather than give a verbal protocol. Klahr & Robinson reported that in an earlier study (Klahr & Robinson, 1976) using this procedure, the execution of the children's suggested moves by E, had provided feedback of the effectiveness of their strategies and some learning had taken place over the course of the experiment. The decision to use verbal protocols as data was to enable a more accurate assessment of baseline performance. Bearing this in mind, it was felt that verbal protocols on the part of deaf subjects were open to the possibility of E misinterpreting the signed utterances. It was also felt that verbal protocols were potentially more disruptive for the deaf Ss as both task and language are visuo-spatial (see above). Providing deaf and hearing subjects were given the same set of problems in the same order, any potential learning will be equated between the groups.

The Ss in Klahr and Robinson's study were given unlimited time, over more than one session, in which to complete the problems. For the reasons outlined in Chapter 6, i.e. minimal disruption to classroom time for the deaf group, a single session of 20 minutes was decided upon. This is the lower limit given by Klahr & Robinson for solving a block of 20 problems. The pilot studies had indicated that executing moves took less time than giving verbal protocols, therefore, 20 minutes seemed reasonable.

Aims

The aim of the study is to examine the problem solving ability of manually educated deaf children in a complex abstract domain. If, as previous work suggests, the deaf are poorer at abstract functioning, because of their language deficiency, then it would be expected that manually educated deaf children will perform as well as hearing children on the task. If inferior abstract functioning is a consequence of deafness then the deaf will perform less well than the hearing, on this task.

METHOD

Subjects

7 hearing 5-6 year old infants, from a small J & I school and 5 deaf children, also aged 5-6, attending a partial hearing unit attached to a mainstream infants school, acted as subjects. The P.H.U. had a total communication policy. These were the same children who had taken part in the study reported in Chapter 5.

Apparatus

The apparatus consisted of a modified version of the Tower-of-Hanoi as described by Klahr & Robinson (1981). Two sets of three pegs, each a different colour, were mounted onto a base board. Two identical sets of three different coloured cups, of diminishing size were used instead of the usual discs. The tops of the pegs were cut at an angle of 45 degrees, so that only legally stacked cups, i.e a large cup on a small cup, would remain on the pegs. The arrangement of cups on the three pegs nearest E represented the goal state; the cups on the three pegs nearest S represented the initial state. See appendix 10 for a drawing of the equipment.

There are 702 possible problems requiring from one to seven moves to complete. The set of problems used here, given in appendix 10, comprises of seven sets of four problems, 28 in all. The first set require a minimum of one move to complete, the second a minimum of two moves and so on to set seven which requires seven moves. All sets contain two tower ending and two flat ending problems.

Design

An independent measures design was used to test the effects of hearing status on problem solving (Tower-of-Hanoi). The same set of problems, and the same order of presentation was used for each child, in each group. Klahr & Robinson, found no order effects for tower-ending and flat-ending problems, therefore, it was not felt necessary to counterbalance, in this respect. Also it was necessary to equate potential learning in the two groups, therefore, the same order of presentation was required.

Procedure

All subjects were tested individually in a room, other than their normal classroom, at their school by the author. All sessions were recorded on video tape. The camera was visible to the children throughout the session. E showed each child the video equipment and explained that the video was to enable E remember how they played the game. The children were then shown themselves on the monitor, which was subsequently turned so that only E could see the picture. The children did not appear to be troubled by the presence of the camera during the session.

The children were shown the apparatus and invited to play a game. The two sets of pegs and cups were pointed out and E explained that one set were Es and the other the child's . If the child appeared ill at ease with the situation some time was spent comparing the colours of the two sets of pegs and cups and in naming the animals which were painted on the cups. Once it was felt that the child was comfortable, they were asked if they could make their cups look the same as Es.

At the end of each problem E positioned the cups for the next problem in view of the child, but in such a way so as not to reveal the solution. Klahr & Robinson asked their Ss to close their eyes or turn their backs while the cups were being set. These procedures were felt to be inappropriate for the deaf children as both cut the deaf child off from their environment and regaining the child's attention is potentially frightening.

At the beginning of each set of problems the child was told the minimum number of moves required to solve the problems in that set. The rules were introduced one at a time as they became necessary, i.e. as the number of moves required to solve the problem increased. At set two the "one at a time" rule was introduced and at set three the "stacking" rule was introduced. The rules were explained both verbally and by demonstration. The child was reminded about the rules if necessary, i.e. if the child made an illegal move. If an illegal move was made the cups were re-positioned to the state they had been in immediately prior to making the illegal move. If the child indicated, either verbally of behaviourally, that they had gone wrong, their cups were re-positioned to the initial state.

The sessions were conducted in spoken English or Sign, according to the hearing status of the child. As with the previous study (Chapter 5) I attempted to keep my vocabulary as similar as possible with the two groups. However, I was aware that I found it very much easier to explain the rules to the hearing children and to explain why a move which produced the required result was illegal. Each session lasted for twenty minutes or until the child had completed all seven sets of problems, whichever was the sooner. The children were given a small packet of sweets at the end of the session.

RESULTS

Treatment of Data

The video tapes of the sessions were transcribed as behavioural acts. All analyses were carried out using the transcripts. Appendix 10 contains an example of a transcript.

In the twenty minute session 1/5 deaf and 5/7 hearing children completed all seven problem sets. The remaining two hearing children reached set five as did one deaf child. The remaining three deaf children reached set four. It should be noted that these figures are only for problems completed and do not necessarily imply success.

Problem Set	Number of children Deaf	Hearing
1 - 4	5	7
5	2	7
6	1	5
7	1	5

Table 10.1 Number of Subjects In Each Problem Set

There are a number of possible reasons why the hearing should complete more problems in a given time, the most obvious being that they are the better problem solvers. However, it was noted earlier that it was very much easier to explain the rules of the game to the hearing children. This is reflected in the number of illegal moves made (see later) and also in the transcripts. The transcripts of the deaf children's sessions are much longer on average. This is almost entirely due to interactions between E and S regarding rules. Hence it is possible that lower number of problems completed by the deaf group in the time given reflects an inability to understand E rather than lack of competence in problem solving. Subsequent analyses will address these possibilities.

Number of Problems Solved

A coding scheme was devised which took account only of the moves the child made to complete the problems. Moves were

Problem Number →	13	14	15	16
Ending	T	F	T	F
Direction	r/l	r/l	r/l	b
	2+I	4	3+I	2+I
	8		8	8+I
				12

Table 10.2 Example of Scoring

scored as legal, i.e. within the rules, or illegal, i.e. contravened the rules in some way; for example trying to stack a small cup on a large cup. The number of moves a child took to solve a problem were then counted. If all the moves for a given problem were legal then the entry on a the score sheet was a single number. Where a sequence of moves included an illegal move this was indicated by an I with the number of legal moves pre and postceding it. As the cups were re-positioned to the state immediately preceding the illegal move the final number in the column is the total number of legal moves taken. Where the cups were re-positioned to the original start position is indicated by a line across the column. An example of a hearing child's score sheet for set four is shown in table 10.2. Complete score sheets for both groups are given in appendix 10. There is some missing data in some of the sets. In set two problem 8 was omitted for two hearing Ss due to E error. Where data is missing from the last set a child attempted this is due to time running out.

The number of problems which were solved in the minimum number of moves without illegal moves, or re-positioning of the cups is given in table 10.3.

Problem Set

	1	2	3	4	5	1-5	6	7
Deaf	75	70	45	62.5	42.86	61.44	25	0
Hearing	82.14	84.62	57.14	46.43	46.15	63.24	10	6.25

Table 10.3 . Percentage of Problems Attempted and Solved in Minimum Moves with no Illegal Moves

These data show little difference between the groups for problem sets 1-5 as is reflected in the overall percentage for those sets (X^2=0.068; df 1; n.s). Although the hearing group completed more problems in the time given they were not especially successful on sets 6 and 7, giving minimal path solutions to only 3 of the 40 problems completed. All subsequent analyses will be on problem sets 1-5.

The above criterion does not exhaustively score the data. Moves can be legal or illegal and solutions can be in minimum moves or non minimum moves. This gives four possible solution types viz:-

	Legal (L)	Illegal (I)
Minimum (M)	M/L	M/I
Non-Minimum (NM)	NM/L	NM/I

Table 10.4 Possible Solution Types

This scheme exhaustively codes the data. The distribution of solutions amongst types is given in table 10.5.

Deaf	L	I	total
M	61.44	27.72	89.16
NM	4.82	6.02	10.84
total	66.26	33.73	

Hearing	L	I	total
M	63.24	5.88	69.12
NM	19.85	11.03	30.88
total	83.09	16.91	

Table 10.5 Distribution of Solutions Amongst Types

These data show that while the groups are similar with respect to minimal path solutions (M/L), the distribution of the remaining three cells is quite different. The deaf give twice as many solutions which contain an illegal move than the hearing. However, of those solutions involving an illegal move the deaf complete four times as many as the hearing in the minimum number of moves. Considering non-minimum solutions; the hearing have three times as many as the deaf. Whereas the deaf have approximately equal number of NM/L and NM/I solutions, the hearing have nearly twice as many NM/L as NM/I solutions.

Klahr & Robinson (1981) define a perfect solution as one in which the problem is solved in the minimum number of moves. Illegal and non minimal path moves are allowed "...as long as they are recognized by the child and self-corrected, ultimately producing the correct solution path." (p123). Applying these criteria to the data gives the results in table 10.6. By these criteria the deaf perform better than the hearing on all sets, with the relative difference increasing as the problems become more difficult. Overall (sets 1-5), this difference is significant (X^2=11.58; df 1; p<.001) between groups. These criteria are less stringent than those used for deriving the results in table 10.3, in absolute terms.

In Chapter 4 it was argued that analyses should take account of process as well as outcome. The criteria of Klahr & Robinson do reflect an essential part of problem solving; the recognition and correction of errors. As the major differences between the groups lies in their relative performances with respect to errors, all subsequent analyses will be reported in detail for the scores derived from the Klahr and Robinson criteria. Only the results of the parallel analyses on table 10.3 scores will be given where applicable.

	Problem Set					
	1	2	3	4	5	1-5
Deaf	95.0	90.0	80.0	87.5	71.42	89.16
Hearing	89.28	88.46	64.28	50.0	53.84	69.12

Table 10.6 Perfect Solution (Sets 1-5) as a Percentage of those Attempted.

Flat-ending and Tower-ending Problems

It was noted that Flat-ending problems were more difficult than Tower-ending problems. The percentage of perfect solutions for tower and flat ending problems was calculated for each problem set for each group. These data are given in table 10.7.

These data show that for the hearing group Tower-ending problems are significantly easier than Flat-ending problems when considered across all problems (set 1-5, X^2=4.421; df 1; p<.05). For the deaf group, the type of ending makes no significant difference, when all problems are considered. These differences are reflected in the between groups comparisons. The deaf and hearing do not differ significantly with respect to Tower-ending problems, but for Flat-ending problems, the deaf are significantly more successful across all problems (X^2=5.228; df 1; p<0.5). Table 10.3 data shows no significant differences within or between groups.

Tower	1	2	3	4	5	1-5
Deaf	100	90	80	80	100	79.54
Hearing	85.71	92.85	85.71	64.29	71.43	78.57
Flat						
Deaf	90	90	100	100	33.3	82.05
Hearing	92.86	83.3	50	50	41.67	62.12

Table 10.7 Percent of Perfect Solutions in each Problem Set by Type of Ending

Comparison With Klahr & Robinson Data

Klahr & Robinson's Ss were assigned planning levels for Tower-ending and Flat-ending problems, which was the maximum number of moves for which the children could produce perfect plans for all problems of a type in a set. Table 10.8 shows the results for the deaf and hearing groups with Klahr and Robinson's data for comparison. These data are also shown graphically in figure 10.1.

	Tower				Flat			
	2	3	4	5	2	3	4	5
K & R	100	92.3	92.3	76.9	100	76.9	69.2	46.1
Deaf	80	60	60	40	80	100	80	0
Hearing	85.7	71.4	42.8	57.1	71.4	14.3	14.3	28.6

Table 10.8 Percentage of Subjects in Each Group at Each Planning Level

These data show that overall, both groups in the present study have lower planning levels than Klahr & Robinson's Ss. For Tower-ending problems the scores for all groups are in the same direction. For Flat-ending problems the deaf groups scores are in a different direction from both hearing groups.

It will be recalled that the procedure used here differed in a number of ways from that used by Klahr and Robinson, the major difference being that the children in this study moved the cups themselves. This suggests, somewhat counter intuitively, that moving the cups makes the task harder than giving a verbal protocol. A first move analysis (see table 11. below) shows that both groups in the present study are more likely to

Figure 10.1 Planning Levels for Tower- and Flat-Ending Problems.

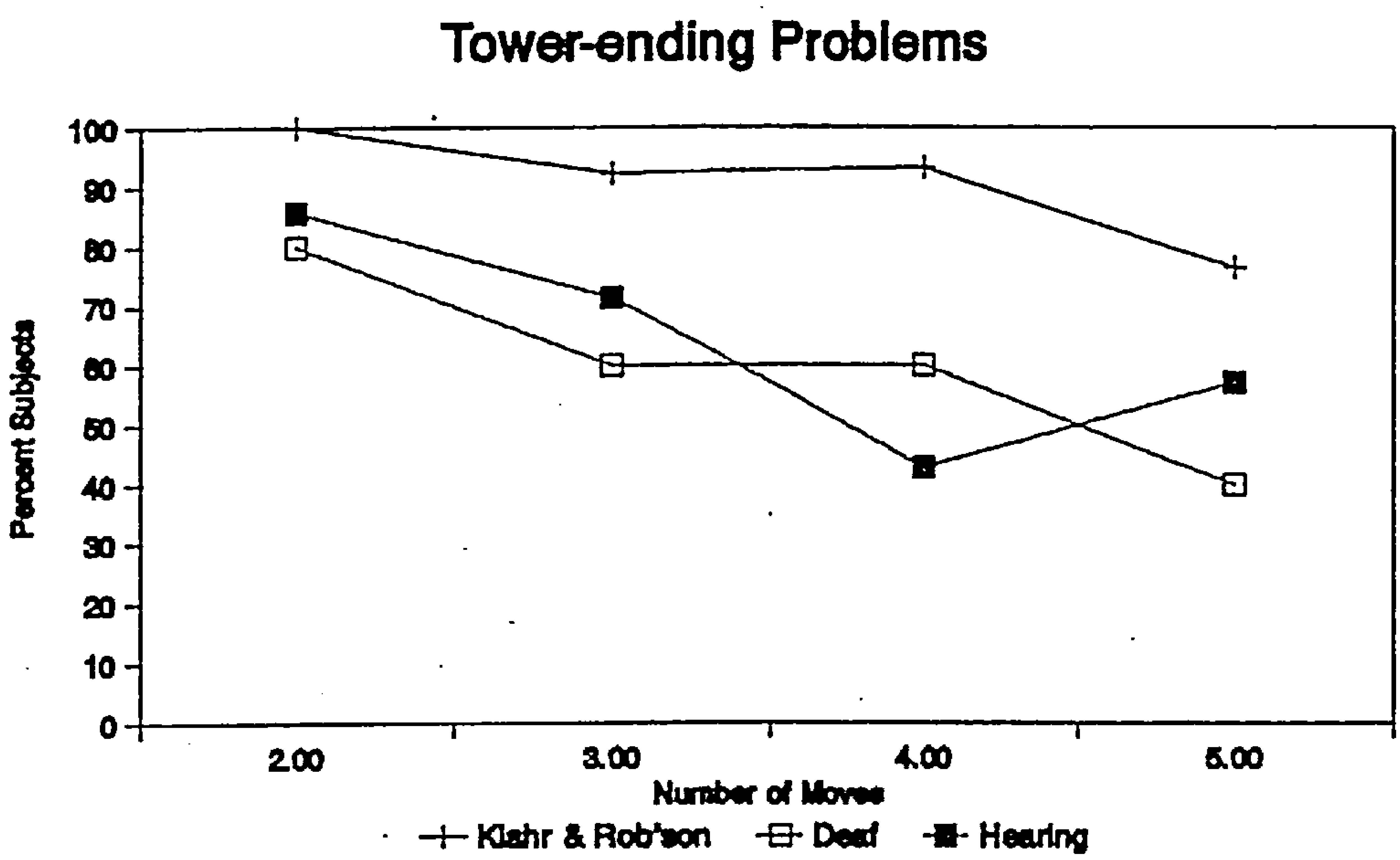

Fig 10.1a Percentage of Subjects at Each Planning Level

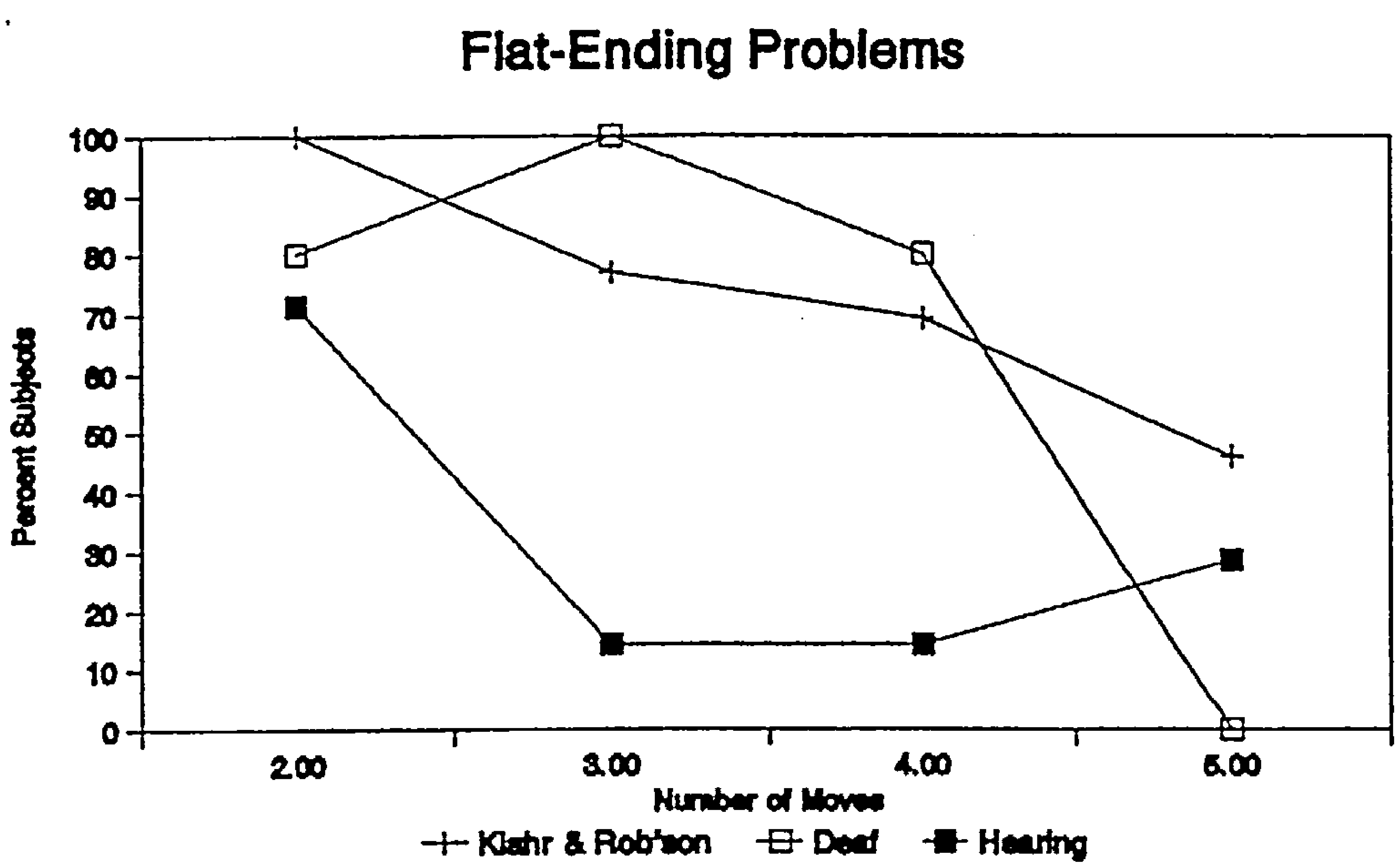

Fig. 10.1b Percentage of Subjects at Each Planning Level

select an optimum first move than Klahr & Robinson's Ss. Therefore, the differences in performance occurred during the course of solving the problem. The implication is that verbalisation aids this kind of problem solving in this age group. There is some evidence of this in the transcripts. When a child found a problem difficult they would verbalise or engage E in dialogue. The following is the transcript of a hearing child solving problem 5. This is a Flat ending 2 move problem, where the 'one cup at a time' rule is introduced.

1. looks at cups
2. lifts yellow cup off peg and looks at cups
3. S says "put this one (yellow) in my hand"
4. E says " before you move another one you've got to put it on a peg or on another cup
5. S puts yellow cup on orange peg and says "put it on there and then the bear (red cup)" moving the red cup onto the yellow cup and looks at E.
6. E says "do yours look like mine now?"
7. S says "no" then moves the red cup to the black peg whilst saying "that goes there after".

This was scored as three moves, 1) yellow cup to orange peg, 2) red cup to yellow cup, 3) red cup to black peg. The first move in this transcript was optimum. The child's error was to make the second required move - red cup to black peg - in two steps. This transcript also indicates the possibility that scoring between this study and Klahr & Robinson's differed. It is possible to argue that the child corrected the move made in line 5 at line 7. My decision to score the moves in lines 5 and 7 as separate moves was based on the fact that the child stopped between the two moves and had to be prompted to continue. Had the child made the two moves consecutively and without a prolonged pause, I would have deemed the second move a correction of the first and scored the whole processes as one move. All such instances were dealt with in the same way.

First Move Analysis

If the children are solving the problems strategically then this will be reflected in the first move. The first move in any problem can be optimum (O), non optimum (NO) or illegal (I).

Obviously, a minimal path solution can never be arrived at from a non optimum first move. For any first move there are three possible illegal moves and three possible legal moves. Of the legal moves, only one is optimum. Hence, if the children are choosing moves at random then the optimum move has a 1/6 chance of being chosen, non optimum moves a 2/6 chance and an illegal move a 3/6 chance. Table 10.9 shows the percentage of first moves in each category for each group. Also included are Klahr & Robinson's data for comparison. These data are also shown graphically in figure 10.2

		Tower			Flat		
	Chance	Deaf	K & R	Hearing	Deaf	K & R	Hearing
O	16.67	63.63	51	68.57	58.97	42	57.57
NO	33.33	11.36	40	24.29	28.21	46	39.39
I	50.00	25.00	9	7.14	12.82	12	3.03

Table 10.9 Percentage of First Moves in Each Category for Tower- and Flat-ending Problems

These data show that both groups in the present study chose optimum first moves at well above chance level for both Tower- and Flat-ending problems, with both groups in the present study being more likely than Klahr and Robinson's Ss to choose an optimum first move. The graphs of the two hearing groups follow the same pattern, both being different from that of the deaf group, for Tower-ending problems, but not for Flat-ending problems. For Tower-ending problems the deaf differ from the other two groups, in that the probabilities of choosing a non optimum and an illegal move are reversed, the deaf being more likely to choose an illegal move, rather than a non optimum move.

Direction of Movement

Whilst watching the children solve the problems it appeared that the direction in which the cups had to be moved affected the relative difficulty of the problems. In table 10.2, the third row is labelled direction. This is an indication of the extent to which the moves required to solve the problem are left to

Figure 10.2 First Move Analysis

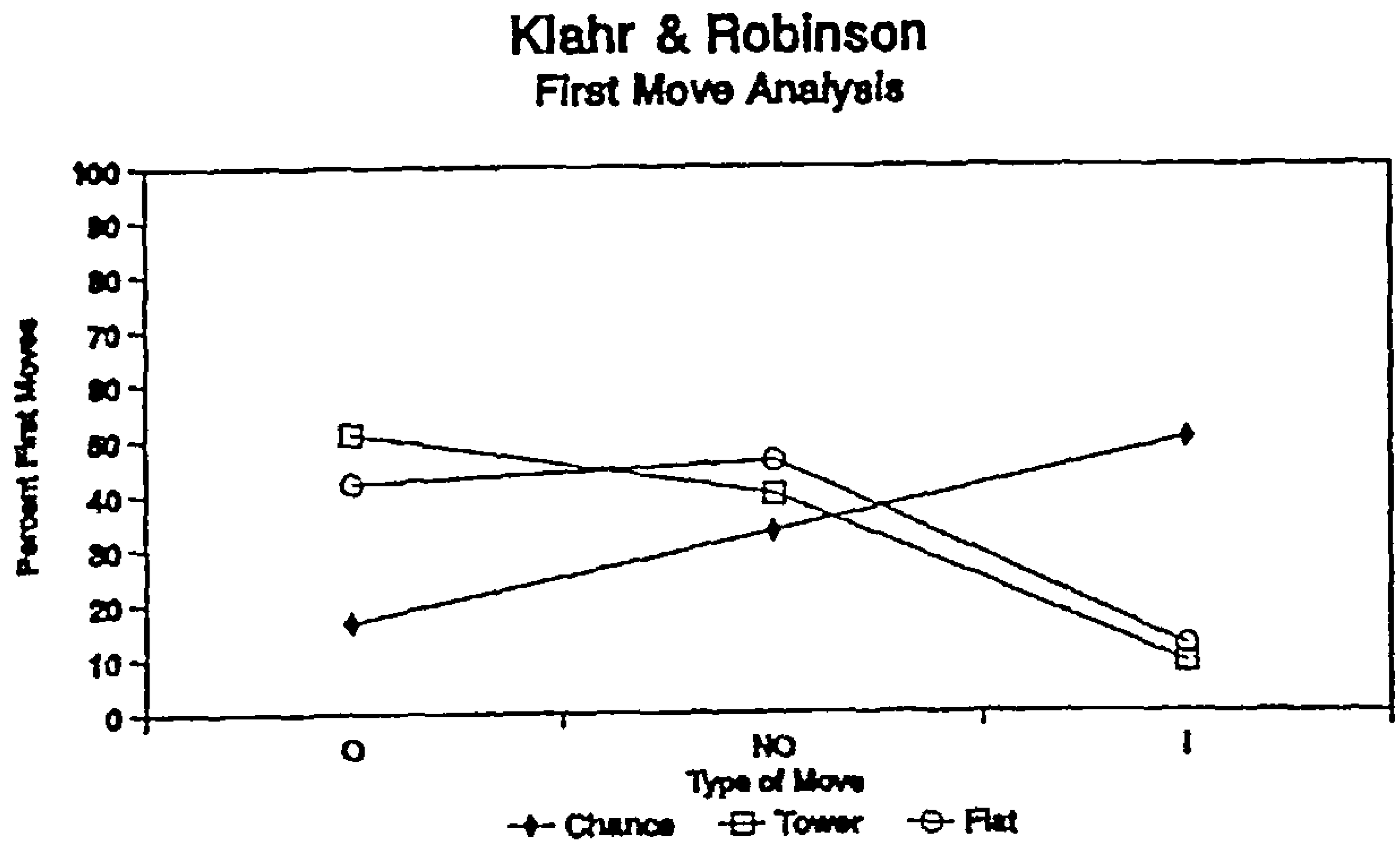

Fig 10.2a Percentage of First Moves In
Each Category for Each Problem Type

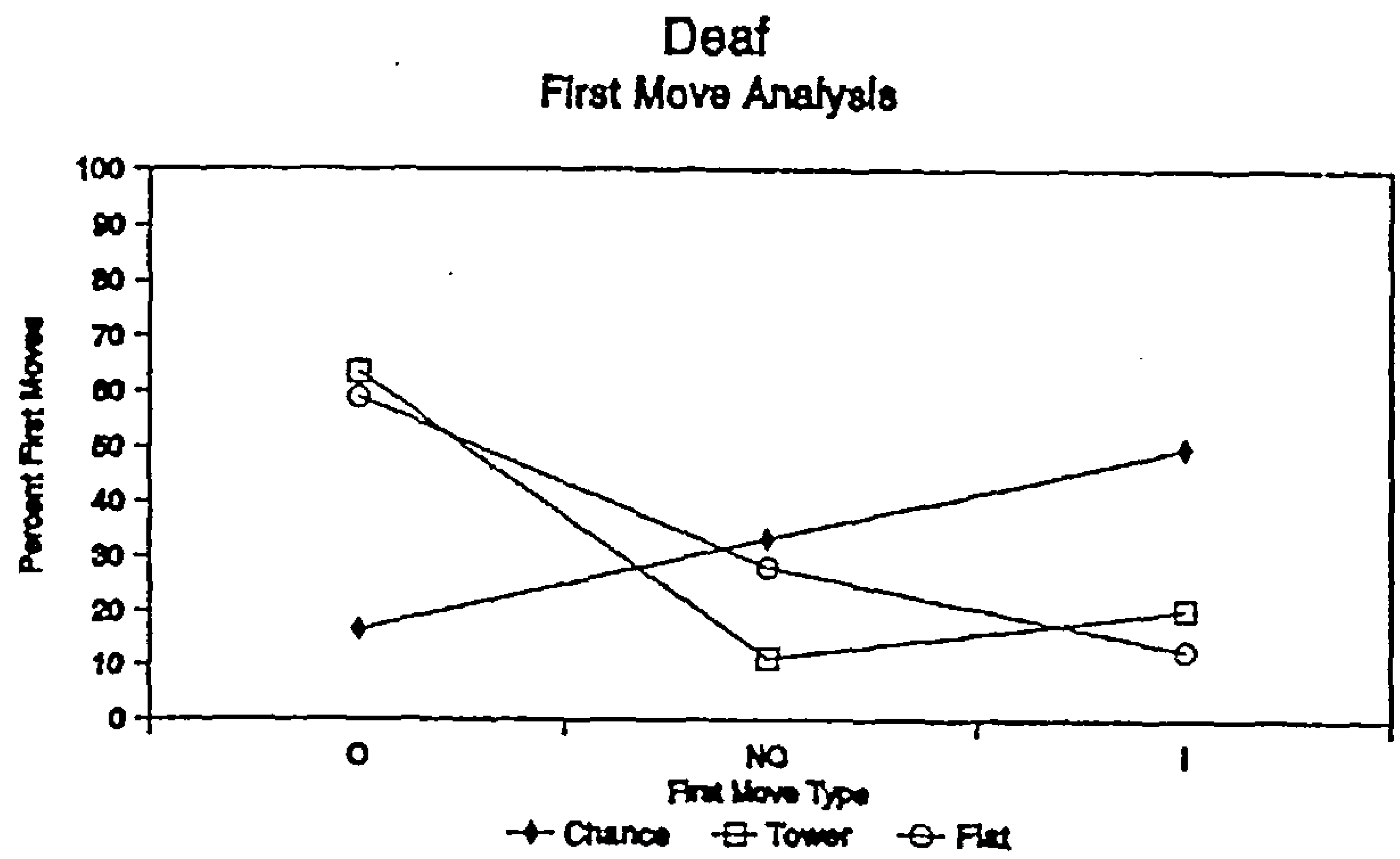

Fig 10.2b Percentage of First Moves In
Each Category

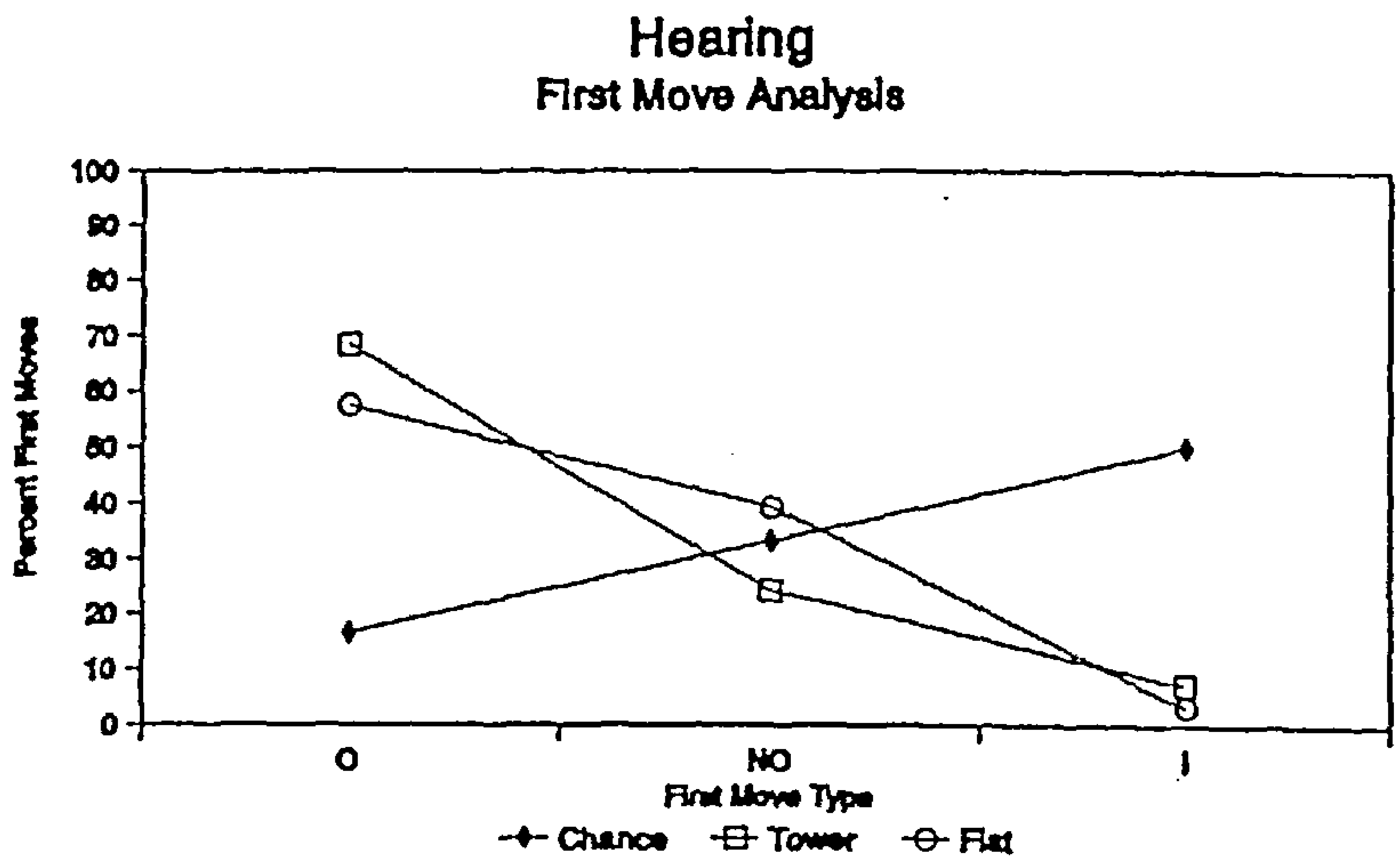

Fig 10.2c Percentage of First Moves In
Each Category

right (L-R) or right to left (R-L). The label indicates that the majority of moves are in that direction. For some Flat-ending problems with an even number of moves no one direction predominates and these are labelled B. Table 10.10 shows the percentage of each type of problem (e.g. Tower L-R) for which a perfect solution was recorded.

	Deaf			Hearing		
	L-R	R-L	B	L-R	R-L	B
Tower	94.12	70.37	-	82.14	71.42	-
Flat	88.33	90.48	91.67	38.46	64.71	63.15

Table 10.10 Perfect Solutions by Direction and Ending

These data indicate that for both groups L-R Tower ending problems are slightly easier than R-L Tower-ending problems. For Flat-ending problems direction makes little difference to the deaf group, but for the hearing group nearly twice as many R-L Flat-ending problems are solved as L-R Flat-ending problems. Table 10.3 data shows no differences between groups.

Illegal Moves

Two children, 1 deaf and 1 hearing, completed sets 1-5 without any illegal moves. Only the deaf child completed all seven sets with no illegal moves. Overall the deaf made nearly twice as many illegal moves as the hearing (59 v 35). There are three possible types of illegal move 1) Moving the Es cups (E); 2) Moving more than one cup at a time (M); 3) Stacking a small cup on a large cup (S). Classifying illegal moves according to this scheme gave the following results (table 10.11).

	E	M	S
Deaf	13.56	72.88	13.56
Hearing	8.57	88.57	8.57

Table 10.11 Percentage of Illegal Moves in each Type

The most common type of illegal move was M for both groups, but with E and S occurring nearly twice as often in the deaf group.

If the frequency of illegal moves is a function of the understanding and application of the rules then this should be reflected in the relative frequencies of illegal moves as the session progresses. It may also be the case that as the number of moves required to solve the problem increases the probability of making an illegal move increases. Table 10.12 gives the number of illegal and legal moves in each problem set for each group. Legal moves are expressed as a percentage of minimum moves required. This table shows that apart from set 3 illegal moves are evenly distributed amongst sets. There is

	1		2		3		4		5		1-5	
	I	L	I	L	I	L	I	L	I	L	I	L
Deaf	7	105	8	105	29	105	8	105	7	128	59	120
Hearing	7	125	5	109	12	113	6	135	5	127	35	124

Table 10.12 Distribution of Illegal Moves Amongst Sets

a sharp increase in illegal moves at set 3 for both groups, although the rise is much greater for the deaf group. This set saw the introduction of the stacking rule and was also the set where subgoals became necessary.

Considering illegal moves in relation to legal moves it can be seen that the increased frequency of illegal moves in the deaf is not a function of an increased number of moves per se. This reflects the data presented in table 10.5, which showed that the deaf were more likely to give minimal path solutions which involved an illegal move than the hearing. Type of ending does not affect the relative distribution of illegal moves, either within or between groups (table 10.13).

	All	Tower	Flat
Deaf	33.73	34.1	33.3
Hearing	17.64	21.43	13.64

Table 10.13 Percentage of Problems with Illegal Moves

DISCUSSION

Summary of Results

In a twenty minute session the hearing group completed more problems than the deaf group. This was almost certainly due to difficulties encountered by E in communicating the rules of the task to the deaf Ss. Although the hearing group completed more problems in the time given, they were not especially successful on the last eight problems, the group solving only three of forty attempted in minimum moves. Hence analyses were confined to the first five sets of problems (1-20).

Although the deaf made more illegal moves than the hearing, the relative distribution across sets and problem type did not differ between groups. Using strict criteria, a minimal path solution with no illegal moves or re-starts, to assess outcome, no significant differences were found between the groups in number of problems solved overall and number of Tower- or Flat-ending problems. Therefore, on the most conservative measure used there is no basis to support the view that deafness adversely affects the ability to solve this kind of abstract problem.

Classifying outcomes by a scheme which also took account of non-minimal path solutions and illegal moves, the behaviour of the two groups was found to differ. The hearing were more likely to produce non-minimal path solutions, either with or without illegal moves, than the deaf. Conversely the deaf were more likely to produce minimal path solutions with an illegal move than the hearing.

A less severe measure of outcome, used by Klahr & Robinson (1981) allows illegal moves and restarts provided that the child recognises their own error and self corrects. Using this measure, the deaf were significantly more successful than the hearing overall. This was due to the enhanced performance of the deaf on the more difficult Flat-ending problems. When direction of movement of the cups is considered, the deaf are unaffected by direction, whilst the hearing groups are less successful with Flat-ending problems in which the predominant movement is left to right.

Comparing data from the present study with that of Klahr & Robinson (1981) indicated that moving the cups made the task more, rather than less, difficult. Comparison of first move analyses indicated that the Ss in the present study made as many optimum first moves as Klahr and Robinson's Ss, confirming that problem solving, initially at least, was strategic.

Interpretation of Results

Previous work indicates that where a task requires information not perceptually given, the deaf do less well than the hearing. The main finding of this study, is that even with a severe outcome criterion, the deaf perform as well as the hearing on this task. The task is more difficult than those normally used to investigate abstract ability in the deaf, and indeed was considered too difficult for any child of this age by Piaget (1976). It is also the case that when less severe outcome criteria are applied the deaf children show enhanced performance, especially for Flat-ending problems. This then raises the question of why this particular group of deaf children can accomplish a relatively difficult task, when older deaf children have failed simpler tasks?

Language and Visuo-spatial Processing

The most obvious reason is that these deaf children use Sign language and cannot, therefore, be considered alinguistic. If language is a necessary part of abstract functioning then these data merely reflect that. The extent to which language aids the solution of these particular problems was discussed in the introduction, as was the sensitivity of the task to cross-modal interference. The relatively lower level of performance by both groups in this study compared to Klahr & Robinson's Ss is certainly suggestive that the procedure used is a determinant of outcome. Their Ss, in both the 1976 and 1981 studies, did not move the cups themselves, but gave verbal instructions which were executed by E (1976) or plans (1981). The Ss here made as many, if not more, optimum first moves. Therefore, the effects of the procedural changes operated on subsequent moves, where maintenance of the mental representation of the task is crucial, if a minimal path solution is to be achieved. Oakhill & Johnson-Laird (1984) found that both verbal and visuo-spatial working memory were used to maintain spatial descriptions. The use of verbal memory was especially evident if these descriptions were difficult. If we assume that for the present task representation is visuo-spatial in nature then the act of moving the cups has the potential to interfere with that representation. Verbalising the solution offers an alternative means of representing the problem i.e. as a set of propositions, which is not susceptible to visuo-spatial interference. That the children did sometimes verbalise solutions supports this view.

Whilst this may reasonably account for the hearing groups performance, the fact that the language of the deaf group is visuo-spatial poses a special problem. For any task, which involves a visuo-spatial component and a language component, the deaf person, whose primary language is Sign, is always in the position of a hearing person in a cross-modal interference task. The full implications of this point will be discussed in Chapter 12. For the moment the discussion will be restricted to points relevant to this task. Presumably, the deaf person and Sign have developed strategies and linguistic devises for overcoming the potential problem of interference. Placement (see Chapter 9) is one such device, in that it removes the necessity to maintain a visuo-spatial representation which is distinct from a linguistic representation.

Consider a signed utterance which is the solution to a three move problem. Placement dictates that there is a one to one correspondence between the spatial layout of the problem, the moves required to solve it and the location and direction of the signs which constitute the uttered solution. In other words, in Sign, the surface structure of the linguistic representation is identical to the operations necessary to effect a solution, and, therefore, identical to a visuo-spatial representation. Assuming that the deep structure linguistic representation is propositional, the transformations to produce the surface string will produce the solution directly. Put simply, moving the cups is verbalising the solution for the deaf child.

Language, Direction and Mirrors

Klahr & Robinson argued that Flat-ending problems are more difficult than Tower-ending problems. In a Tower-ending problem the order in which the cups must reach the goal peg is immediately apparent, hence, subgoals are implicit in the final configuration, whereas this is not the case for Flat-ending problems. They also noted that when cups were in the form (xy/-/z) and moving x to the empty peg is not the optimum move, this error was four times more likely to be made during Flat-ending problems than Tower-ending problems. This move produces a configuration which approximates to the goal state, and, therefore, has a strong perceptual pull. By this reasoning, it would be expected that the deaf would find these Flat ending problems more difficult than the hearing. That they did not argues against those who characterise the deaf as being perceptually bound (e.g. Oleron, 1953).

There is some evidence that the deaf were less affected by the Flat-ending problems than the hearing. This was because the direction of movement of the cups did not affect the deaf group's ability to solve the problems, whereas the hearing group were adversely affected by predominantly left to right movements. This is counter intuitive, in that reading and writing give practice in dealing with left to right information processing. Also English sentences are right branching.

The following is a state description of two Flat-ending problems which require three moves:

	Problem 9 R-L	Problem 11 L-R
Initial state	G/-/RY	RY/-/G
1st move	RG/-/Y	Y/-/RG
2nd move	RG/Y/-	-/Y/RG
Goal state	G/Y/R	G/Y/R

It will be noticed that these problems are mirror images of one another, for all configurations. This is also the case with the two Flat-ending problems in set 5 and some pairs of Tower-ending problems. In all pairs of problems which are mirror images, a right to left problem precedes a left to right problem. We have already seen (Chapter 8) that placement in Sign requires a facility for dealing with mirror images, and that deaf children spend time exploring and using mirror images. It was suggested that placement requires that the treatment of space is isotonic. In other words the coding of spatial relations must be such that a reference to an aspect of that space, by any participant in a conversation is unambiguous. Assuming that this process underlies the coding of spatial relations in these problems, then there is a sense in which mirror image problems are in fact identical problems for the deaf. It is also necessary to assume that coding is different in the hearing.

If this is the case then we would expect to see a practice effect in the deaf, but not in the hearing. Table 10.14, shows the percentage of L-R problems for which the solutions were better than, worse than, or the same as for the preceding R-L problem. Due to the small numbers involved, the values are for both Tower-ending and Flat-ending problems.

	Deaf	Hearing
Better	47.6	15.6
Worse	14.28	31.3
Same	38.09	53.1

$X2=6.679$; df 2; $p<.05$

Table 10.14 Percentage of L-R Problems With the Same, Better or Worse Solutions than a Preceding R-L Problem

This shows that the deaf are three times as likely to improve their performance on a L-R problem which is a mirror image of a preceding R-L, with decrements in performance being half that of the hearing. The distribution for the hearing group, indicates not only the lack of a practice effect, but also interference. This suggests that some commonality is observed between the mirror image problems, but that this cannot be separated from, or accessed independently of chirality. If the decrement in performance on L-R Flat-ending problems in the hearing is due to this kind of interference, then repeating the study with L-R problems first would lead to a decrement in R-L problems.

This observed practice effect suggests a second reason why, the deaf evidence an enhanced performance, on the less severe criteria, namely that the problem is, in some aspects at least, a visuo-spatial one. The cogntive-linguistic skills of the deaf are, on this occasion, more efficient at dealing with the information and abstracting common principles. Whilst, this may seem a bold statement, it is no more so that saying oral language is more efficient at preserving order information (see next Chapter). The two statements are in fact saying the same thing; that where the structure of information and language are coterminous, then language is an efficient means of preserving it.

Illegal Moves

The foregoing has concentrated on those aspects of the task on which the deaf performed better than the hearing. It still remains that the deaf made consistently more illegal moves than the hearing. Chulliat & Oleron (1955) and others have commented on the perseverance of the deaf, in pursuit of inefficient strategies. The frequency of illegal moves can be viewed as another example of that kind of behaviour. However, having looked beyond the perseverance, we find that the deaf are not inefficient. This is not to say that such behaviour should be ignored, or treated as noise in the experimental situation. It is a part of what deaf children do and, therefore, to understand deaf children, requires that we understand this aspect of their behaviour. It is difficult to understand why the deaf children persisted in making illegal moves. Their behaviour, such as making the illegal move when they thought E was not looking, indicates that they knew the move was wrong. Once, dissuaded from making illegal moves, the probability was that they would produce a minimal path solution.

Methodological Note

On strict quantitative comparisons we find no difference between deaf and hearing in numbers of problems solved, but a difference in the number of illegal moves made, the deaf making twice as many illegal moves as the hearing. By using less stringent criteria, and a more detailed specification of individual problems, it was possible to make a more qualitative analysis of the data. This allowed relationships between task characteristics, language structures, and outcome measures to emerge. This method gave quantitative results which can viewed as confirming previous findings, (e.g. abstract ability, Furth, 1971; perseverance, Oleron, 1953) or refuting previous findings (e.g. abstract ability, Wright, 1955). The method also demonstrated that going beyond the quantitative produced qualitative data which indicated that different processes, which are related to the experience of deafness, underlie essentially similar results.

CHAPTER 11: Visual Memory for Non-Linear Sequential and Spatial Patterns in Deaf and Hearing Preschoolers

INTRODUCTION

Memory is a fundamental aspect of cognitive abilities, which is reflected in a large literature on the subject for hearing populations. Surprisingly, therefore, reviews up to 1980 covered only 16 studies of memory in the deaf.

Memory is concerned with the recording, organisation, retention and recall of information from the environment. As such it might be expected that preferred mnemonic strategies and organisation have a far reaching influence on those cognitive skills which memory subserves. Equally the potential methods of encoding information available might be expected to have an influence on the performance of memory. In the case of the prelingually profoundly deaf, the channels available for the reception of information differ in that the auditory channel is not available. An obvious consequence of this is that encoding based on the auditory features of information is greatly reduced if not excluded. If this is the case then we might expect to find greater reliance on visual aspects of information. If this is the case then what are the consequences for memory in the deaf and how is this reflected in memory tests?

Memory Research with the Deaf

Reviews by Furth (1964, 1971), Meadow (1980), Myklebust (1964) and Ottem (1980) of studies of various aspects of short term memory (STM) in the deaf show that the pattern of results obtained differs from that found in the hearing, with the deaf showing superior, equivalent and inferior performances depending on the type of stimulus material, the method of presentation and recall requirements. In general, for material which is non-verbal and items simultaneously presented the deaf show enhanced or equivalent performances to the hearing (e.g. Blair, 1957); for material which is linguistic and sequentially presented the deaf show inferior performance (e.g. Olsson & Furth, 1966). For non-verbal sequential material and verbal simultaneous material the pattern of results is more irregular, but indicate that for ordered recall sequentially presented items are more problematic than simultaneously presented items, irrespective of type of material. For example, Withrow (1968) reports that in deaf adults memory span for successively presented forms is below that for hearing adults, although equivalent for simultaneously presented forms. This is confirmed by Olsson & Furth (1966), who also demonstrate that for digit spans, the performance of deaf adults is inferior irrespective of method of presentation.

The results are also taken to indicate that for the deaf, absolute memory span, the number of items which can be held in STM, is below that of the hearing. This is because the non-verbal span of the deaf is taken to represent their ceiling. In the hearing,digit or other verbal spans,are always longer than non-verbal spans, hence the hearing have a greater STM capacity than the deaf. This advantage is taken to stem from the availability of a speech based code to the hearing (see below). Data from Klima & Bellugi (1979) on serial recall of signs supports this view, in that deaf adults recalled significantly fewer signs than hearing adults recalled words. On average the deaf recalled one item less, than the hearing group, but other aspects of performance are similar. For example, the deaf have the same type of serial position curve, and show intrusion errors based on formational aspects of sign analogous to intrusion errors based on phonetic similarity.

Visual Coding

The above was more concerned with the performance of memory than the type of encoding which was being used. An obvious code for the deaf is one which makes use of visual aspects of the stimuli, and is indicated by the presence of the intrusion errors noted above. Frumkin and Anisfeld (1977) investigated the codes used by deaf children in memory using false recognition errors as an index of coding. They presented 6 - 15 year old deaf Ss with list of words which contained semantically related and orthographically related words. They found a false recognition effect for both semantically related words and orthographically similar words. A second experiment using a series of manual signs on video tape found false recognition effects for signs which were semantically related and for signs which were cherologically[1] similar. On the basis of their results they argue that the visual codes of orthography and cherology are effective for deaf children. They also note the consistently strong semantic effect in the young deaf children which is not found in young hearing children. The generality of this semantic effect was further tested by using lists of concrete and abstract signs. Given the role of imagery in memory, which has been found to be analogous in deaf and hearing subjects (Conlin & Paivio, 1975) the authors argued that if the semantic effect were only to be found for the concrete list then this would suggest imagery based coding rather than semantic coding per se. The results again showed a strong semantic effect which was equivalent for both the abstract and concrete lists. They suggest that the young deaf child has no effective speech based code leading to greater reliance on semantic codes than is the case with young hearing children. They suggest that this semantic effect indicates that cherological coding (i.e. visual) does not have the same coding capacity for the deaf child as the analogous phonetic coding of the hearing child.

MacDougall (1979) also demonstrated the importance of visual coding in the deaf. Groups of 5 letters, were presented visually to deaf and hearing Ss. Their task was to write down the letters in the same order as they were presented on the slide, immediately after presentation. There were two conditions using different typescript for the letters. Evidence of visual coding was examined by comparing the pattern of

1. Cheremes are the Sign analogues of Phonemes

errors for the two typescripts. A similar pattern for both typescripts would be taken to indicate the use of a code not based on visual features of the stimulus. The results showed that the deaf relied predominantly on visual coding, with the young deaf group being more 'visual' than the older deaf. In the case of the hearing groups this trend was reversed with the older hearing group being more 'visual' than the younger. However in this study all the letters of the alphabet were used, rather than subsets chosen specifically for their orthographic or phonetic confusibility. Hence, a second analysis was carried out which determined the number of visual, acoustic or overlap (items which were confuseable in either modality) errors for each typescript. This analysis showed little difference in the pattern of errors for the young and old deaf groups, visual errors out numbering acoustic errors c5:1. In the hearing groups the younger Ss made approximately equal numbers of acoustic and visual errors, while the older group made approximately twice as many visual as acoustic errors. Therefore, this second analysis confirms the developmental trend advanced for the hearing group, but not the deaf S's, and further confirms the predominance of visual coding in the deaf. The author argues that this reliance on visual coding may be an important factor in the deaf child's difficulties in learning to read, given that hearing children apparently develop from auditory to visual-auditory coding.

> "An important point to keep in mind in this connection is that independent of the modality of processing in this study, and indeed all other studies on this topic, deaf S's make substantially more errors than hearing S's when presentation is visual (Conrad, 1970; Wallis & Corballis, 1973). As hearing S's become older and use visual coding, they seem to be more efficient than deaf Ss as far as absolute memory is concerned. This raises the possibility that the type of visual processing that is being used by deaf and hearing S's is in fact different." (p21)

He suggests that his data support this notion of differential visual processing by the fact that the deaf and hearing Ss in his study show a different pattern of visual errors across the two conditions. He then goes on to suggest that the deaf may be impaired in their ability to use visual memory per se, which is contrary to the data reported by Blair (1957) which shows a superior ability in visual memory for designs. Whilst the argument of differential visual processing may be supported by the reported data, it is not clear on what basis he makes the assertion of impairment, nor the statement that the deaf always make more errors when presentation is visual. The overall number of errors for the deaf and hearing, collapsed across ages and conditions are 633 for the deaf and 715 for the hearing, with the old-hearing group i.e. the most visual of the hearing groups making more errors than the young deaf group (361 v 281) On these data the use of visual coding reduces the efficiency of the hearing group in this study.

In both the above studies, it has been asserted that visual coding is inferior to speech based coding for the tasks in questions. This conclusion is also reached by Wallis & Corballis (1973) using visually presented 4- and 5-letter sequences. However, with the exception of the sign condition in Frumkin & Ainsfield, all three used material which was oral linguistic in nature and the two latter required retention of order information.

Sequencing and Language

Of the research results, it is the poor ability shown for dealing with sequentially presented material and reduced memory span, which has received most attention. The prelingually profoundly deaf, with a few exceptions, fail to acquire a competence in oral language. This is equally true for either spoken or written forms of language. It has also been noted that other language disabled groups (e.g. Aphasics) show similar deficits in these kinds of sequential span tests. From this it is argued that a common process underlies language and sequencing abilities. For example, syntax is concerned with the order in which words and information are given. Lake (1980) points out that deaf children do not pay attention to word order when learning English and there is widespread agreement that the greatest difficulty the deaf have with oral language is aspects of syntax (e.g. Quigley & Paul, 1984).

Auditory perception requires the discrimination and integration of series of temporal events, with spatial aspects of the signal being less important. By contrast visual perception is concerned with the processing of simultaneous (i.e. spatial) information, with temporal aspects of the signal being less important. Oral language is a linear distribution of events in time and the perception of language requires rapid temporal discrimination and integration of these events. It is argued that it this experience which accounts for the enhanced performance of hearing populations in sequential or memory span tasks where recall of temporal order is the central requirement.

A second explanation of the superior performance of hearing groups is the availability of a speech based code. It is argued that speech codes not only enhance STM capacity per se, but are also ideally suited for coding order information, such as sequences (e.g. Healy, 1975; 1977). Evidence for a speech based code comes from studies of confusion errors in recall (e.g. acoustic Conrad, 1962; articulatory Hintzman, 1967). Given that most previous work perceives the deaf as being alinguistic it can be argued that they have no speech based code, thus necessitating the adoption of alternative, visually based strategies.

Accepting sign language as linguistic still precludes a speech based code although not, as Klima & Bellugi (1979) point out, a linguistic code. However, it has already been noted that this code still does not lead to similar results in the deaf and hearing, when order information is important. This is confirmed by Hanson (1982), who found that deaf adults recalled fewer items from a list when ordered recall was required. Irrespective of mode of presentation, i.e. sign or written word, Ss showed evidence of using a speech based code. However, for the sign presentation condition there was also evidence of the use of a sign based code. Despite this accuracy of ordered recall was correlated with the use of a speech based code. Hanson argues that the data support the view that a speech based code facilitates the retention of order information. In a second experiment, which required only item recall, the performance of deaf and hearing adults was comparable. Whilst there was no evidence of a speech based code being used by the deaf Ss, neither was there evidence of the use of a sign based code. The authors suggest the Ss are using a visual code, but from Frumkin & Ainsfield it is possible that they were using a semantic code. However, the implication from these two studies is that a sign based code can be used to retain order information, but that a speech based code better preserves order information.

The discussion of sequences and the retention of order information has thus far centred on the idea of temporal order, i.e. the distribution of events in time and the relationship this has with speech based codes. It is also true that a one dimensional sequence can be presented visually as a sequence of spatial locations, e.g. from left to right. A simultaneously presented group of letters such as used by Macdougall (1979) could also be viewed as a spatial sequence. In this case it is difficult to see why a visual based code should be at a disadvantage for preserving order information. In fact the deaf Ss in the MacDougal study made less errors than the hearing Ss. This suggests that one dimension along which encoding strategies can vary is spatial - temporal, dependant on the type of information to be encoded and also that visuo-spatial codes can preserve order information. The use of such codes by hearing Ss has been demonstrated by Healy (1977), where Ss used a spatial-temporal code to preserve item and order information, when use of a speech based code was prevented. However, the serial position curves produced by these spatial-temporal codes differs from the 'U' shaped curves reported for serial recall of linguistic items, in being flatter and inverted.

Order Information and Spatial and Temporal Coding.

The above arguments suggest that the adoption of a coding strategy may be a function of a) modality of input, b) type of information c) task requirements or d) some combination of these. O'Connor & Hermelin (1972) investigated the influence of modality of input on coding strategy. They used a three item array, presented sequentially, such that the spatially central item was never the temporally central item. Items were presented visually in one of three linear display panels, or in the auditory modality in one of three linearly arranged loudspeakers. These ambiguous sequences were presented in the auditory modality to blind and sighted Ss and a control group of sighted Ss wearing blindfolds and in the visual modality to deaf and hearing Ss with a control group of hearing Ss wearing earmuffs.

The results showed that modality of presentation predicted the strategy adopted, i.e. when the arrays were presented visually S's chose the spatially central digit, irrespective of hearing status, but when the arrays were presented in the auditory modality the Ss chose the temporally central digit, irrespective of seeing status. In a second experiment they examined the effects of simultaneous auditory and visual presentation with hearing Ss and found that responses were predominantly spatial (317 out of a possible 320 responses). However when Ss were first exposed to auditory and then simultaneous presentation the responses were predominantly temporal (no figures given). The authors attributed this to 'set' induction by the preliminary auditory presentation. On the basis of these results they concluded that modality of input induces either a spatial or temporal set. Therefore, deaf children, with no access to auditory input will behave as if they had a visually induced set and organise events spatially.

In a later study (O'Connor & Hermelin, 1973) deaf, hearing, and autistic children were presented with ambiguous three digit visual arrays. In this task Ss had to recall all three digits. The results showed that deaf and autistic Ss recalled the spatial order of the digits, whilst the hearing group recalled the temporal order. As measured by number of errors neither strategy was more efficient than the other. A recognition task was used to test the hypothesis that recall forced the adoption of a particular strategy. These results followed the same pattern as for the recall task.

These data apparently contradict the findings of the 1971 study, which, given the modality of input, would have predicted all groups to organise the materially spatially. However, taken together, they suggest a possible interaction of modality of input and task requirements (a & c above). In the 1971 study the Ss had to report only one item i.e. the middle digit, whereas in the 1973 study all three items had to be retained. The term middle is relative and induces a set to look for a specific item. In the visual condition it is not unreasonable to expect that S's would fixate on the middle of the three display windows and wait for a digit to appear. Similarly for the auditory condition an efficient strategy would be to wait for the second digit and retain only that. The sighted controls could have waited for the digit presented in the spatially central loudspeaker. That they obviously did not suggests that 'middle' in an auditory context refers to a position in a temporal sequence rather than a position in space. Thus a combination of the task requirements and modality of presentation interact to determine the encoding strategy adopted.

The retention of three items in a given order is more demanding than retention of a single item and therefore it can be assumed that Ss will adopt the most efficient strategy irrespective of modality of presentation. In terms of numbers of errors temporal and spatial coding were equally efficient in the above study. If the two strategies are equally efficient why are the two types of organisation not found equally amongst all the groups? The autistic children were included because of their "marked auditory unresponsiveness and verbal disability" (p336). As their results were statistically identical to the deaf group auditory experience and/or oral language experience are implicated.

Whilst the deaf may show a preference for spatial coding in certain tasks, it is not to say that they cannot deal with temporal information or temporal processing. Whilst sign language may be described as a spatial language it is also true that signs follow one another in temporal sequence. Poizner and Tallal (1987) used deaf adult signers as Ss in four experiments, two concerned with the sensory processing of rapidly varying temporal information and two with memory for the temporal order of rapidly varying nonlinguistic stimuli. They found no differences between deaf and hearing Ss on any of the four measures and conclude;

> ".....that deaf signers have no deficit in temporal processing, when temporal processing and processing English are not confounded" (p60).

Kyle (1983) showed deaf native signers, hearing bilinguals and hearing non signers a silent movie. The Ss task was to recall the story in either sign or English. The story was recalled immediately after presentation and again after a delay of one hour. The deaf and hearing Ss recalled the events to the same extent but an analysis of the recall of the order of events showed that the deaf recalled fewer events out of order than did the hearing and that the delay in recall increased this difference. Of particular interest are the results of the bilinguals. These fell midway between those of the deaf and hearing. This suggests that there is some effect due to deafness and some due to the language code used.

These data could be interpreted as suggesting a rigidity, or lack of flexibility in dealing with temporal order in the deaf. The fact that the hearing bilinguals fell midway between deaf signers and hearing speakers indicates that the grammar of sign does not contain those structures which allow reference to past and future out of temporal context. However the greater tendency by the deaf to recall the events as seen implies some difference in the way the story is coded.

Rational for Present Study

The particular subset of memory studies considered here are especially concerned with spatial and temporal processing as evidenced by memory tasks. The evidence reviewed seems to suggest that dealing with sequences per se is not problematic for the deaf (e.g O'Connor & Hermelin,1972; 1973), nor the processing of temporal information per se, (e.g. Poizner & Tallal, 1987). When the material and task requirements allow visual and/or spatial coding to be employed and order information is to be preserved then the deaf are as efficient as the hearing (O'Conner & Hermalin, (1975). There is evidence that the number of items of which can be held in STM using visual based codes and sign based codes is lower, by one item, than the number that can be held using a speech based code. The deaf have difficulty where temporal order is not observabley related to spatial order or oral linguistic processing is a task requirement.

The memory studies reviewed typify the methodology of comparing deaf and hearing on the basis of what the hearing can do and what oral language enables, and focusing on the inferior performances of the deaf. Myklebust's (1964) review notes three areas of memory where the deaf show superior performance; memory for design, movement and tactual memory. For memory for object location deaf and hearing performances are equivalent. In line with the arguments advanced in Chapter 4 what would a memory task look like if it were devised on the basis of what the deaf can do and how would the hearing fare if they are compared to the deaf on these terms?. The present study uses a task designed to allow just such a question to be asked.

The work reviewed indicates that the deaf prefer to use a visuo-spatial coding strategy. Ellenberger & Steyaert (1978) note the relationship between sign language and spatial skills, suggesting;

> "What appears to be simple gesturing may actually require a fairly advanced mastery of cognitive skills involving spatial relationships." (p 268).

A sign can be construed as a pattern in three dimensional space. Signs are not only static patterns but can also include movement. The place in space where a sign is made is not arbitrary, location being a necessary part of the sign. In discourse movement and location play grammatical roles. These aspects of signing can be seen to be related to those aspects of memory for which the deaf show enhanced or equivalent performance. In the past these have been examined individually. Effective use of sign requires that these individual aspects of memory be used together. The deaf child who has experience of sign from an early age might be expected to show well developed memory skills for these aspects of memory acting together, compared to a hearing child who has not. To demonstrate this would require a task which involved patterns and movement and location. So as not to confound memory processing with language processing, the task would need to be as alinguistic as possible. A further linguistically derived requirement is that the task should include more than one dimension. In the past order information recall studies with the deaf have used a linear or one dimensional array. Sign language is three-dimensional, whereas oral language is linearly constrained in time (Winograd, 1977).

The task used here is based on one reported by Gazzaniga (1988) to test memory in Ss with a callosul section. In that study patterns of dots were displayed in a two dimensional 4 x 4 matrix. Recall was immediate and demonstrated by pointing to the locations where the dots had appeared. A similar task was used by Ichikawa (1982) to examine visual memory span in adults. Again recall was immediate, and demonstrated by marking the position of the dots in a blank grid. He reported that visual memory span measured by this test has a very low correlation ($r=.23$) with verbal spans measured by digit sequences. The visual memory span of adults was defined by Ichikawa as the number of dots in a pattern in a 5 x 5 or 6 x 6 matrix which could be perfectly recalled 50% of the time. This gives a span of approximately five.

The adult data for these dot-in-matrix tasks indicates that the task is not an easy one. Pilot studies with hearing children aged 9 to 11 years showed that a 3 x 3 matrix containing 3 dot patterns produced a ceiling effect but 4 dot patterns did not. Therefore, it was considered that these tasks would be a difficult but practical task to use with preschoolers. In the present study an additional task has been included. In this task the pattern is formed by a single dot appearing in a sequence of locations in the grid, hence the pattern is an abstraction of the stimulus. Piloting with hearing children and adults indicated that this was a difficult task. In view of this the tasks were piloted with one deaf child aged 57 months, with a deaf adult acting as experimenter. This confirmed that although the tasks were difficult they were within the child's capabilities.

Aims

The aim of the study is to examine the effects of differential hearing and linguistic status on memory for static and sequential 2-dimensional patterns and to determine the coding strategies used by deaf and hearing subjects for these tasks.

METHOD

Subjects & Experimenters

Four profoundly deaf children ages 48 to 56 months (mean age 51.75 months) attending the departmental playgroup for the deaf and six hearing children ages 47 to 57 months (mean 51.5 months) attending an L.E.A. nursery school acted as subjects. Hearing children were tested by the author; deaf children were tested by a profoundly deaf adult, using BSL. for communication.

Materials & Apparatus

Static and moving patterns were generated using a B.B.C. model B computer, with double disk drive, programmed by the author. Details of the programmes are in appendix 11[1]. Responses were made on an A.B. Electronics plc. concept keyboard (A4 size), overlaid with a replica of the matrix which appeared on the screen, and recorded on disk by the programme. The programme recorded the type of pattern, which square had been pressed, and in what order.

Patterns were generated in a 3 x 3 matrix and contained 3 or 4 discs. Patterns could be static i.e. all discs appearing simultaneously, or moving, i.e. one disc occupying consecutive positions in the matrix. Static patterns remained on the screen for the same number of seconds as there were discs in the pattern (i.e. 3 secs for 3-disc patterns; 4 secs for 4-disc patterns). For moving patterns the disc remained in each position for 1 second, hence, a moving pattern was displayed for the same length of time in total as the corresponding static pattern. For both types of pattern the child's response was a sequentially constructed static pattern i.e. for each square pressed a disc appeared in the corresponding square on the screen and remained there until all the responses had been made. The number of responses was limited by the programme to the number of discs in the pattern.

Design

A 2 (hearing status) x 2 (pattern type) x 2 (number of pattern elements) factorial design was used, with repeated measures on the factors of pattern type and pattern elements. 10 different patterns were generated for each number of elements. 5 were presented as static and 5 as moving patterns, hence static and moving patterns were different. Order of presentation of

1. Program listings and/or disk are available from the author.

patterns was counterbalanced across subjects. The same order of testing static, moving, 3-disc, 4-disc patterns was used for each child.

Procedure

Children were tested individually, in their normal playrooms. The children were not taken to a separate room for testing at the request of parents. The child was asked if s/he would like to play a game on the computer. The practice programme was loaded and the experimenter pointed out the correspondence between the matrix on the screen and the matrix on the concept keyboard. It was explained to the child that the computer would produce a pattern and they had to make it reappear by pressing the correct squares on the their keyboard. No specific instructions were given concerning the order in which the pattern elements were to be recalled leaving the child free to adopt their preferred strategy. Practice trials with both static and moving patterns were continued until the experimenter felt confident that the child understood the task requirements. The main programme was loaded and the child was given 5 trials of each pattern type for each number of elements (20 trials in all). After each block of 5 trials the child was told that pattern type would change and what that change would be. Recall was immediate for all trials. The child was praised after the completion of each trial, but no feedback was given regarding the correctness of the child's attempt to reproduce the pattern.

RESULTS

Scoring Method

The raw data was printed out from the data collection files and scored. For static patterns a score of 1 was given for each element which appeared in the correct position in the matrix. For moving patterns each element was scored on two variables; spatial and temporal. A score of 1 was given for each element in the correct spatial position (S), and a score of 1 given for each correct position in the correct temporal order (T).

Therefore, the maximum possible score for each child is number of elements x number of trials. There are two sets of scores for moving patterns. The data are summarised in table 11.1.

Pattern type

The Static scores are directly comparable with the moving spatial scores. These data show that for the static condition more elements of 3-disc patterns were correctly recalled than elements of 4-disc patterns. A Wilcoxon test shows that this difference is significant for the hearing group (T=0; N=6; p<.05 tt) but not for the deaf group. This pattern of results is repeated in the moving condition, the hearing group recalling significantly fewer elements of the 4-disc moving patterns (T=1; N=6; p<.05 tt).

	Static		Moving			
	3-disc	4-disc	3-disc		4-disc	
			S	T	S	T
deaf	68.3	58.75	52.0	19.96	47.9	9.58
hearing	76.66	67.5	56.63	32.18	27.08	3.75

Table 11.1 Mean Percentage of Pattern Elements Correct for each Condition.

Comparing between groups the data show that the deaf recall fewer elements of 3- and 4-disc static patterns than the hearing. However, this difference is not significant for either condition. For Moving patterns there is little difference between the groups for the 3-disc condition, but for the 4-disc patterns, the most difficult task, the deaf recall nearly twice as many elements as the hearing. A Mann-Whitney U test shows this difference to be significant at the 1% level of confidence (U=0; p<.01). The differences between the spatial and temporal scores for both conditions for both groups indicate that coding is predominantly spatial. The next section examines this further.

Spatial v Temporal Coding

The moving patterns may be coded as a pattern i.e. spatially, as a sequence i.e. temporally or by using some combination of these. To assess the relative contributions of temporal and spatial coding in serially presented patterns three serial position curves were constructed. Temporal recall curve is the number of times a position was recalled in the correct temporal order. The Mixed recall curve is the number of times a position was correctly recalled irrespective of temporal order. The Spatial recall curve is the number of times a position is correctly recalled, but not in the correct temporal order. The data are summarised in tables 11.2 and 11.3 and shown graphically in figure 11.1

	serial position					
	1		2		3	
	H	D	H	D	H	D
temporal recall	40.5	25.0	31.2	20.0	22.8	15.0
mixed recall	60.5	50.0	60.5	40.0	49.4	60
spatial recall	20.00	25.0	28.8	20.0	26.6	45.0

Table 11.2 Mean Percent of Elements Recalled for each Serial Position: 3-disc Patterns

	serial position							
	1		2		3		4	
	H	D	H	D	H	D	H	D
temporal recall	13.3	23.33	13.3	10.00	3.3	0.00	13.3	5.0
mixed recall	43.3	46.66	53.3	30.0	60.00	58.33	63.3	56.65
spatial recall	30.00	23.33	40.00	20.00	56.6	58.33	50.0	51.65

Table 11.3 Mean Percent of Elements Recalled for each Serial Position: 4-disc Patterns

The mixed recall curve indicates the overall success in recalling the pattern. The spatial and temporal curves indicate the relative contribution of these strategies to overall success.

The classic serial position curve is U shaped. This can be seen in the mixed curve for the deaf 3-disc patterns and in the temporal curves of the 4-disc patterns for both groups. A number of findings (e.g. Healy 1975) have suggested that serial position curves for visually presented material or for tasks requiring retention of spatial order, are bow shaped i.e. an inverted, flattened U. This type of curve can be seen for the mixed and spatial curves of the hearing 3-disc patterns and the deaf and hearing 4-disc patterns.

Figure 11.1 Serial Position Curves for 3- and 4-disk Moving Patterns

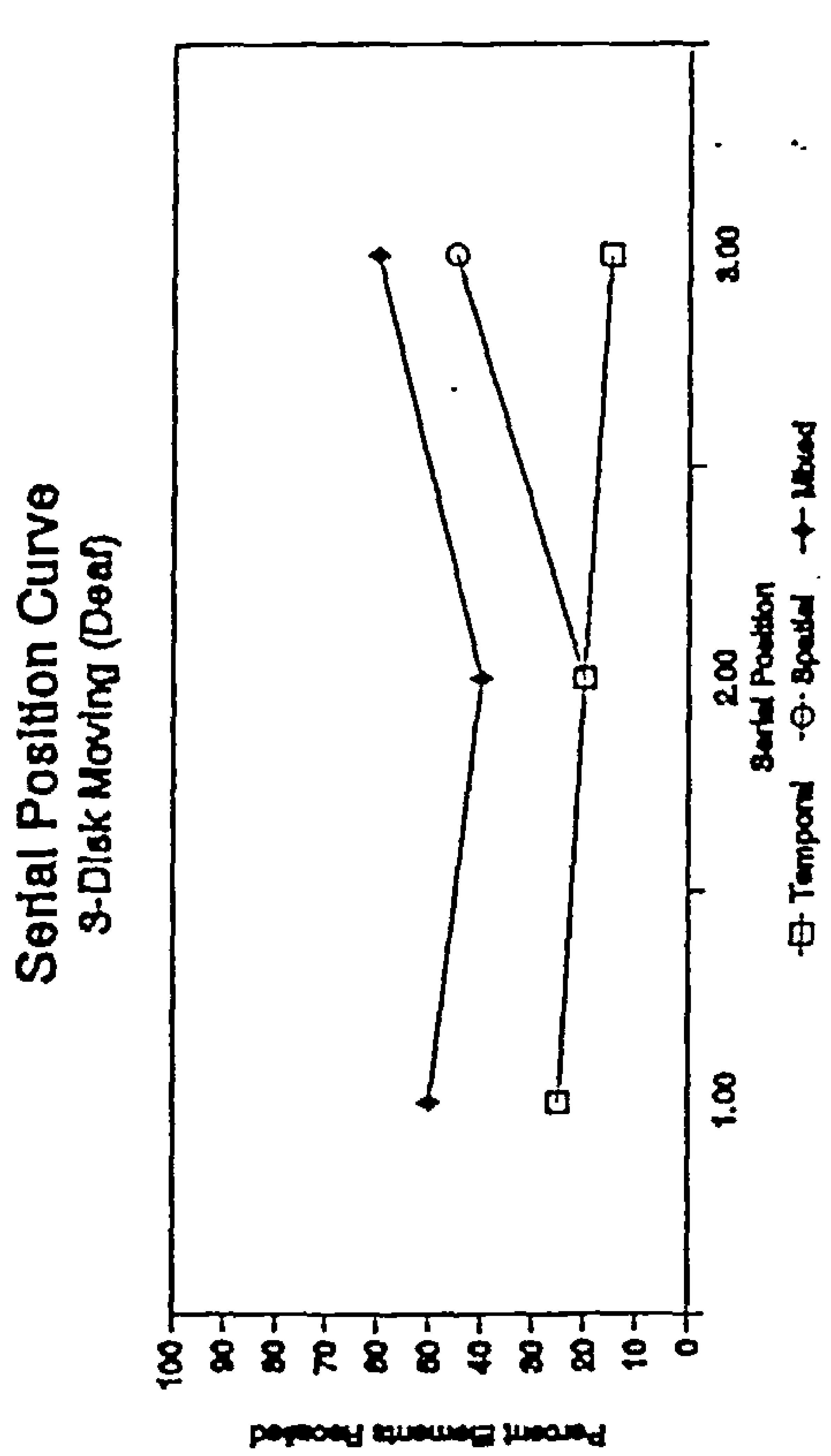

Fig 11.1a Percentage of Elements Correctly Recalled at Each Serial Position

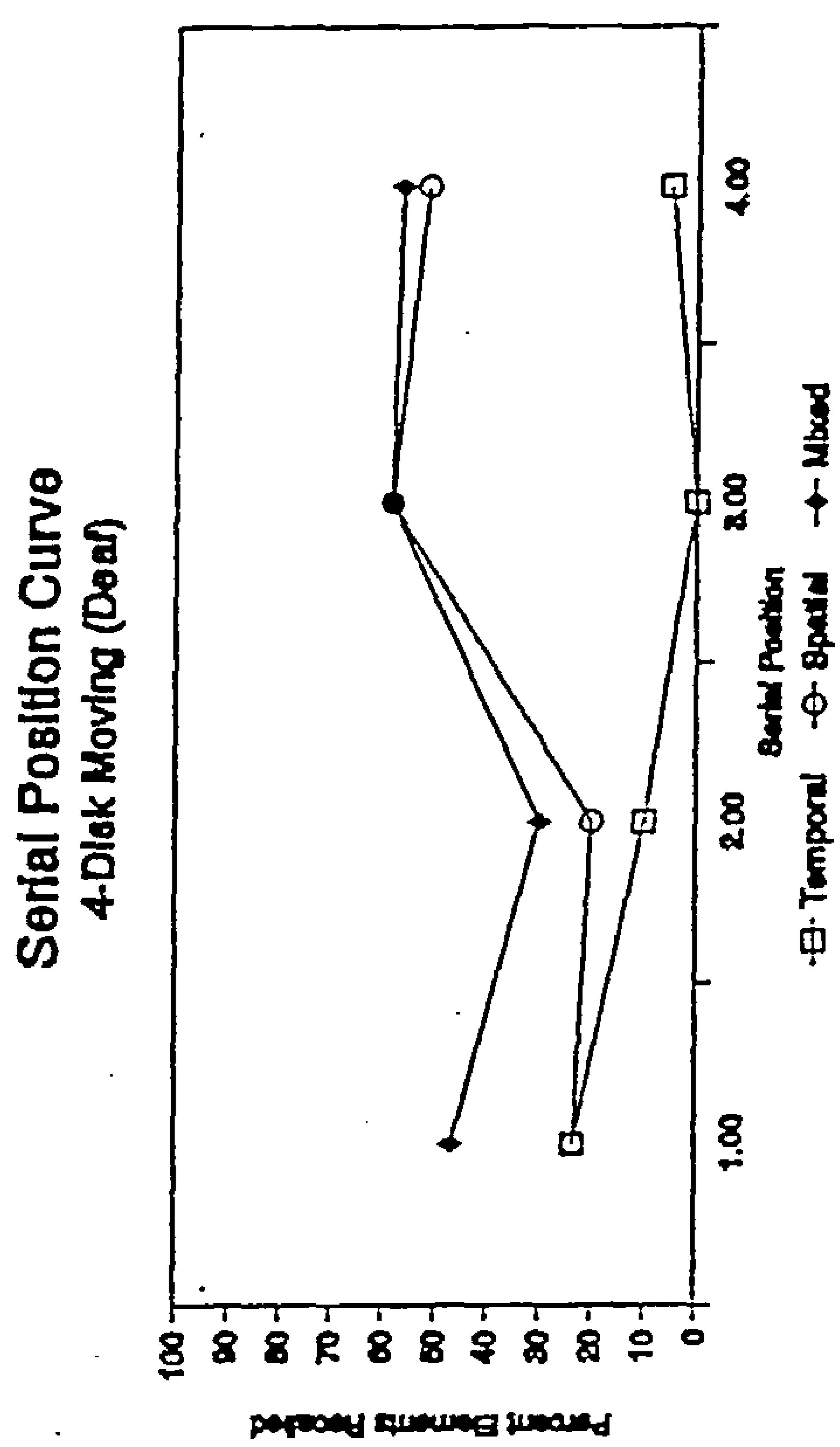

Fig. 11.1c Percentage of Elements Correctly Recalled at Each Serial Position

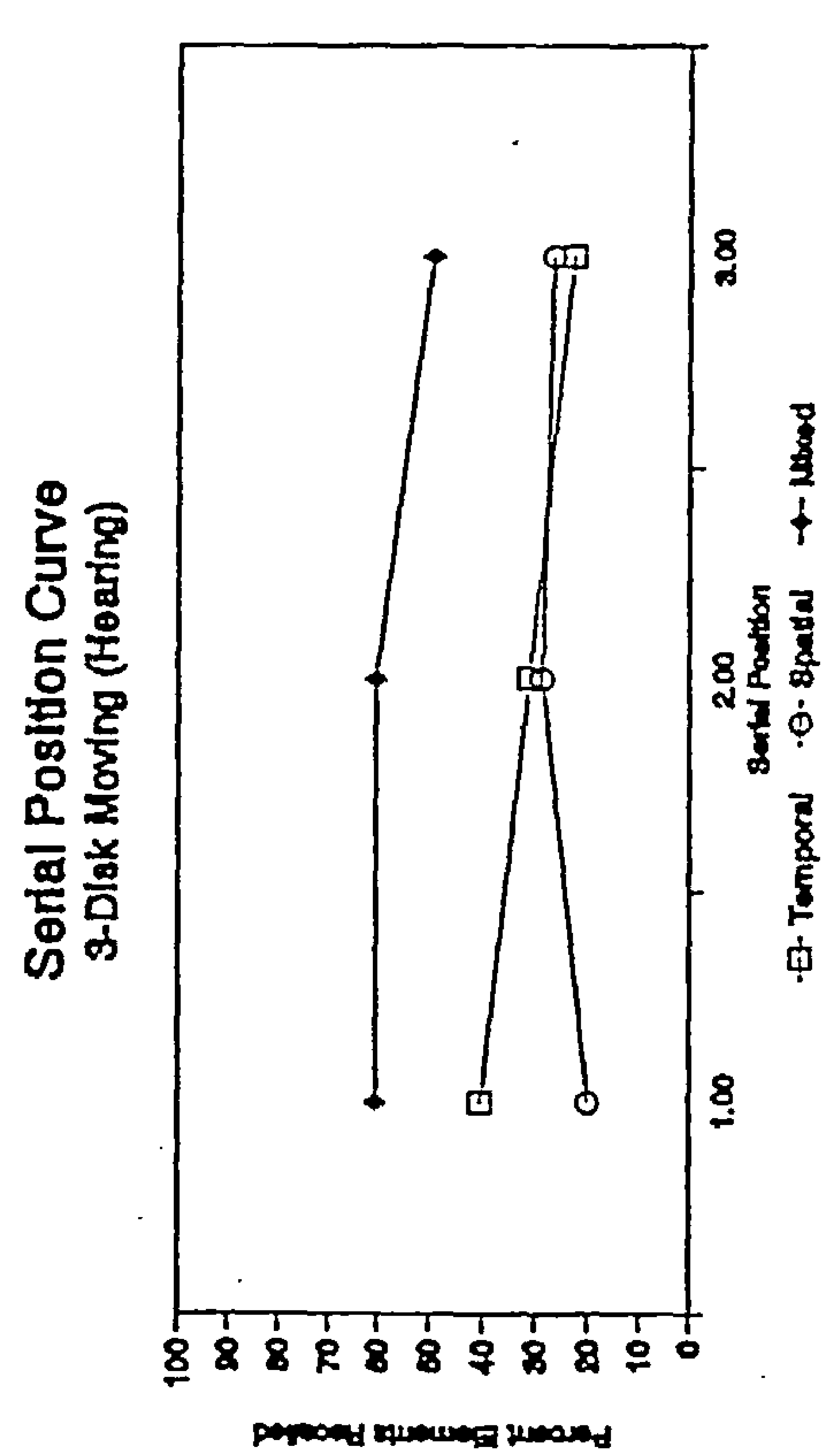

Fig 11.1b Percentage of Elements Correctly Recalled for Each Serial Position

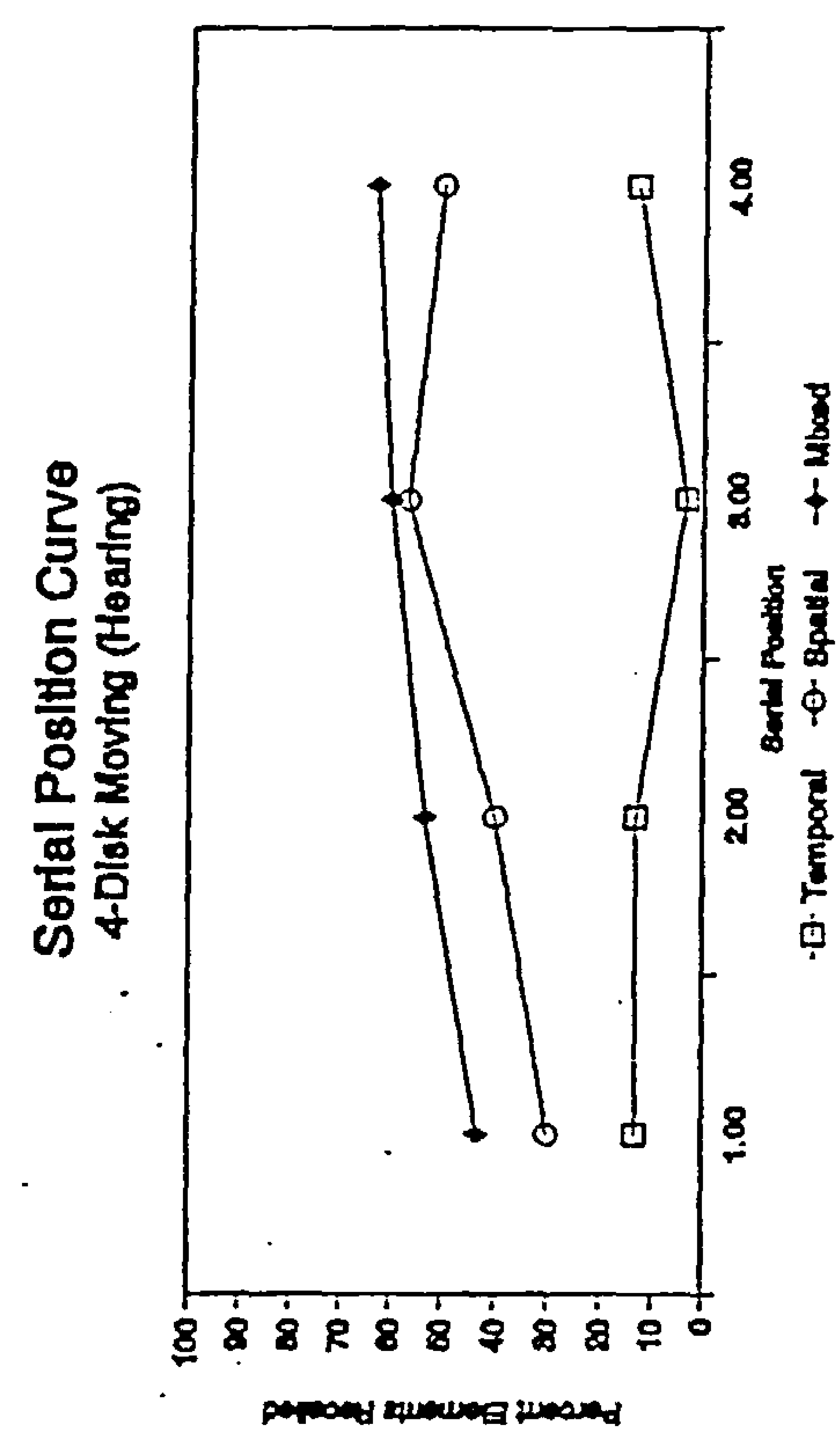

Fig. 11.1d Percentage of Elements Correctly Recalled at Each Serial Position

Hearing Children

For the 3-disc patterns temporal recall is the major contributory factor for the first serial position, in that if this element is correctly recalled it is twice as likely to be recalled in the correct temporal order than in some other temporal position. In the second and third serial positions spatial and temporal recall contribute about equally. Elements in the third serial position are recalled less well overall (i.e. depressed recency).

For the 4-disc patterns spatial recall is the major contributory factor for all serial positions. This seems to indicate a change in coding strategy from that used in the 3-disc patterns. Here spatial recall accounts for 80% of the mixed recall curve compared to c44% of the 3-disc mixed recall curve.

Deaf Children

For the 3-disc patterns spatial and temporal recall contribute equally to overall success for the first two serial positions. Primacy on the spatial curve is suppressed. For the third serial position the spatial curve shows a marked recency effect, with the temporal curve showing a corresponding suppression of recency. The overall effect is a classic U shaped serial position curve, with spatial-temporal recall accounting for primacy and spatial recall for recency.

For the 4-disc patterns again spatial and temporal recall contribute equally to success for the first two serial positions. Temporal coding shows a primacy effect with depressed primacy on the spatial curve. For the third serial position spatial recall accounts for all the data, and most for the fourth serial position. These data tend to suggest that the children initially adopted a spatial-temporal strategy, changing to a spatial strategy after the second serial position. The net effect is to produce a bow shaped mixed curve, as has been reported previously for spatial memory tasks. The data do not suggest such a clear change in strategy for the deaf children as was the case with the hearing children. Rather, the data suggest an extension of that used for the 3-disc patterns.

Comparison Deaf & Hearing

Two features of the data clearly differentiate the deaf and hearing. The first is the shape of the shape of the mixed recall curve for 3-disc patterns, this being in opposite directions for the two groups. This is in part due to the second feature, which is the suppressed recency of the spatial curve of the hearing compared to that of the deaf. This spatial recency effect is also apparent in the 4-disc curve of the deaf. These data for the deaf group are in line with findings by Dodd et al (1983) who found enhanced recency effects for both deaf and hearing Ss for moving manual signs, compared to static signs.

Previous studies predict that where there is a choice between temporal or spatial strategies, as in this study, hearing S's will opt for a temporal strategy and deaf S's a spatial strategy. These data do not support such a clear cut distinction, however, Healy (1975,1977) has suggested that under certain conditions hearing Ss use a spatial-temporal code, of an unspecified nature. The data here are indicative of such a code, with temporal aspects playing a greater role in the coding of the deaf than has previously been allowed.

Error Analysis

The stimuli used here differ from those normally used to investigate coding in short term memory in that they consist of a 2-dimensional array rather than a linear array. With a linear array both spatial and temporal coding require only unidimensional representation i.e. need one piece of information to uniquely identify its position, and that would be identical to its temporal or spatial position. If 2-dimensional stimuli are coded using either a verbal, or a more abstract propositional type code, each element of the pattern must have two pieces of information attached to it for accurate recall of the pattern. Verbal coding would require something like "top left" or "middle right" to uniquely identify an element position. A more abstract (e.g. propositional) code would require equivalent information in say terms of cartesian co-ordinates. This information is always identical with an elements spatial position, but never with its temporal position. Information regarding temporal position would require additional coding resulting in three pieces of information for each element.

Visual coding of a 2-dimensional array could reduce the amount of information by coding only the relations between elements of the pattern, i.e. only the overall shape is retained, information locating the elements in unique positions being lost. If this is this case then an error analysis would be expected to show evidence of correct pattern shapes, but wrongly located in the matrix. This same analysis would also indicate the extent to which the moving patterns are coded as a pattern rather than a sequence of positions.

Table 11.4 summarises the number of patterns which were recalled correctly. Maximum possible score for each pattern type is ten. For moving patterns only position of elements are scored.

	Pattern Type		
	Static	Moving	All
Hearing	50	16.67	33.33
Deaf	20	10.52	15.38

Table 11.4 Percentage of Patterns Correctly Recalled.

The data show that the hearing were more successful than the deaf, in recalling complete static and moving patterns. The data confirm that even the static task was not an easy one for the children. No child achieved a maximum score, the range (deaf and hearing) being 0 to 9. The deaf's low score for moving patterns stands in contrast to their relatively enhanced

performance when only pattern elements are considered. The error analysis may indicate possible reasons for this.
The raw data were transcribed into 3 x 3 matrices and the resultant patterns compared with those generated by the computer. Errors were classified according to the following scheme:-

1. Orientation (O) - The pattern shape is correct but is reoriented within the grid. This could be by rotation through 90, 180, or 270 degrees; a mirror image or an inversion
2 Displacement of Whole Pattern (D) - the overall shape and orientation of the pattern are correct, but the pattern is displaced in the grid.
3 Displacement of Part of Pattern (DP)- The orientation of the pattern is correct but one element of the pattern is displaced by one square.
5. Apparent Motion (moving patterns only) (A) - The responses of the child include those squares through which the moving disc apparently passed. (NB as the number of possible responses the child could make was limited to the number of discs in the pattern a child following this strategy could never complete a pattern)
6. Sequencing (moving patterns only) (S) - pattern elements were correctly located but the child's responses were not in the same temporal order as the stimuli.
7. Other (Ot) - errors which could not be classified reliabley in the above categories.

Table 11. 5 gives the percentage of errors in each category for the four types of pattern. The data are shown graphically in figure 11.2

In the 3-disc static condition the majority of classifiable errors are Partial Displacement for both groups. This suggests that the coding took the form of relations between elements e.g. two together and one underneath. This would give a 1 in 3 chance of the underneath element being located correctly. There are few errors in the displacement category, none for

Figure 11.2 Percentage of Patterns in Each Error Category for Each Condition, for Each Group.

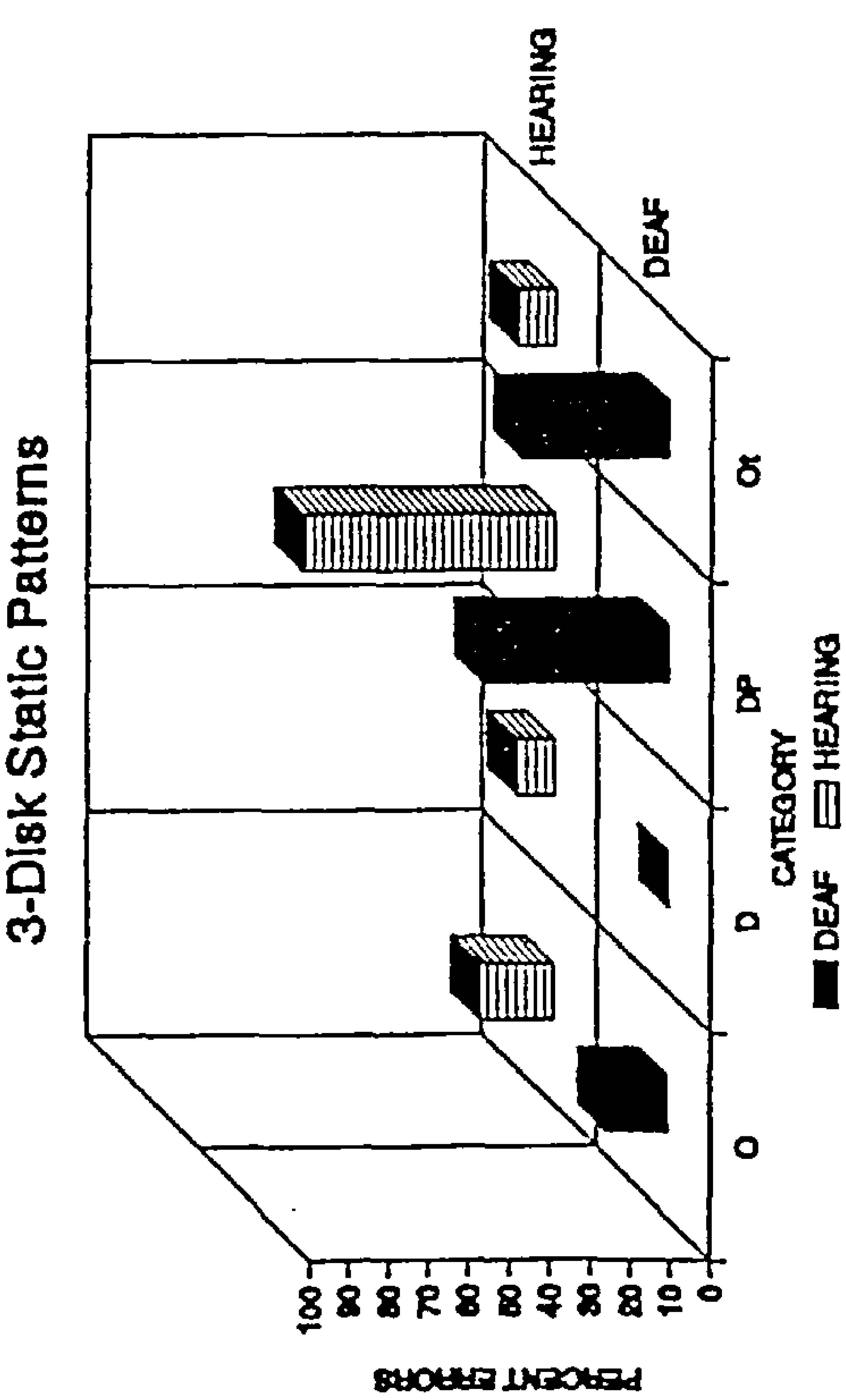

Fig. 11.2a Percentage of Errors In Each Category

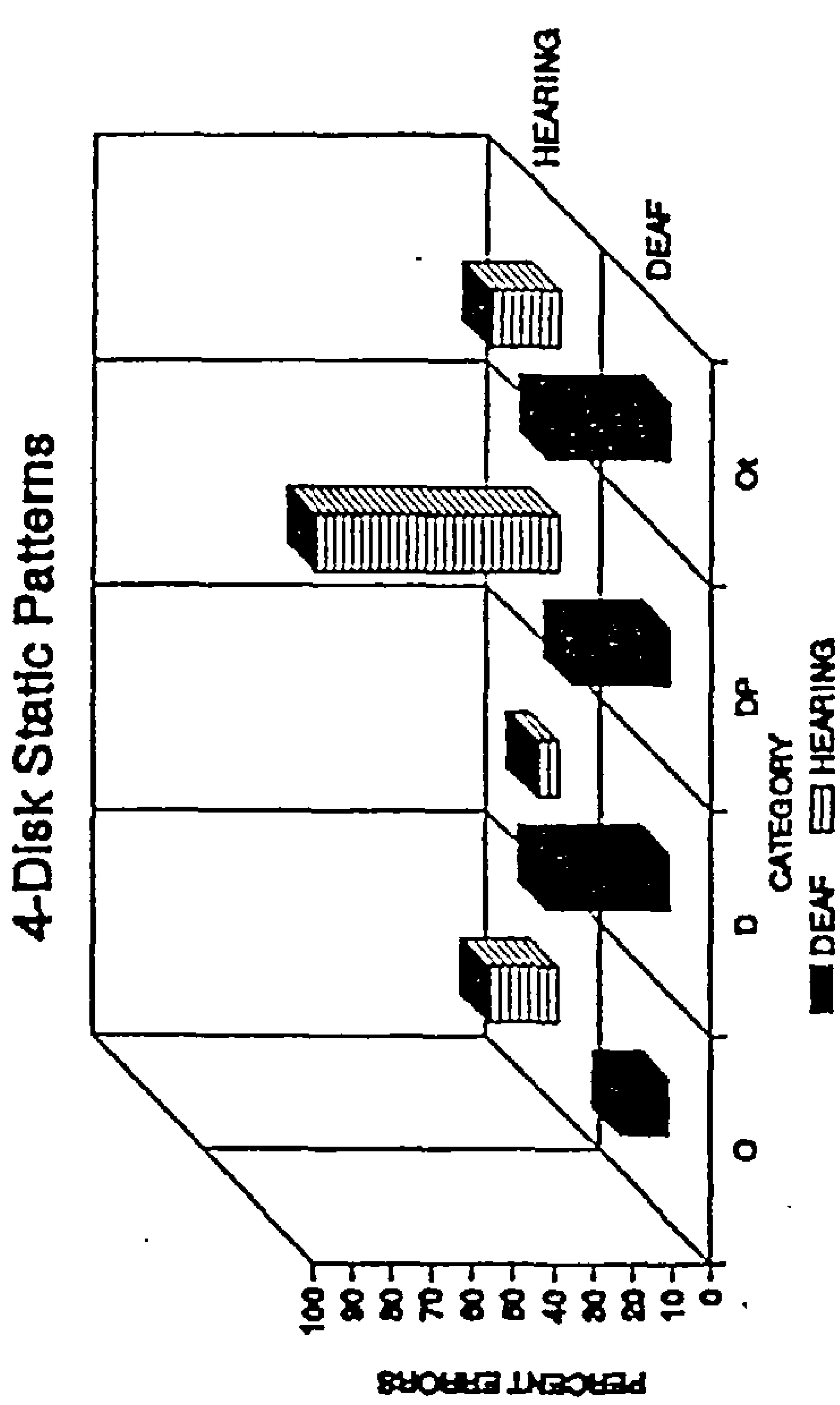

Fig. 11.2b Percentage of errors In Each Category

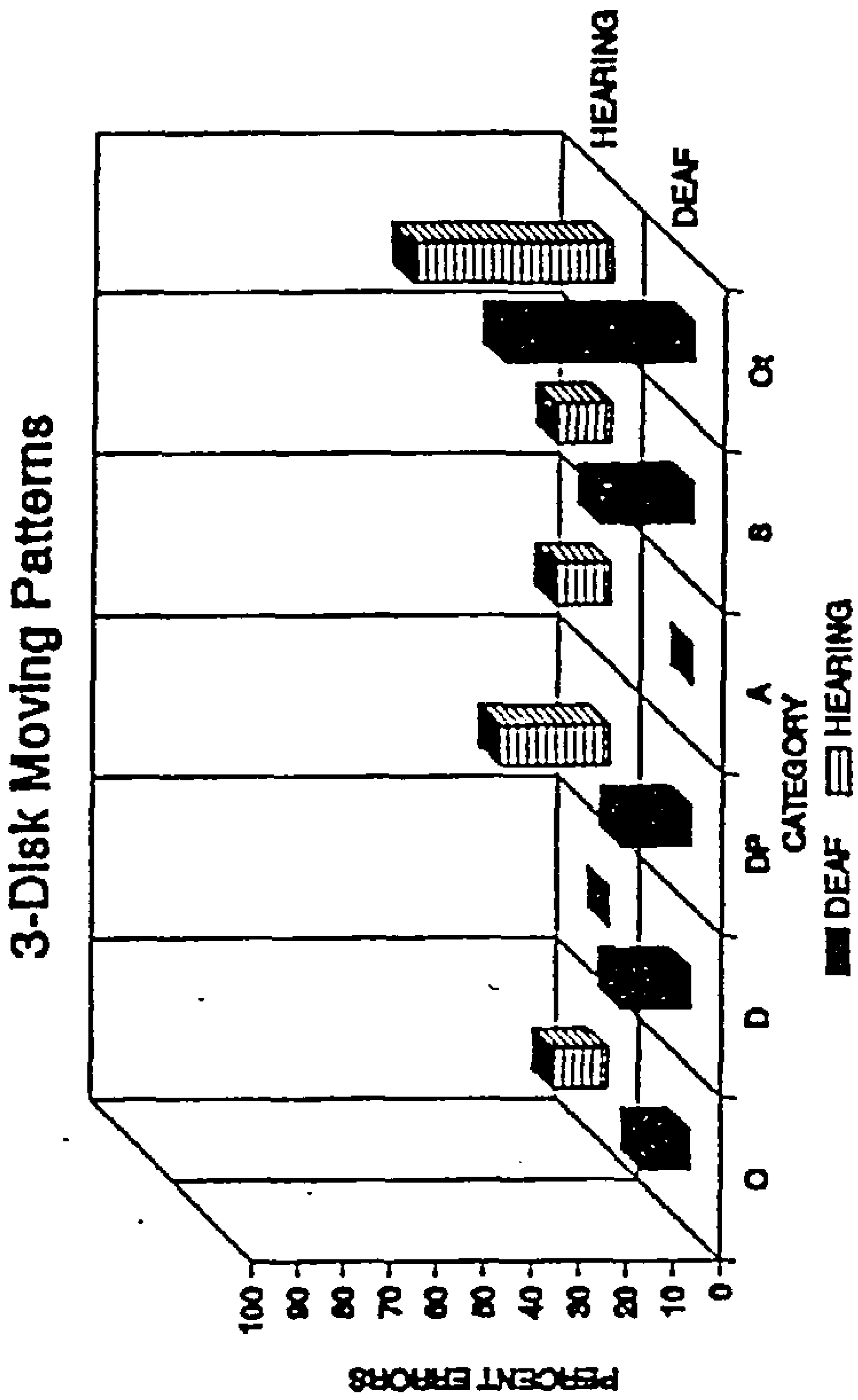

Fig. 11.2c Percentage of Errors In Each Category

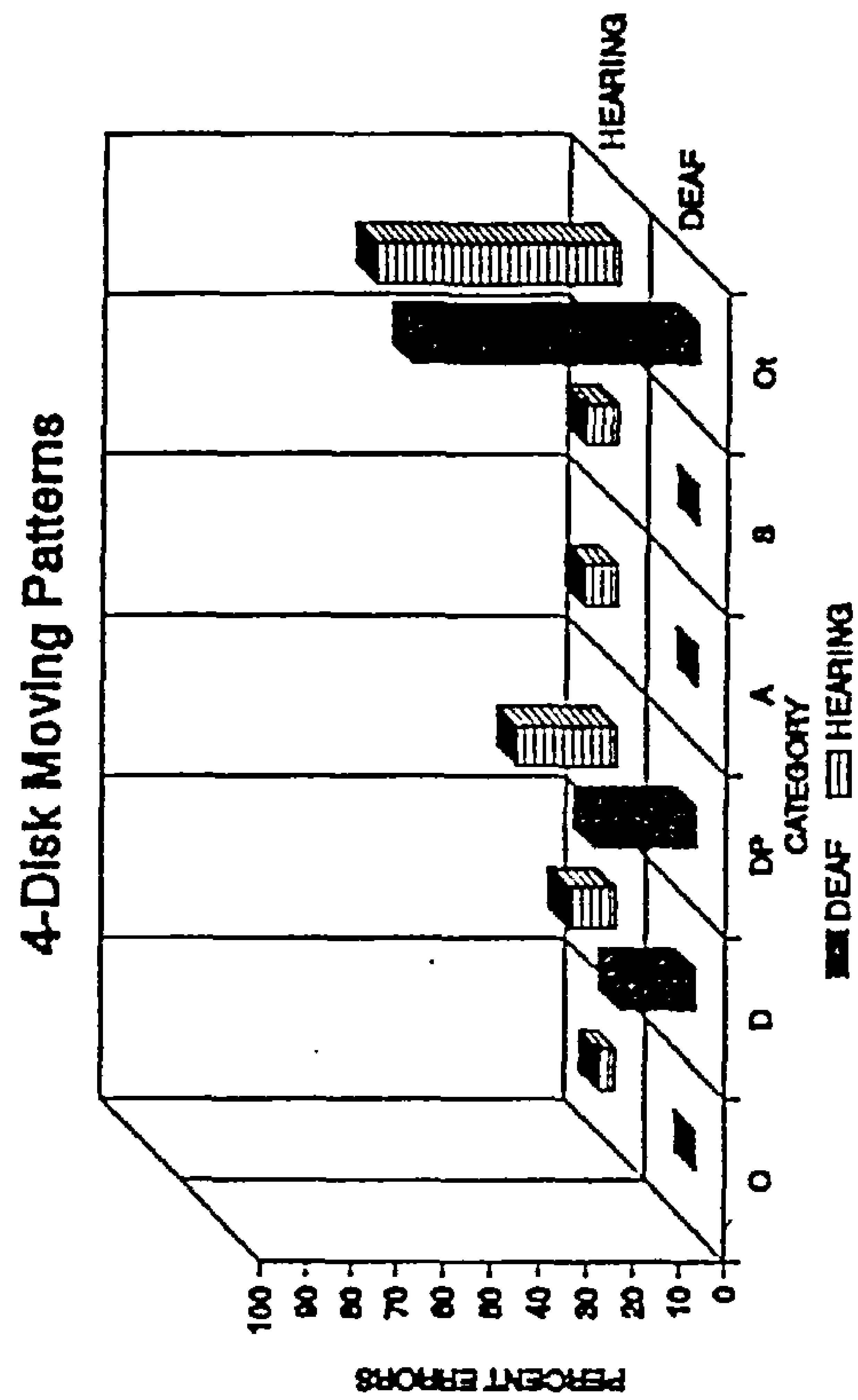

Fig. 11.2d Percentage of Errors In Each Category

the deaf and 9.1% for the hearing. This suggests that some information regarding exact location is coded. Taken together with the serial position data it could be suggested that those elements occupying the first serial position are coded in full and hence act as an 'anchor' for the rest of the pattern, which is then coded as relations. The deaf group have by far the highest percentage of errors which are not classifiable. As this category (Ot) includes patterns which are wrong, this again suggests that the deaf perform less well than the hearing on this task.

	Static				Moving					
	O	D	DP	Ot	O	D	DP	A	S	Ot
3-disc patterns										
Deaf	15.4	0	46.1	36.5	10.0	15.0	15.0	0	20.0	40.0
Hear	18.2	9.1	63.6	9.1	11.53	0	23.1	11.5	11.5	42.3
4-disc patterns										
Deaf	12.50	31.2	25.0	31.2	0	16.6	22.2	0	0	61.1
Hear	16.6	5.5	61.1	16.6	3.4	10.3	20.7	6.9	6.9	51.7

Table 11.5 Percentage of Errors in each Category

For the 3-disc moving patterns, the percentage of errors which are not classifiable differs little between the two groups. Of the classifiable errors Partial Displacement again accounts for the highest percentage of the hearing groups errors, whereas Displacement and Partial Displacement are equally frequent for the deaf group. There are no errors in the Apparent Motion category for the deaf group and relatively few for the hearing group, suggesting that the pattern is perceived and coded as a whole. The deaf group have the highest percentage of sequencing errors, which further strengthens the view that the deaf attend more to the temporal characteristics of a stimulus than is indicated by previous work.

For the 4-disk patterns, Partial Displacement accounts for the largest percentage of classifiable errors for the hearing group and Displacement for the deaf group. The deaf have the highest percentage of unclassifiable errors, although the difference between the deaf and hearing groups is not so great as was the case for the 3-disc static patterns.

The 4-disc moving patterns have the highest percentage of unclassifiable errors of all conditions, for both groups, reflecting the difficulty of this task for this age group. Also this condition shows least between groups difference in the distribution of classifiable errors, the majority being in the Displacement and Partial Displacement categories.

Considering errors overall, inspection shows that the deaf have the highest percentage of unclassifiable errors, the greatest difference occurring for the easier static patterns. For the static patterns the hearing group are more likely to make of errors of Partial Displacement and the deaf errors of for Displacement. For the moving patterns the deaf are more likely to make errors of Displacement than the hearing but have equal numbers of Partial Displacement errors.

DISCUSSION

Summary of Results

In terms of number of elements correctly recalled, the hearing recall significantly more elements from 3-disc than from 4-disk patterns, and significantly more elements from Static than Moving Patterns. For the deaf there are no significant differences in the recall of elements for any condition. Between groups there is no significant difference in the recall of 3- or 4-disc Static Patterns. For Moving patterns, there is no significant difference between the groups for 3-disc patterns, but for 4-disc patterns the deaf recall significantly more elements. These results are not reflected in the in the numbers of complete patterns correctly recalled by the groups. The hearing recall over twice as many complete Static patterns as the deaf. For Moving patterns, there is little difference between the groups.

The element data for Moving patterns was used to construct serial position curves, to examine the influence of spatial and temporal strategies on recall. For 3-disc patterns the overall (mixed) recall curves of the two groups were in opposite directions; the deaf group having a typical 'U' shaped SPC, usually associated with temporal recall. By contrast, the curve of the hearing group was typical of those reported for spatial order recall curves, i.e. a flat bow shape. For the deaf group, spatial and temporal coding contributed equally to recall of the first two serial positions, with a marked spatial recency for the third serial position. For the hearing group, temporal primacy contributed most to the recall of the first serial position, with spatial and temporal coding contributing equally to the recall of the second and third serial positions.

For 4-disc patterns the curves of the two groups were more similar, both being characteristic of spatial order recall curves. However, some differences were apparent. For the deaf group, spatial and temporal coding contribute equally to the recall of the first serial position. For the third and fourth serial positions, spatial recall accounts for nearly all the data. For the hearing group, spatial recall is predominant for all positions. The data indicate that the deaf pay more attention to temporal aspects of stimuli, than has been suggested previously.

Interpretation of Results

It was suggested that experience of BSL as a primary means of communication, along with a greater reliance on vision, necessitated by deafness, might give the deaf children an advantage in these tasks, over their hearing peers. In general, this does not appear to have been the case, with the deaf showing a poorer performance than the hearing according to a number of measures, and an equivalent performance on others. The exception to this, was in the case of the 4-disc moving patterns, the most difficult task given to the children, where, in terms of number of elements correctly recalled, the performance of the deaf was superior to that of the hearing.

However, within groups the deaf were more consistent across the four conditions. In other words, the deaf tended to maintain a level of performance, whilst the performance of the hearing group, declined relatively. This is indicated most clearly, by the comparison of number of complete Static and Moving Patterns recalled.

The relative difficulty of the task, is some justification for using elements recalled as an index of success. Had recall of complete patterns on the easier tasks been equivalent between the two groups, then the difference in performance on the 4-disc Moving patterns could be taken to support the hypothesis with some confidence. However, with the deaf scoring at only half the level of the hearing on the easier Static task, the significance of the element data for the 4-disc Moving patterns must be viewed with some caution, unless some viable reason can be advanced to account for the reduced performance of the deaf on the easier task.

Visual Attention

In general, sensory systems respond maximally to change; changes in intensity of a stimulus serving to orient attention towards the stimulus. Habituation occurs when stimulus intensity remains invariant and there are no other factors causing attention to be directed towards it. Essentially, habituation serves to free attention. In the hearing person both sight and hearing perform the function of environmental monitoring, sounds often serving to orient sight (e.g. a noise behind), or one functioning as sentinel while attention is concentrated on the other,. In the absence of hearing, the deaf must rely almost exclusively on vision for environmental monitoring. When visual attention is occupied, say in the performance of a task or during communication, the deaf person is essentially cut off from his/her environment and any changes which may occur in it. Under certain conditions some information is available to them, from vibration etc, but for the most part they are dependant on vision for information.

In view of this, it would not be unreasonable to expect the deaf to develop strategies for maximising the amount of information they can collect from the environment. Observations in the nursery have suggested that peripheral vision is enhanced, particularly in the adults, and the children scan the environment frequently, and are highly distractable by visual stimuli, especially movement.

It was stated earlier that habituation serves to free attention. If the demands on the sensory system are high, and there is no other system which can effectively reduce the load by sharing functions, then an increased rate of habituation, would seem to be both logically plausible and ecologically valid. In the case of the deaf this would lead to a rapid habituation to visual stimuli, unless there is some other factor to cause attention to remain directed toward it. There is some evidence to support this view in Chapter 8, where an age related decrease in time spent watching a non-task related event was reported.

The stimuli used in the tasks reported here were of two kinds; Static and Moving. It could be argued that attentional demands of the two types of stimuli differed, with Moving patterns being more demanding of attention than Static patterns. The Static patterns remained on the screen for three or four seconds, depending on the number of discs in the pattern. If static patterns are indeed less attentionally demanding, this would result in rapid habituation, leaving an amount of time in which attention could be redirected, leading to possible interference. The effect of this would be to reduce recall. The increased attentional demands of the Moving patterns would not result in habituation, and hence recall would not be impaired. Taken together this would lead to the pattern of results observed here.

Observations of the children during the task, are in line with this argument. The deaf children looked away from the screen very quickly after presentation of a static pattern, and were impatient to begin responding. While waiting for the response screen to appear, they would look around the room and comment to E on the activities of the other children. Very often their attention would have to be redirected to the response screen, once it appeared.

Whilst this explanation is admittedly post hoc, it does give rise to a testable hypothesis; "Increasing the attentional demands of the static pattern stimuli, will lead to increased recall in the deaf." This could be tested by either reducing the amount of time the pattern remains on the screen and thereby reduce the possibility of interference, or increase the attentional demands of the pattern itself, by for example, causing the discs to flash or change colour. The program is easily modifiable in both these respects (see appendix 11).

Other Explanations.

MacDougal (1979) suggested that the deaf may be impaired with respect to visual memory, or less efficient. The data reported here could be taken as supporting that position. In particular, the high proportion of unclassifiable errors and the low number of correctly recalled complete Static patterns. With respect to the unclassifiable errors, the only counter argument is that for the more difficult Moving patterns the two groups did not differ.

Any subject can only demonstrate what they have remembered by giving a response. The responses here, were made on a concept keyboard, overlaid with a replica of the matrix which appeared on the screen. To make a response, the child had to look at the keyboard and determine which square corresponded to the one on the screen s/he wanted the disc to appear in. Hence, the very act of responding was a visual task, which might itself, result in impaired recall.

This argument would apply equally to the hearing, assuming that the task was entirely visual, i.e. there was no verbal aspect. However, it was noted in the last chapter that Sign appeared efficient at coding the kind of information necessary to solve the TOH. Again the signed solution to the moving condition of this task, is identical to the sequence of moves necessary to effect the solution on the keyboard. In other words, Sign can give an effective verbal coding, as opposed to a visual coding, for this task, which oral language cannot, thereby reducing the possibility of interference. Coding the pattern as a Sign sequence, would also preserve temporal order, in the sequential order of the signs. The effect of Sign coding would give the pattern of results observed here.

One further point with regard to responses. It was noticed that some of the children would point to the screen, at the squares where the discs had been. These responses tended to be more accurate than the subsequent responses on the concept keyboard. The obvious implication here is that a different mode of response would give a different result. The program is easily modifiable to allow a touch sensitive screen to be used for responding, and hence, test this suggestion (see appendix 11).

Spatial v Temporal Coding

Given the child's task was to reproduce the pattern, and that recreating the pattern in the order in which it was presented was not specifically asked for, the child was free to adopt either a spatial or a temporal strategy. Extant data predicts that the deaf child would choose a spatial rather than a temporal strategy and vice versa for the hearing child. The data reported here do not support such a clear cut distinction. However, Healy (1975; 1977) presents data which suggests where verbal coding is not possible, hearing Ss use a spatial-temporal code. The nature of such a code remains unspecified, as does its status as either derivative of or independent of other memory codes/strategies.

The data treatment here implies a derivative code, but it is not intended to exclude the possibility of a unique code. The interesting fact to emerge from this analysis is the greater use, by the deaf, of temporal aspects of the stimuli, than one might expect from previous studies. The data suggest that the deaf make greater use of an integrated spatial-temporal code, than do the hearing, who appear to maintain more of a distinction between spatial and temporal aspects of the stimuli. This distinction of course is just that which applies between the two language codes. In Chapter 4, the example of Sign required the dimensions of both space and time to indicate the properties of the utterance.

Methodological Comments

The SPC data is indicative that the mnemonic strategies used by the two groups differ, in a way which can be related to their differing language experience. These differing processes give rise to quantitative outcomes which show both similarities and differences between the groups. The small number of subjects makes any of the arguments here somewhat speculative. However, there is a sufficient consistency of individual data within groups to warrant a larger scale study, incorporating the modifications suggested above.

CHAPTER 12: Conclusions

Introduction

The aim of this project was to demonstrate the theoretical and practical utility of the conceptual and methodological approach outlined in Chapters 1 to 4. To demonstrate the extent to which this aim has been achieved, this chapter examines the theoretical and practical implications of the reported data.

Control of Attention - Data

Control of attention is control of visual attention for the deaf child. The vast majority of information must be received visually, be it linguistic or otherwise. To reduce information overload, the deaf develop strategies which increase the efficiency of information collection from the environment. As the child becomes older, the amount of time spent watching an environmental distractor decreases (Chapter 8.).

A corollary of this is that less complex visual stimuli are undemanding on the deaf child's attention (Chapter 11). Therefore, in visually undemanding environments deaf children show sustained attention for on going activity, i.e. they are not so distracted by environmental stimuli (Chapter 7).

Deaf adults serve to reduce distractability, or increase attention in the deaf child in a number of ways. The changes they effected in the playroom were to reduce the visual complexity (Chapter 7). They also appear to serve as an external prompt, by redirecting the child's attention to the on going activity after they had been distracted, a function which the child can perform him/herself in some circumstances, e.g. when playing by the mirror (Chapter 8). Here it appears that the mirror gives a visual prompt to attention, by allowing the child to view both the environmental distractor and him/herself at the same time.

Deaf children divide their attention between social and non social stimuli, 2/3 to social stimuli and 1/3 to non social stimuli, for problem solving situations at least. This distribution is invariant with respect to the hearing status of the experimenter. However, the presence of a deaf experimenter results in an improvement in problem solving performance by the deaf child (Chapters 5 & 9).

Control of Attention - Implications

In Chapter 3 it was noted that deaf children of deaf parents evidenced better performances on a range of scholastic and other tests. The data reported here (Chapters 5 & 9) indicate that this advantage can also be conferred on deaf children by deaf adults other than parents. It will also be recalled that in the presence of the deaf experimenter, the 'impulsive behaviour' of the children, decreased. To what extent are previous reports of 'more impulsive' the observed consequence of the deaf child's effort to understand a non-contingent environment?

Mogford et al (1980) suggested that deaf parents may be more sensitive to the ebb and flow of their deaf child's attention than a hearing parent. The Markov model data indicates, but by no means proves, that the deaf child is consistent in his/her distribution of attention to aspects of the environment.

If this is the case then, what the deaf adult brings to an interaction is a knowledge of that distribution, perhaps because the deaf adult shares it? A related point is the observation by Vernon (1967) that more experienced researchers are less likely to find differences between deaf and hearing in I.Q. scores. It could be that as researchers become more experienced at working with the deaf they come to share this aspect of the deaf world. This is an obvious candidate for further work. Educationally, the implications are far reaching. They point to a need for the active participation of deaf adults in the educational process, both for the deaf child and hearing teachers of the deaf (see also Elf 1988/9).

The attentional demands of stimuli do not appear to have been considered in previous work. One of the most widely quoted findings in deafness research is that by Furth (1961), that deaf children have difficulty in mastering the concept of 'opposite'. To what extent does this finding reflect the fact the stimuli used in this study were extremely simple? In two studies reported here (Chapters 10 & 11) more complex stimuli have shown a relatively enhanced performance by the deaf. It is also the case that heavy reliance on the visual channel for information can result in overload (e.g. Draw-a-Man, Chapter 7). The obvious implication here is that the design of experiments and curricula should include a consideration of the attentional demands of the materials and the deaf child's ability to deal with them.

The attentional demands of the environment is also a factor which influences the attentional control of the deaf child. Some experienced teachers of the deaf tell me that they often arrange their classrooms so that all visual materials are behind the children when they are sat at their desks. One teacher said "I wondered why I did that, because its not what we are taught." What the observations reported here imply, is that we need to know much more about what level of visual stimulation is stimulating for the deaf child and what is over stimulating or distracting. It is only with this knowledge that teachers can design effective teaching materials for deaf children.

Visuo-spatial Processing - Data

Sign language is a visuo-spatial language, and all the tasks given to the children in the work reported here contained visuo-spatial aspects. This was a deliberate device to examine the relationship between Sign and cognitive functioning.

Competence in Sign requires a mastery of spatial skills and deaf children actively seek to learn these skills (Chapter 8). A unique aspect of Sign is the need to treat space and spatial locations as being absolute, i.e. left and right have no meaning in this use of spatial locations. The children show an ability to ignore, or otherwise deal with, the inverted laterallity of actual mirror images (Chapter 8) and mental representations of mirror image problems (Chapter 10).

Although language was not logically necessary for the tasks used here, the use of Sign or sign structures/processes was suggested as an explanatory factor for the data of the deaf (Chapters 8, 10 & 11). Interference has also been appealed to as an explanatory factor, for both inferior (Chapter 5) and superior performances by the deaf (Chapters 10 & 11), in the two latter cases as a function of Sign.

The visuo-spatial processing ability of the deaf has been shown to vary as a function of attentional control (Chapters 5 & 9), attentional demands of the stimuli (Chapter 11) and task and information characteristics (Chapters 10 & 11). Tasks which are considered difficult for hearing subjects are not necessarily difficult for deaf subjects (e.g. Flat- versus Tower-ending problems, Chapter 10) and vice versa. The difficulty of a problem is related to the information processing strategies in which the subject is well rehearsed.

Visuo-spatial Processing - Implications

As with attentional control, there is a sense in which information processing in the deaf is visuo-spatial processing, even for linguistic information. If this statement is true then the implications extend to the whole of cognitive functioning in the deaf. This project has focused on the relationship between Sign language and thought, in problem solving and memory. Even within this limited domain it is necessary to consider the theoretical problems of representation and the structure of information.

Any theory of deaf cognitive functioning has to be able to account for the ability of the deaf to process visuo-spatial and linguistic information at the same time. Such a theory would have to postulate a model, in which the form of the representation of information is such, that it could generate linguistic and behavioural output which is identical.

This last statement sounds silly, except that it is a description of the signed solution of the Tower-of-Hanoi and the movement of the cups needed to solve the problem. McNeill (e.g. 1985) has argued that language and gesture, in the hearing, share a common computational stage; a stage where action and language are coterminous. This is a contentious point of view, although the empirical evidence, including that from deaf populations, tends to support this position (e.g. Sheehy, 1987).

The data reported here, is also best explained by McNeill's argument, with representation being analogue, as opposed to imagistic or propositional (cf Kosslyn & Pomerantz, 1977). Analogue representation is suggested by the need to treat space as absolute; propositional coding (assumed in Chapter 10) requires coding specific to each modality. Imagistic coding would require the use of visual processing space, which would be prone to disruption during the reception of linguistic information. Analogue representation, logically necessary to a point of view such as Fodor's (1972; 1978), is non specific with respect to modality. Such considerations bring into question the extent to which the deaf are 'concrete and perceptually bound' or "tied to the level of imagery" (Myklebust, 1964).

One of the most radical implications is that the deaf offer the opportunity to view linguistic, cognitive and epistimological processes at a deep level, because their language and its structures is such, that the surface string more directly represents the underlying structures. This is related to the point I raised in Chapter 10.

A related point is the efficiency of language to code information. Sign and oral language appear to be equally efficient at coding information, providing the form of information is similar to the form of the language. Interference, in cross modality tasks is usually negative. However, interference can also be additive (positive). It is this kind of interference which gives rise to the un-scored notes referred to in Chapter 4. The ability of the hearing to deal with order information and the deaf to deal with spatial information can both be seen as instances of additive interference. This has obvious implications for what is taken to be the relationship between language and thought.

In Chapter 10 (and Chapter 11 to some extent) it was evident that the deaf child could generate and use sequential information in a spatial context, yet in many simpler sequencing tasks, deaf children perform poorly. Hearing children are taught to sequence from early age, for example counting. For the hearing child, learning to use language is learning to translate nonlinear information into linear form (cf for example Winograd, 1977 or Pask, 1980). For example, a (oral) verbal description of a tree is a sequence of parts. A tree has a trunk on which there are branches. On the branches are twigs and on the twigs are leaves, etc.

Now imagine miming the description of a tree. You will, in effect, be drawing a picture of a tree in space (cf McNeill). True, there will be a sequential aspect to your actions, but it will be a sequence in 3-dimensional space. The deaf child's knowledge of the world is in this form, and his/her language does not necessitate the same kind of sequential analysis that the use of oral language entails. However, his/her language does entail a sophisticated spatial analysis, and where tasks require just such an analysis we see the deaf child perform well.

The ability of the deaf child to deal with mirror images suggests another possible explanation of the deaf child's perceived failure to sequence, and one which has implications for the description of 'more egocentric'. Imagine a deaf child and a tester sat opposite one another. The child is given three cards depicting an orange being peeled, and asked to arrange them in order. The child arranges the cards 1) peeled orange, 2) half peeled orange, 3) un-peeled orange. Looking at the cards from the child's position the sequence is wrong, and would be scored as such, but viewed from the testers position the sequence is correct. Whenever possible, the deaf instructors in the nursery sat at right angles or next to the children.

From the foregoing, it might be expected that the deaf child finds activities such as drawing easy, yet paradoxically, this is not the case (Chapter 7). Clearly, we need to more about the visuo-spatial processing abilities of the deaf. Educationally, this has implications for the way information is presented to the deaf child.

Conclusion

I would argue that the data reported here, point to the need to re-examine the cognitive functioning and abilities of the deaf child, from a point of view which allows all their adaptations to emerge. The methods used here have given rise to observations, in line with those previously reported, (e.g perseverance, Chapters 5 & 10), but it have also demonstrated that deaf children can successfully complete tasks, such as the Tower-of-Hanoi, which, previous conceptions of deaf functioning would predict they could not.

I am aware that the brief interpretation given in this Chapter is only one of many possible, and reflects the assumptions, and beliefs which I originally set out. However, my stated aim was to test the utility of an approach based on these ideas. I suggested that the critical outcome, would be the potential of the data to offer a richer description of deaf cognition than "more concrete, more rigid, more impulsive, and more egocentric". My conclusion is that these four terms are inadequate to summarise the cognitive abilities of the deaf children which the data reported here describes.

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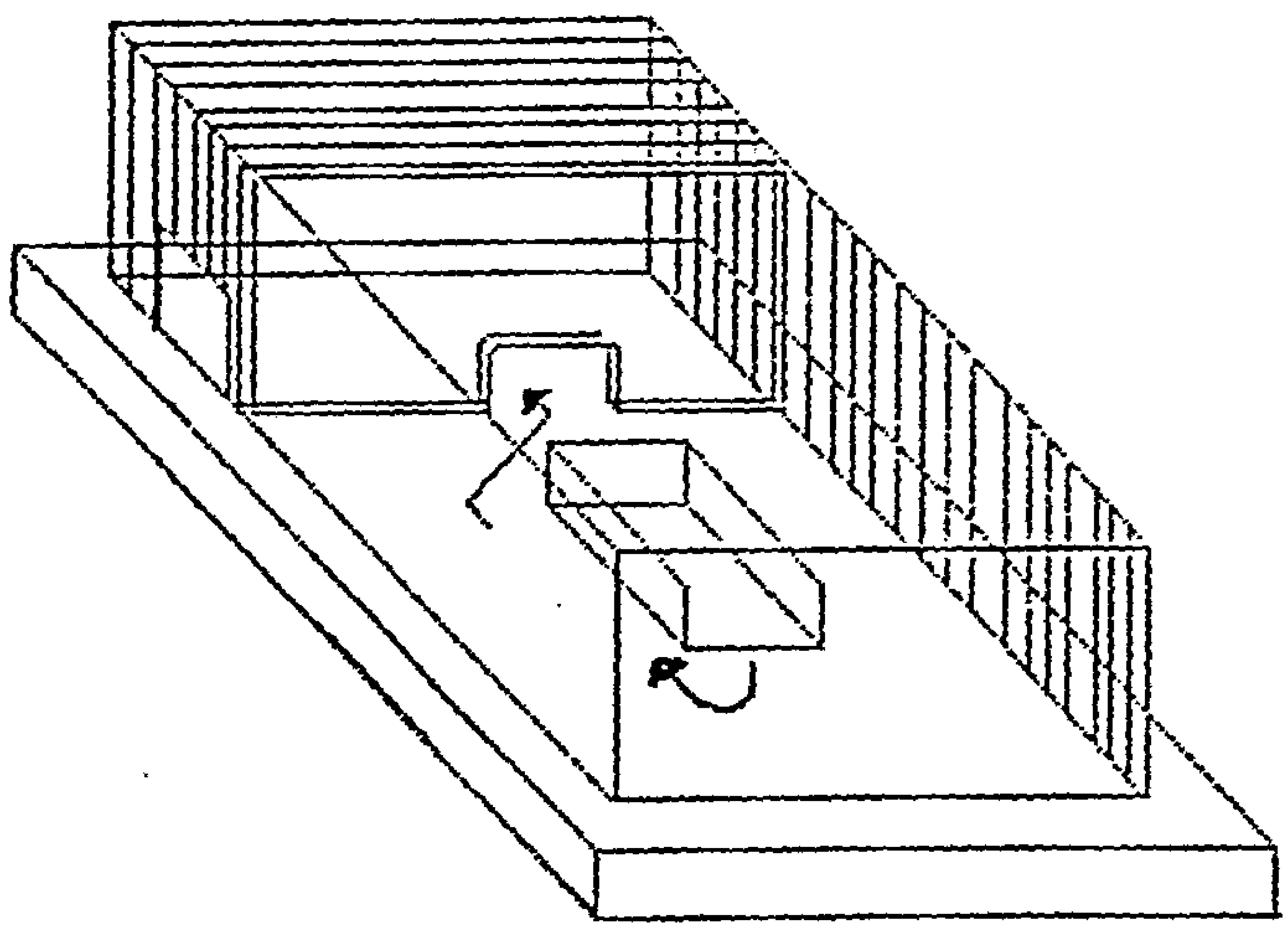
APPENDICES

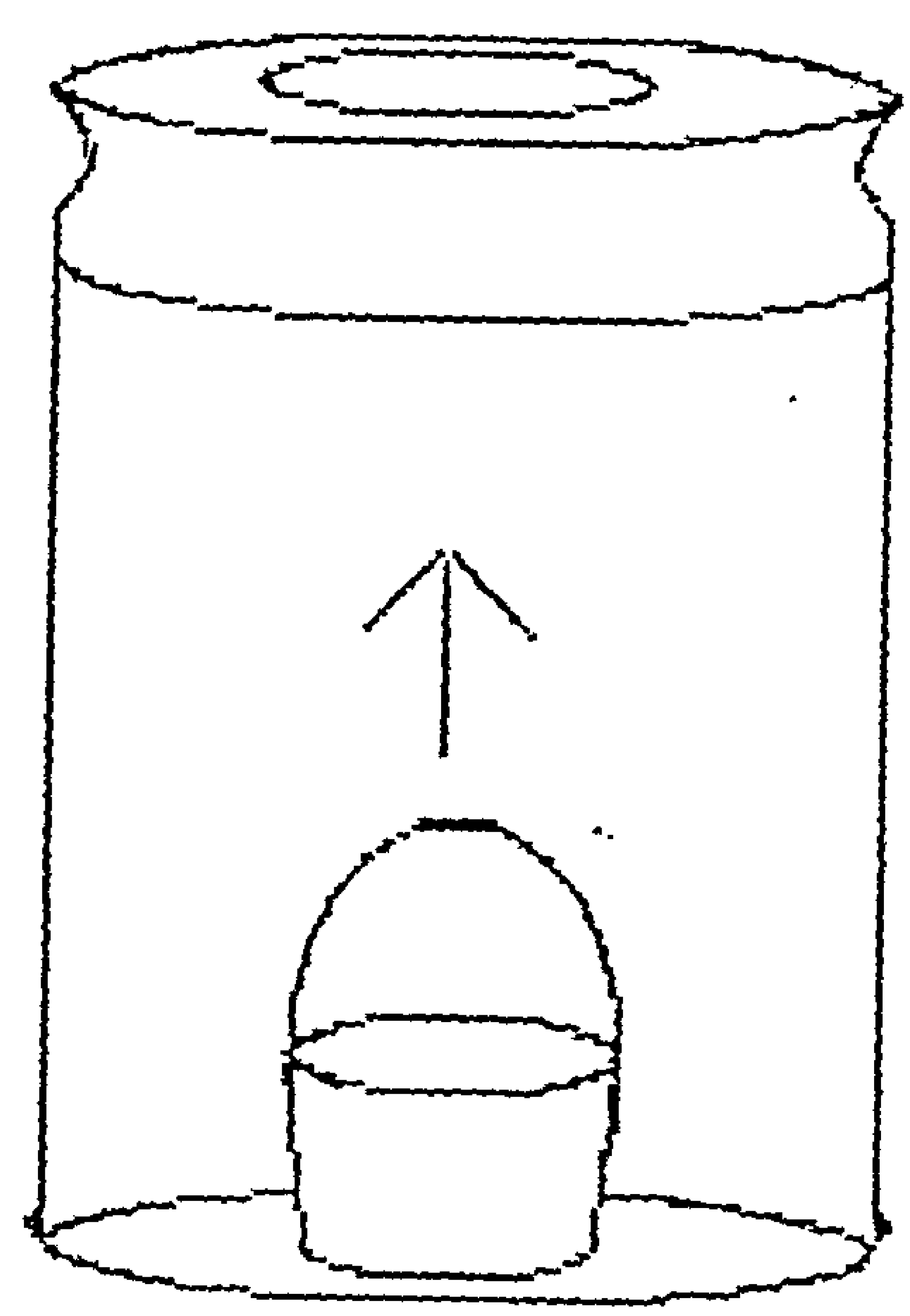
Appendix 5

1. Drawings of Cage, Bottle and Slider Problems, used in Chapters 5 and 9.
2. Timing schedule used by Chulliat & Oleron
3. Example of transcript
4. Raw data for distribution of visual behaviours preceding a tool change.
5. Dominance matrices
6. Transitional probability matrices
7. Data for Markov Model proofs

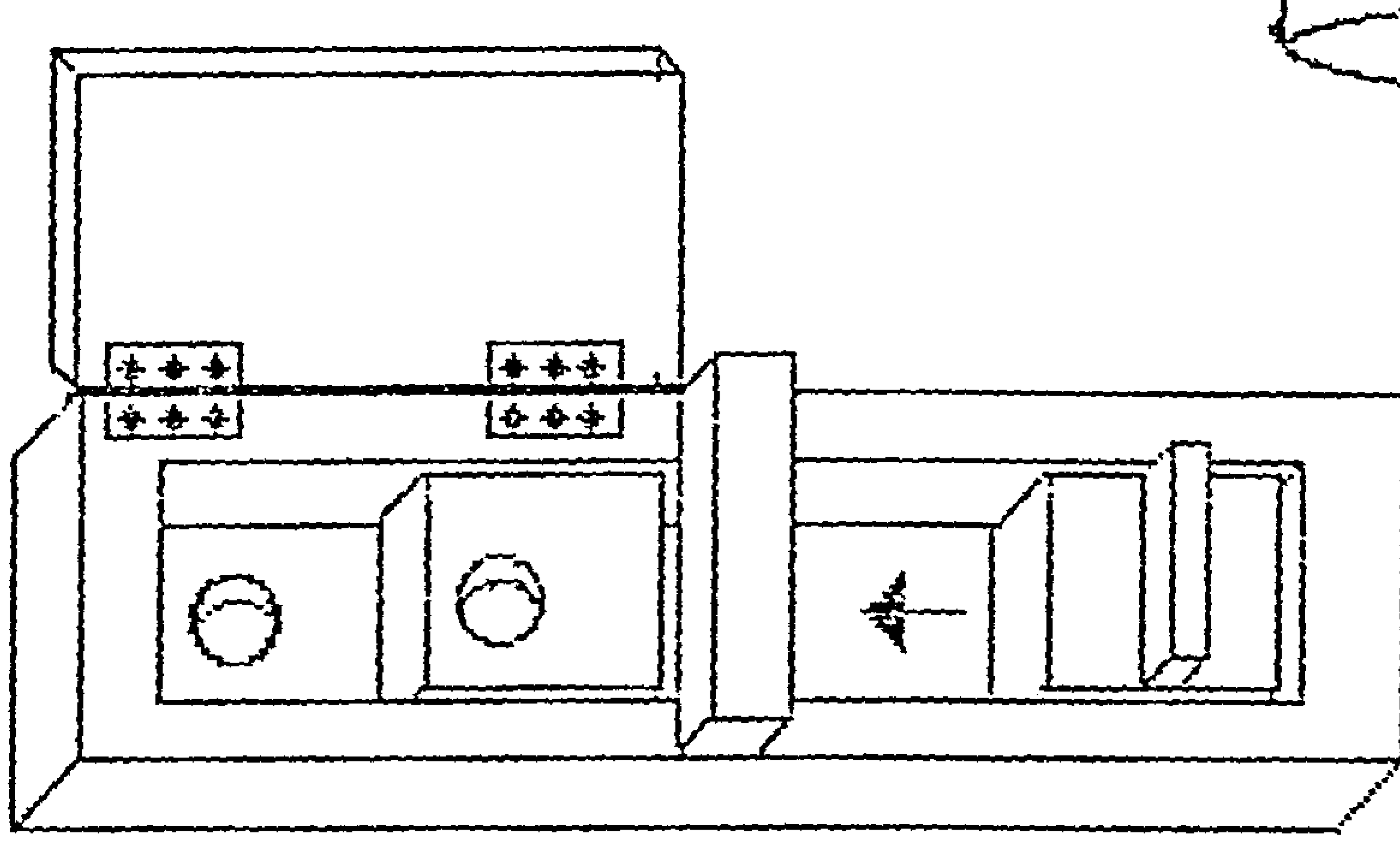
CAGE PROBLEM



BOTTLE PROBLEM



SLIDER PROBLEM



<u>Time Schedule for Lure Retrieval Problems from Chulliat & Oleron (1955)</u>

<u>Cage Problem</u>

1. Si l'énfant echoue, faute d'utiliser un bâton, après trois minutes environ, il lui présente la petite baguette.

2. Si l'enfant ne parvient pas à résoudre convenablemnt le problème, il montre avec insistance l'ouverture.

<u>Bottle Problem</u>

Dans un premiere temps, l'expérimentateur observe le comportment spontané du sujet après administration de la consigne (trois minutes).

2 En cas d'inaction, il montre les fils métalliques et en place un devant le bocal.

3. En cas d'inaction ou d'échec, après deux minutes, il plie plusieurs fois un fil par le milieu pour mettre sa malléabilité en évidence.

4. Si le sujet échoue encore, après deux minutes, il met à sa disposition deux instruments qu'il fabrique sous ses yeux: un chrochet trop grand et inefficace et un crochet adapté au diamètre du bocal; il y joint un fil droit et invite l'enfant à utiliser l'instrument qu'il juge convenable.

<u>Slider</u>

1. Après trois minutes, si l'enfant reste inactif ou si son action est étrangère au problème, l'expérimentatuer répète la consigne.

2. S'il n'y pas de progrès après deux minutes, il présente la régle de 12 centimètres (Premiere suggestion)

3. Deux minutes plus tard, la règle est placée sur le côté parallèlement à la lacune pour former un suggestion optique (Deuxsieme suggestion)

4. Enfin, si le sujet résiste encore à toutes ces suggestions, la règle est placée dans la lacune entre A (slider) et B (sweet shelf).

Chulliat & Oleron (1955) pages 289, 291 & 295.

1 S looks in box picks up grey rod and looks at E
2 replaces grey rod and looks in box
3 S picks up wire and looks at E
4 E signs try
5 S inserts wire in cage and touches sweet box.
6 looks at E
7 pushes on turntable with wire and glances in mirror
8 withdraws wire and looks at E then round room
9 points to covered window and looks at E
10 E nods signs stop the nosey people watching out there
11 S reinserts wire in side of cage
12 Looks at E E signs that's not working
13 s continues then points to padlock and signs orange
14 E signs what? sweet you sweet you
15 S continues with wire in side of cage
16 Looks at E E signs don't know try something different and points to box
17 S looks in box
18 picks up yellow rod and looks at E
19 E signs you try
20 S inserts yellow rod in side of cage and manipulates turntable
21 slides box off turntable
22 lloks at E
23 pokes at sweet box with finger
24 E points to perspex door S continues poking at box with finger
25 E signs not with finger with stick
26 S uses yellow rod to push box
27 pushes box to perspex door and looks at E and mouths yeah
28 inserts rod through far end of cage appears frustrated and looks at E
29 E shakes head S looks at E and offers her yellow rod
30 E signs no you do it
31 E turns cage round
32 S inserts rod in side of cage and pushes turntable
33 Looks at e
34 E guides childs hand so rod is above turntable
35 S looks at E and signs box goes through door
36 E points to slots in bars and signs which
37 S gets rod behind box and moves it looks at E and signs sweet
38 E signs try to get the sweet smiles and nods yes go on
39 S moves box looks in mirror looks at E looks in mirror wipes mouth and looks at E sings there
40 E nods and points to sweet box
41 E shows perspex wall and signs how

Percentage of Visual Behaviours in Each category

	D1	D2	D3	D4	D5	D6	D7
CAGE PROBLEM							
E	100.0	100.0	100.0	14.3	100.0	100.0	100.0
A							
T				14.3			
U				71.4			
BOTTLE PROBLEM							
E	52.9	66.7	14.3		80.0		100.0
A	5.9	16.7	57.1	11.1	20.0		
T		16.6	28.6	33.3			
U	41.2			55.6			
SLIDER PROBLEM							
E	100.0	60.0		25.0	100.0	66.6	100.0
A			12.5				
T		20.0	37.5	75.0		33.3	
U		20.0	50.0				

	H1	H2	H3	H4	H5	H6	H7	H8
CAGE PROBLEM								
E	16.7	12.5	50.0	66.7		50.0		16.7
A	50.0	12.5			100.0		100.0	16.7
T	33.3	50.0	50.0	33.3		50.0		66.6
U		25.0						
BOTTLE PROBLEM								
E	30.0	25.0	100.0	28.6	33.3	33.3		25.0
A	10.0	12.5				33.3		12.5
T		25.0		57.1	33.3			25.0
U	60.0	37.5		14.3	33.3	33.3		37.5
SLIDER PROBLEM								
E		20.0	100.0	33.3				
A	28.5	25.0		66.7			20.0	12.5
T	28.6				50.0	75.0	70.0	75.0
U	42.9	25.0			50.0	25.0	10.0	12.5

Dominance Matrices - Chapter 5

First Order Deaf

Cage

	E	A	T	U
E	1	0	0	1
A	0	0	0	0
T	0	0	0	1
U	0	0	0	1

Bottle

	E	A	T	U
E	1	1	1	0
A	0	0	0	0
T	0	0	1	0
U	1	0	0	1

Slider

	E	A	T	U
E	1	0	1	0
A	0	0	1	0
T	0	0	1	0
U	0	0	0	1

Second Order

	E	A	T	U
E	1	0	0	2
A	0	0	0	0
T	0	0	0	1
U	0	0	0	1

	E	A	T	U
E	1	1	2	0
A	0	0	0	0
T	0	0	1	0
U	2	1	1	1

	E	A	T	U
E	1	0	2	0
A	0	0	1	0
T	0	0	1	0
U	0	0	0	1

Third Order

	E	A	T	U
E	1	0	0	3
A	0	0	0	0
T	0	0	0	1
U	0	0	0	1

	E	A	T	U
E	1	1	3	0
A	0	0	0	0
T	0	0	1	0
U	3	2	3	1

	E	A	T	U
E	1	0	3	0
A	0	0	1	0
T	0	0	1	0
U	0	0	0	1

Summary Matrices

	E	A	T	U
E	1.83	0.00	0.00	3.00
A	0.00	0.00	0.00	0.33
T	0.00	0.00	0.00	1.83
U	0.00	0.00	0.00	1.83

	E	A	T	U
E	1.83	1.83	2.33	0.00
A	0.00	0.00	0.00	0.00
T	0.00	0.00	1.83	1.00
U	3.00	2.17	1.50	1.83

	E	A	T	U
E	1.83	0.00	3.00	0.00
A	0.00	0.00	1.83	0.00
T	0.00	0.00	1.83	0.00
U	0.00	0.00	0.00	1.83

Dominance Matrices - Chapter 5

First Order — Hearing

Cage

	E	A	T	U
E	1	0	1	0
A	0	0	0	0
T	0	1	1	1
U	0	1	0	1

Bottle

	E	A	T	U
E	1	1	1	0
A	0	0	0	0
T	0	0	1	1
U	1	1	0	1

Slider

	E	A	T	U
E	1	0	1	1
A	0	0	0	0
T	0	1	1	1
U	0	1	0	1

Second Order

	E	A	T	U
E	1	1	2	1
A	0	0	0	0
T	0	2	1	2
U	0	1	1	1

	E	A	T	U
E	1	1	2	1
A	0	0	0	0
T	1	1	1	2
U	2	2	1	1

	E	A	T	U
E	1	2	2	3
A	0	0	0	0
T	0	2	1	2
U	0	1	0	1

Third Order

	E	A	T	U
E	1	3	3	3
A	0	0	0	0
T	0	3	1	3
U	0	2	1	2

	E	A	T	U
E	2	2	3	3
A	0	0	0	0
T	3	3	2	3
U	3	3	3	2

	E	A	T	U
E	1	5	3	6
A	0	0	0	0
T	0	3	1	3
U	0	1	0	1

Summary Matrices

	E	A	T	U
E	1.83	1.50	3.00	1.50
A	0.00	0.00	0.00	0.00
T	0.00	3.00	1.83	3.00
U	0.00	2.17	0.83	2.17

	E	A	T	U
E	2.17	2.17	3.00	1.50
A	0.00	0.00	0.00	0.00.
T	1.50	1.50	2.17	3.00
U	3.00	3.00	1.50	2.17

	E	A	T	U
E	1.83	2.67	3.00	4.50
A	0.00	0.00	0.00	0.00
T	0.00	3.00	1.83	3.00
U	0.00	2.17	0.83	2.17

Matrix Analyses Chapter 5

PROBABILITY MATRICES

	E	A	T	U
E	1.00	0.00	0.00	0.00
A	0.00	(1)	0.00	0.00
T	0.00	0.00	0.00	1.00
U	0.20	0.00	0.00	0.80

CAGE - DEAF

	E	A	T	U
E	1.00	0.00	0.00	0.00
A	0.00	0.00	0.50	0.50
T	0.43	0.00	0.43	0.14
U	0.00	0.00	0.75	0.25

CAGE - HEARING

	E	A	T	U
E	0.65	0.00	0.05	0.30
A	0.67	0.00	0.00	0.33
T	0.25	0.00	0.38	0.38
U	0.33	0.08	0.25	0.33

BOTTLE - DEAF

	E	A	T	U
E	0.42	0.00	0.00	0.58
A	0.25	0.00	0.00	0.75
T	0.44	0.00	0.44	0.11
U	0.30	0.00	0.30	0.40

BOTTLE - HEARING

	E	A	T	U
E	0.86	0.00	0.07	0.07
A	0.00	0.00	1.00	0.00
T	0.29	0.00	0.57	0.14
U	0.16	0.00	0.17	0.67

SLIDER -DEAF

	E	A	T	U
E	1.00	0.00	0.00	0.00
A	0.00	0.00	0.40	0.60
T	0.05	0.05	0.68	0.21
U	0.14	0.00	0.71	0.14

SLIDER - HEARING

Observed Probability Vectors

	Deaf	Hearing
Cage	[.62 0.00 0.00 .38]	[.33 0.00 0.48 .19]
Bottle	[.49 0.02 0.16 .32]	[.37 0.00 0.20 .43]
Slider	[.54 0.00 0.25 .21]	[.15 0.03 0.59 .23]

Markov Model

Notes. 1. The Markov model requires that all the rows in the matrix add up to 1. For the deaf cage matrix the A,A, cell has been given an entry of 1 in the probability matrix, even though there are no entries for the A row in the frequency matrices. This was a device to allow the matrix to be used in calculations. The justification, is that the value of 1 represents the probability of remaining in the state A, which is in this instances negative. This is admittedly arbitary, and could be argued to weaken the model. However, the remainder of the data is sufficient without the cage matrix.

2. There are two kinds of Markov model; simple Markov chains, which are the type described here and Absorbing Markov chains. It wil be noticed that some of the matrices can be rearranged to give a matrix of the form;

$$\begin{matrix} 0 & 1 & p & p \\ 1 & 0 & p & p \\ p & p & p & p \\ p & p & p & p \end{matrix}$$

where p = a probability.

This is the form of matrix associated with absorbing Markov chains. Although it was recognised that an absorbing model might be relevant, especialy for the hearing data, it was felt that a) the small numbers involved and b) the prelimanary nature of this investigation did not warrent the more complex model. Obviously this should be considered in future investigations.

Further Proofs.

Deaf Model - Slider

Bottle observed vector x Slider matrix

[.524	0	.29	.12]	f[14.7	0	8.12	3.36]		
				obs[15	0	7	6]	n.s.	

Cage observed vector x Bottle matrix squared

[.496	0	0	.318]	f[13.9	0	0	8.9]

Observed frequency vector and predicted frequency vector from bottle eqilibrium vector for cage.

observed	[8	0	0	5]	
predicted	[6.9	0	0	4.5]	n.s

Observed and predicted frquency vectors for Bottle problem

observed	[21	1	7	14]	
predicted	[23.1	1.1	4.9	13.2]	cage vector x Bottle Matrix
equilibrium	[20.1	1.1	7.1	13.4]	

Hearing Model

Observed and predicted frequency vectors for Slider

observed	[5	1	20	8]
chance vector x Slider matrix	[10	.8	15.23	8.1]
Cage matrix3 x Cage vector	[23.4	0	8	2.6]
Bottle vector x Slider matrix	[15.1	.34	15.1	3.5]

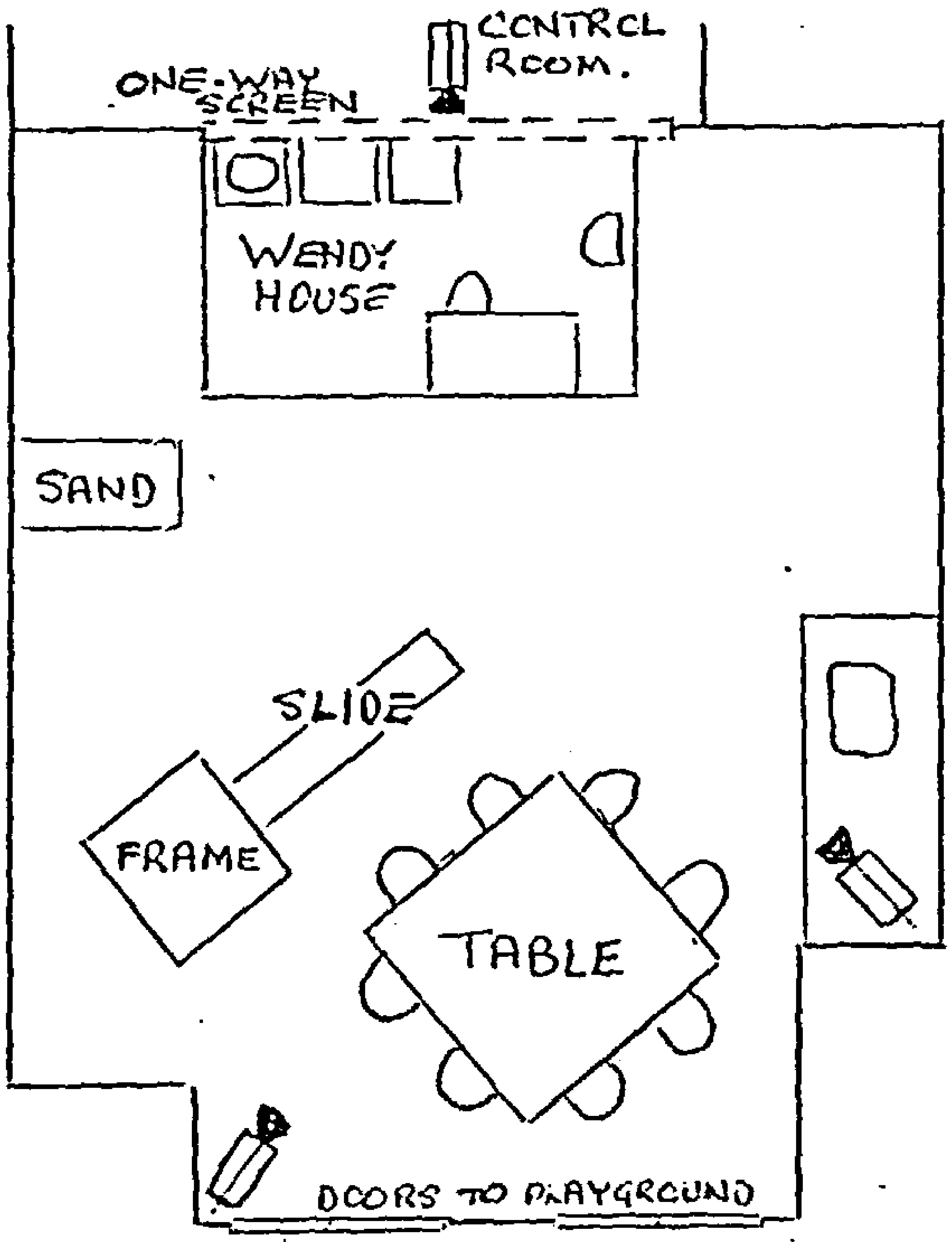
Observed and predicted frequncy vectors for Bottle problem

Observed	[13	0	7	15]
Cage vector x Bottle matrix	[14	0	9.2	15.8]
Chance vector x Bottle matrix	[12.3	0	6.5	15.8]
equilibrium vector	[12.9	0	7.5	13.9]

BLANK IN ORIGINAL

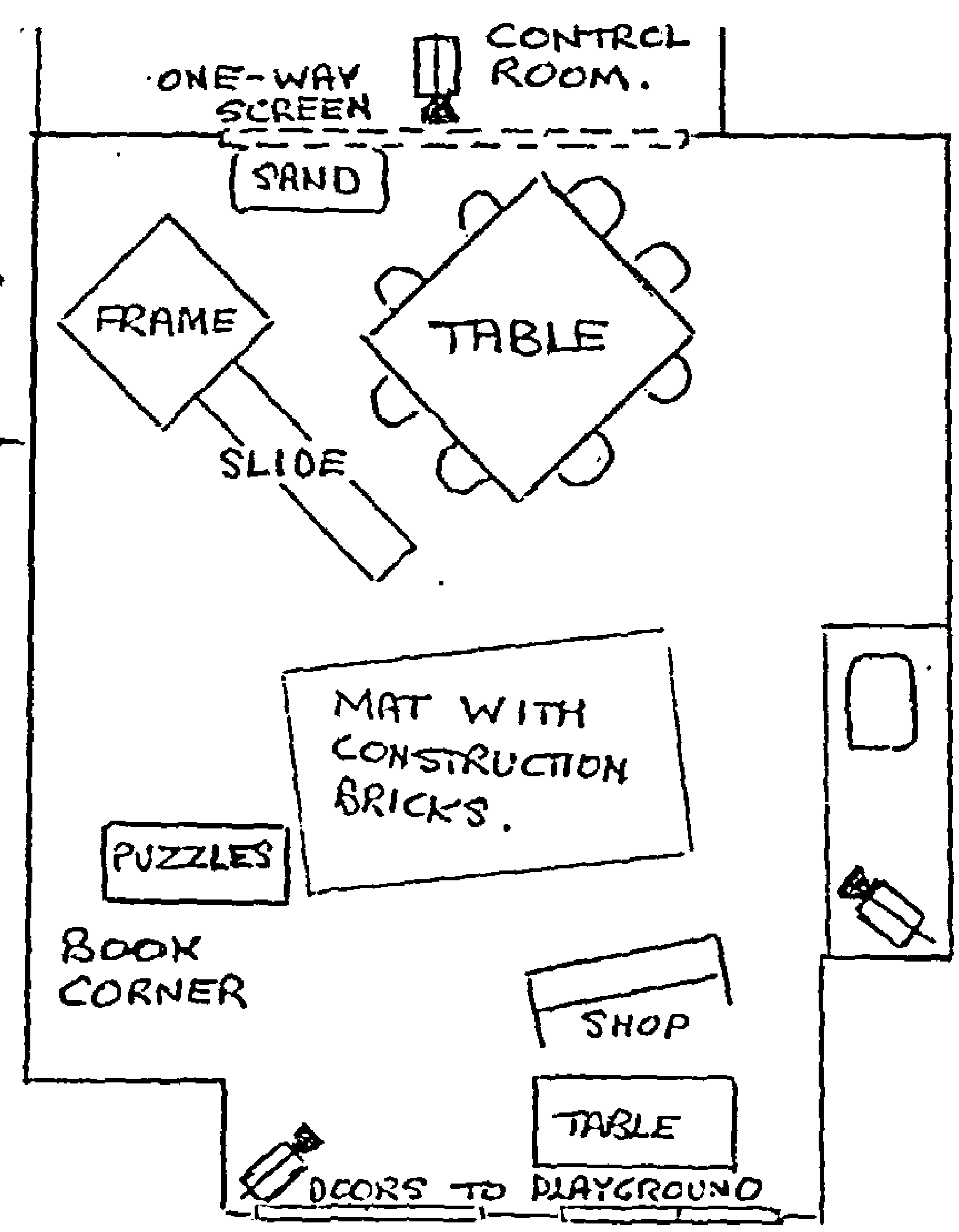
Appendix 6

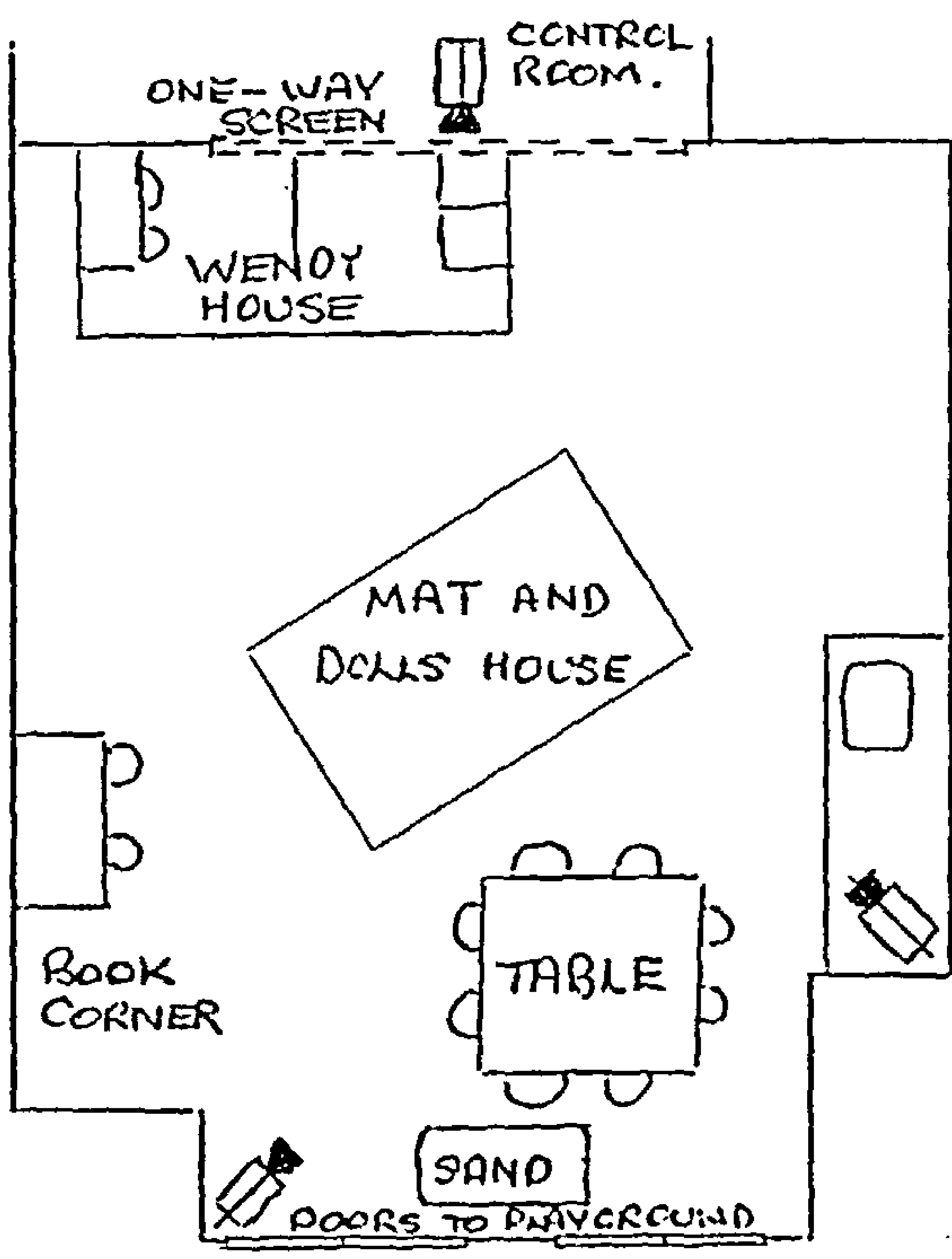
Floor plans of equipment layout in nursery for first three months



LAYOUT 1.

LAYOUT 2.



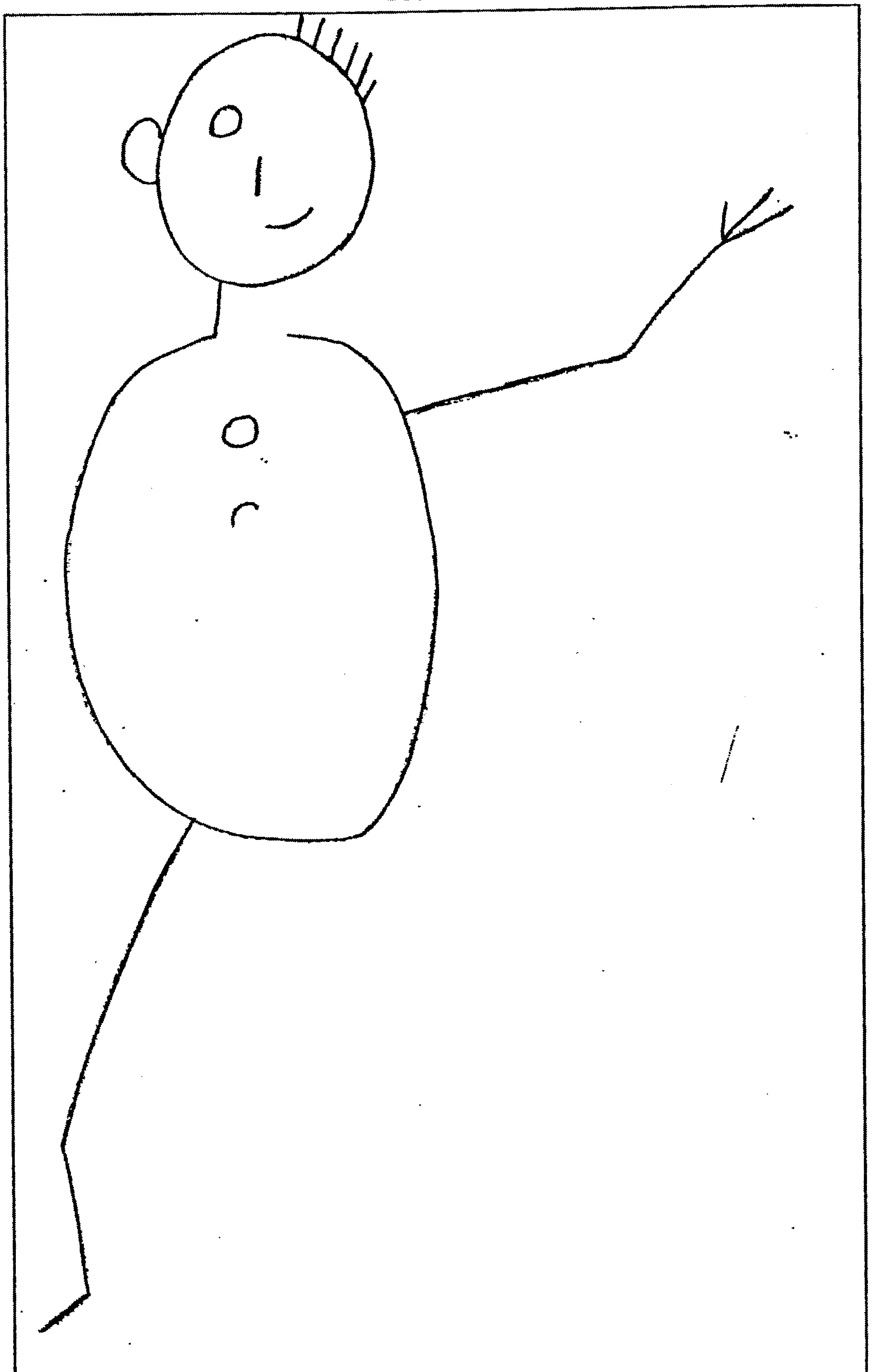


LAYOUT 3.

Appendix 7

1. Score sheet for interaction observations
2. Stylistic half complete man.

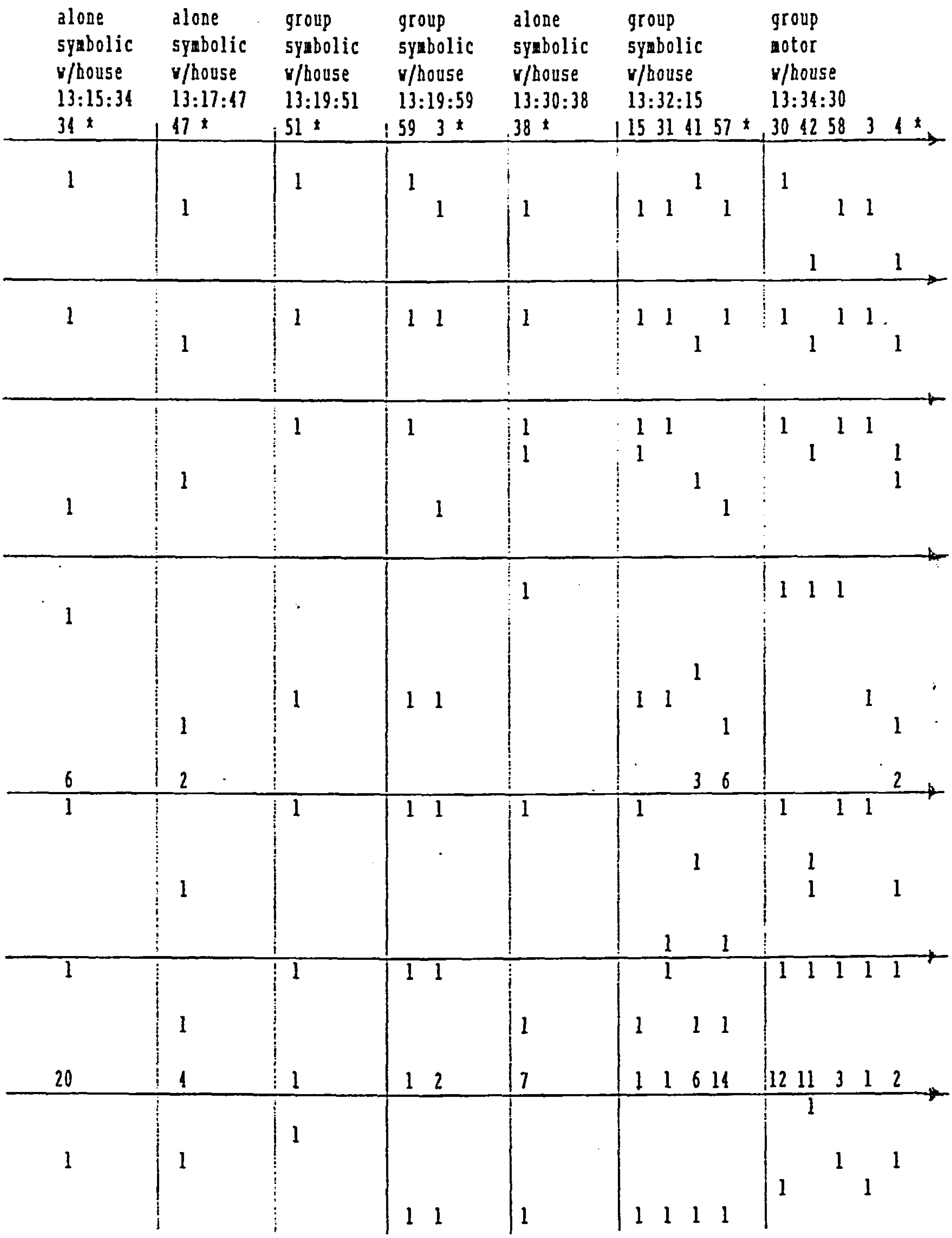
INTERACTIONS			coder:	
child	method	from child to	to child from	No. turns
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
	V T S M	A C S	A C	
Comments				

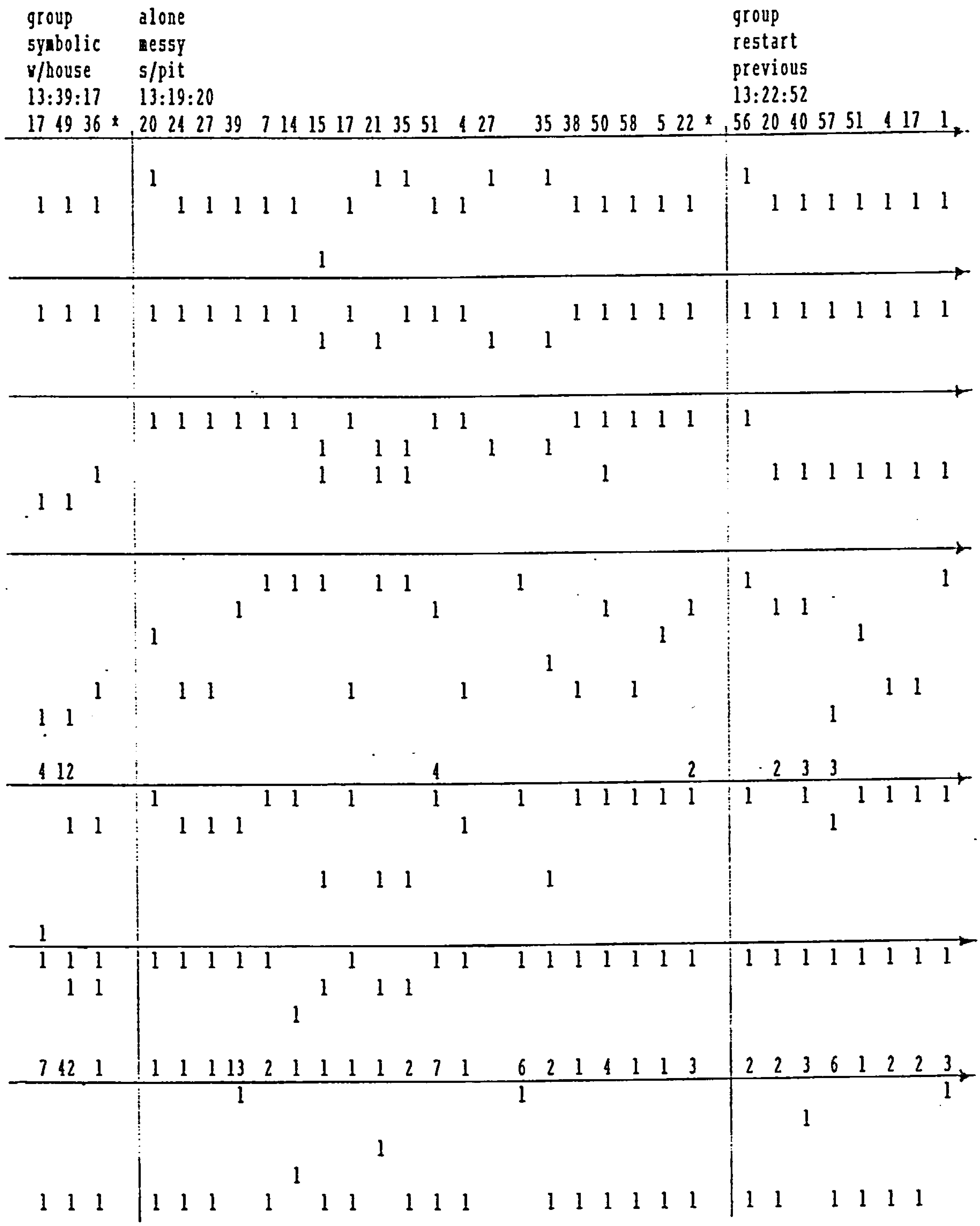


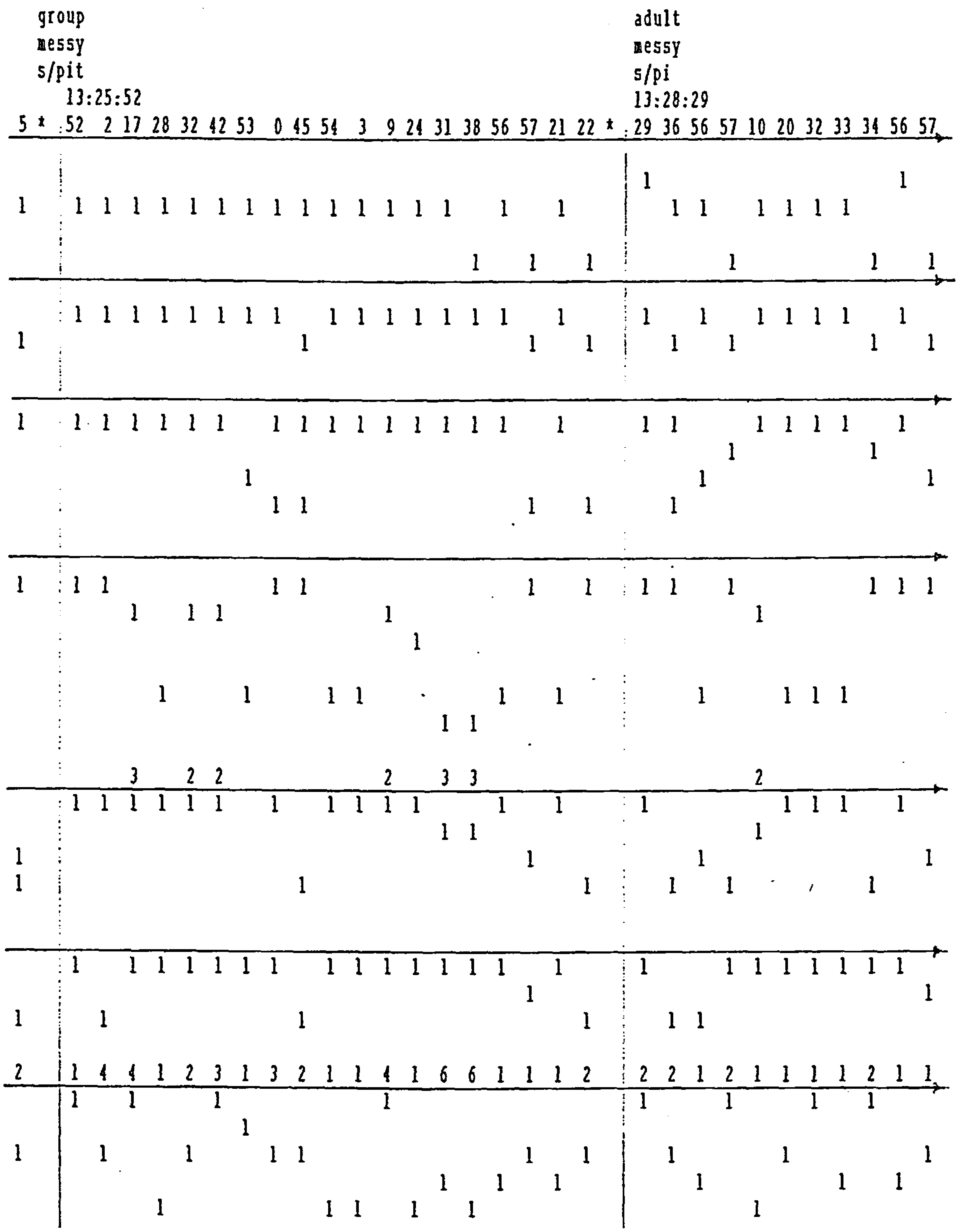
Appendix 8

1. Raw data for mirror interactions

Event Analysis		Old Deaf Group														
		present	chi		cildren		children	children			adult				group
		type play	symb		parallel		parallel	parallel			f/play				symbolic
		location	w/house		table		table	table			w/house				w/house
		time	13:33:42		13:52:19		13:52:23	13:45:19			13:08:29				13:09:
		unit	0	4 *	19	24 *	23 *	19	25	26 *	29	31	32	33 *	36 *36
	Event Triger														
intention	Incidental	1	1								1				1
	Deliberate	2		1			1	1	1					1	
	Not known	3			1										
	Continuation	4				1				1		1	1		
focus	Sees self	5	1	1						1	1	1	1	1	
	Sees other	6			1		1	1	1	1					1
	sees event	7													
location	front	8									1	1	1		
	behind	9													1
	left	10			1			1	1	1					
	right	11	1	1			1							1	
	Event Content														
type	watch	12	1		1			1	1		1		1		
	converse	13													
	monitor	14												1	
	explore	15					1								
	comment	16		1		1				1		1			
	dialogue	17													
	initiate	18													1
	number turns	19					2								
focus	self	20	1	1		1		1	1		1	1	1	1	
	self as other	21													
	child	22			1		1	1	1	1				1	
	adult	23													1
	environment	24													
	imaginary	25													
direction	neccessary	26				1					1	1	1		1
	peripheral	27	1		1										
	optional	28		1			1	1	1	1				1	
	Terminate														
	duration	29	3	1	5	1	3	4	1	1	2	1	1	1	5
End type	Distracted	30					1						1		
	natural end	31													
	switch to real	32	1					1		1				1	1
	another mirror	33			1				1		1	1			
	return to activ	34		1											


alone symbolic w/house 13:15:34
alone symbolic w/house 13:17:47
group symbolic w/house 13:19:51
group symbolic w/house 13:19:59
alone symbolic w/house 13:30:38
group symbolic w/house 13:32:15
group motor w/house 13:34:30
34 *
47 *
51 *
59 3 *
38 *
15 31 41 57 *
30 42 58 3 4 *


group
symbolic
w/house
13:39:17
alone
messy
s/pit
13:19:20
group
restart
previous
13:22:52
17 49 36 * 20 24 27 39 7 14 15 17 21 35 51 4 27 35 38 50 58 5 22 * 56 20 40 57 51 4 17 1


group
messy
s/pit
13:25:52
adult
messy
s/pi
13:28:29
5 * :52 2 17 28 32 42 53 0 45 54 3 9 24 31 38 56 57 21 22 * :29 36 56 57 10 20 32 33 34 56 57

				group watch bike 13:31:02			child messy s/pit 13:31:37																		child messy s/pi 13:32:21					
2	11	53	*	2	3	*	37	39	1	3	6	15	27	35	42	44	46	48	52	1	19	31	12	*	21	23	24	25		mean
																													0	
				1			1																						17	
1	1	1							1			1	1		1		1		1	1		1	1		1				72	
																													1	
					1			1		1	1			1		1		1			1					1	1	1	24	
																													0	
1	1				1		1		1	1	1	1	1		1		1		1	1		1	1		1		1	1	85	
		1		1				1								1		1			1					1			29	
														1															1	
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1	1			1	1		1	1	1	1			1		1		1		1	1		1	1		1		1	1	67	
		1									1			1		1		1			1					1			19	
		1										1						1								1			26	
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													1						1	1								1	14	
		1		1							1							1			1								17	
		1		1				1			1	1				1					1					1			22	
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1		1			1		1	1	1	1	1		1	1	1	1	1		1	1	1	1	1		1	1	1	1	86	
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	1			1								1																	21	
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1	1	9		1	1.		2	1	2	3	7	1	8	1	2	1	2	1	4	18	3	38	1		2	1	1	3	412	3.614
					1																								15	
																						1	1					1	6	
1	1	1									1	1		1				1			1								28	
				1			1		1	1			1		1		1			1					1	1	1		24	
								1								1			1										41	

s.d. maxmin
3.529 17 2
5.975 42 1

Event Analysis Young Deaf Group

	type play																						
	location	t/table	do						do			do										do	
	present	group																					
	time	14:45:02	14:45:45						14:45:50			14:52:47				53	54		55	56		14:53:	
	unit	2 *	45	48	50	53	54	*	50	51	*	47	48	50	53	29	45	54	45	10	*	52	12
	Event Triger																						
intention	Incidental	1							1			1										1	1
	Deliberate		1	1		1								1	1	1	1		1	1			
	Not known																						
	Continuation				1		1			1			1					1					
focus	Sees self	1		1		1			1			1				1	1			1			
	Sees other		1		1		1			1			1	1	1			1	1			1	1
	sees event																						
location	front		1				1						1	1	1			1				1	1
	behind																						
	left			1		1			1	1		1				1	1						
	right	1	1		1		1						1						1			1	1
	Event Content																						
type	watch	1	1		1		1			1			1	1	1			1	1	1			
	converse															1	1						
	explore																						
	comment			1		1			1			1										1	1
	dialogue																						
	initiate																						
	number turns															3	5						
focus	self	1		1		1			1			1				1	1					1	1
	self as other																						
	self as actor																			1			
	child		1		1																		
	adult						1			1			1	1	1			1	1				
	environment																						
	imaginary																						
direction	neccessary	1		1		1			1			1				1	1			1		1	1
	peripheral				1		1			1			1					1	1				
	optional		1											1	1								
	Terminate																						
	duration	14	2	2	2	1	3		1	8		1	1	2	2	5	9	1.	3	4		2	2
End type	Distracted															1				1			
	interrupted																						
	natural end																						
	switch to real		1		1		1			1			1	1				1	1			1	1
	another mirror			1		1			1			1					1						
	return to activ	1													1								

					do			symbolic v/house alone					t/table group																			mes s/p chi
52		54			14:54:55			14:21:43					14:30:55			37			40			42	43					44		45		13:
34	36	47	52	*	55	4	*	43	45	46	56	*	55	13	22	30	43	55	32	35	37	58	1	28	36	42	45	56	58	6	*	0
					1								1						1													1
1		1				1		1	1	1	1			1	1	1		1				1		1			1	1				
	1		1														1			1	1		1		1	1			1	1		
1	1	1			1	1		1	1	1	1		1	1	1	1		1	1	1		1		1	1		1	1	1			1
			1														1				1		1			1				1		
	1	1						1	1	1	1				1			1							1							
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	1	1	1		1								1	1	1	1	1	1	1		1	1	1	1		1	1		1	1		1
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	1	1																														1
2	5	5	3		6	2		1	1	2	1		6	7	1	13	6	5	3	2	4	3	1	8	6	2	6	2	8	2		1
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sy it ld 45:00				messy s/pit sib 13:47:08 48			alone		t/table children 14:31:49															t/table children 14:46:41	symbolic w/house alone 13:42:	
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										32	33	2	4	37	39	21	19	25	20	22	29	28	44 *			
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	1		1		1	1	1		1		1					1		1		1	1	1	1		1	
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								1		1														1		
	1	1	1					1	1													1				
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									1	1								1			1					
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									9	6	4		7		4			2	4		2					
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	1		1	1	1	1						1		1		1	1						1	1	1	1
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							1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	
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	1			1	1	1																1				1
1	1	1	5	1	2	1	1	1	19	10	6	2	13	2	7	5	4	5	6	3	3	4	3	8	3	17
															1	1	1									
										1	1								1				1			
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				1	1	1	1		1				1					1		1	1			1		

33 20 45	47 11	26	49 0	7	51 47	50	54	57	52 1	*	r/t w/house child 13:45:35 35	39	46 46	50 41	43	46	47	48	57	58	51 25	34	39	40	49	52 29	46	58	59	53 1	symbolic group 26	54 10
					1						1										1											
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						1	1	1	1							1	1	1		1				1					1	1		
			1	1	1			1			1	1	1	1		1	1		1			1	1	1	1	1	1		1	1	1	1
1	1	1				1			1						1			1		1								1				
							1														1											
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		1				1	1		1									1										1				
1															1					1												
				1										1		1	1		1		1				1		1				1	1
1	1	1		1	1	1		1	1		1	1	1	1	1		1	1		1				1	1			1	1			
			1																							1					1	
							1														1											
																1			1			1	1				1			1		1
			3																							5					2	
					1						1			1		1			1													1
			1																			1	1								1	
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							1														1											
		1	1		1	1	1	1	1		1		1			1			1			1	1	1				1	1		1	1
														1						1	1											
1	1			1								1			1		1	1							1	1	1			1		
5	8	3	6	2	3	4	3	4	2		2	1	5	1	3	1	1	2	1	1	2	3	1	1	4	8	1	1	2	1	4	1
1			1	1																												
		1																														
	1								1											1						1	1			1		
					1	1	1	1							1	1	1		1				1					1	1			
											1	1	1	1				1			1	1		1	1						1	1

32	56 15	16	17	*	r/t w/house child 13:50:40 40 *		mean	s.d.	max	min
						20				
1	1				1	59				
						0				
		1	1			33				
						0				
1	1	1	1			77				
					1	32				
						3				
	1	1	1			53				
						17				
						27				
1					1	35				
						0				
	1		1			72				
1						11				
						2				
		1			1	23				
						4				
						0				
6						65	4.333	2.024	9	2
		1				26				
1						16				
	1		1			37				
					1	14				
						18				
						2				
						0				
1		1				73				
						12				
	1		1		1	26				
						0				
13	1	1	4		1	420	3.750	3.362	19	
						9				
						5				
						0				
						28				
	1	1				33				
1			1		1	37				

Appendix 9

1. Frequency matrices
2. Dominance matrices
3. Transitional probability matrices
4. Data for Markov Model proof

Chapter 9 Data for Matrix Analyses

Frequency Matrices

Cage

	E	A	T	U
E	15	1	3	0
A	2	0	1	0
T	4	0	2	2
U	0	1	0	1

Slider

	E	A	T	U
E	3	1	2	1
A	1	0	0	0
T	2	0	0	0
U	1	0	0	0

Dominance Matrices

First Order

	E	A	T	U
E	1	1	1	0
A	0	0	0	1
T	0	1	1	0
U	0	0	1	1

	E	A	T	U
E	1	1	1	1
A	1	0	0	0
T	1	0	0	0
U	1	0	0	0

Second Order

	E	A	T	U
E	1	2	2	1
A	0	0	1	1
T	0	1	1	1
U	0	1	2	1

	E	A	T	U
E	4	1	1	1
A	1	1	1	1
T	1	1	1	1
U	1	1	1	1

Third Order

	E	A	T	U
E	1	3	4	3
A	0	1	2	1
T	0	1	2	2
U	0	2	3	2

	E	A	T	U
E	7	4	4	4
A	4	1	1	1
T	4	1	1	1
U	4	1	1	1

Summary Matrices

	E	A	T	U
E	1.80	3.00	3.30	1.06
A	0.00	0.30	0.80	1.00
T	0.00	1.80	2.06	0.80
U	0.00	0.80	1.80	0.30

	E	A	T	U
E	5.30	2.80	2.80	2.80
A	2.80	0.80	0.80	0.80
T	2.80	0.80	0.80	0.80
U	2.80	0.80	0.80	0.80

Transitional Probability Matrices

	E	A	T	U
E	0.79	0.05	0.16	0.00
A	0.67	0.00	0.33	0.00
T	0.50	0.00	0.25	0.25
U	0.00	0.50	0.00	0.50

	E	A	T	U
E	0.43	0.14	0.28	1.40
A	1.00	0.00	0.00	0.00
T	1.00	0.00	0.00	0.00
U	1.00	0.00	0.00	0.00

Observed Probability Vectors

Cage [.66 .06 .19 .09]
Slider [.64 .09 .18 .09]

Further Proofs

Observed and predicted frequency vectors for Cage problem

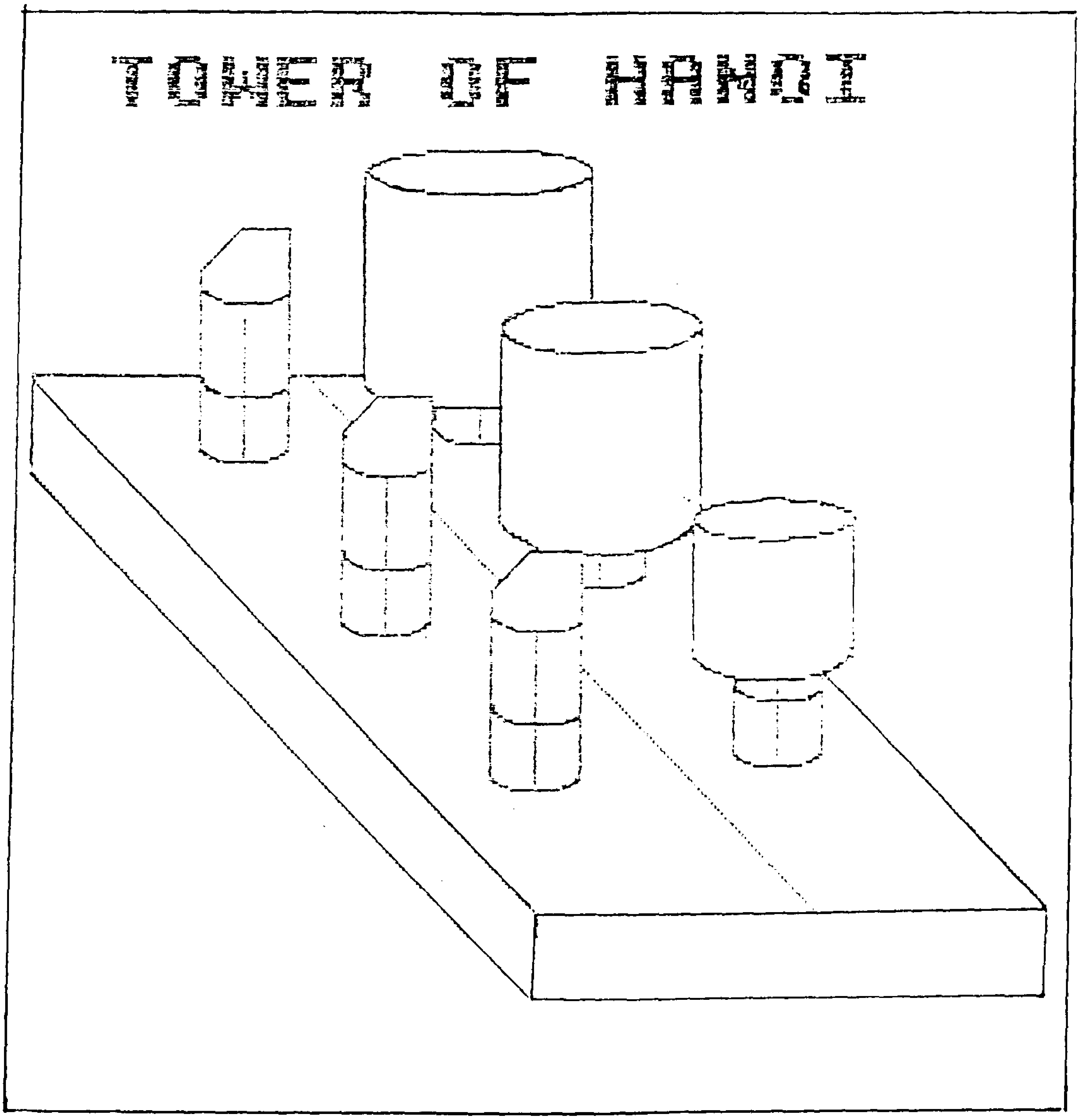
observed	[21	2	6	3]
Equilibrium vector	[19.8	2.3	5.3	2.7]
Slider equilib. vector x Cage matrix	[20.6	2.4	5.5	2.7]
Chance vector x Cage Matrix	[15.5	4.4	5.9	5.9]

Observed and predicted frequency vectors for Slider Problem

observed	[7	1	2	1]
Cage vector x Cage $matrix^2$	[6.9	.9	2	1.5]
Equilibrium vector	[6.7	.9	1.9	.9]
Chance vector x Slider Matrix	[9.4	.4	.77	.38]

Appendix 10

1. Drawing of Tower-of-Hanoi
2. Problem sets
3. Example of transcript
4. Score sheets


TOWER OF HANOI

Problem Sets - Tower-of-Hanoi

	Intial state			Goal state		
				1 MOVE		
1	X	Y	R/G	R	Y	G
2	G	Y	R	G	R/Y	X
3	X	X	R/Y/G	R	X	Y/G
4	R	Y/G	X	X	R/Y/G	X
				2 MOVE		
5	R/G	X	Y	G	Y	R
6	G	Y	R	R/Y/G	X	X
7	Y	R	G	X	X	R/Y/G
8	Y	X	R/G	R	Y	G
				3 MOVE		
9	G	X	R/Y	G	Y	R
10	G	X	R/Y	R/Y/G	X	X
11	R/Y	X	G	R	Y	G
12	X	R/Y	G	X	X	R/Y/G
				4 MOVE		
13	X	R/Y	G	R/Y/G	X	X
14	X	G	R/Y	G	Y	R
15	X	G	R/Y	R/Y/G	X	X
16	R	X	Y/G	G	Y	R
				5 MOVE		
17	X	Y	R/G	R/Y/G	X	X
18	X	X	R/Y/G	G	Y	R
19	R/Y/G	X	X	R	Y	G
20	G	Y	R	X	X	R/Y/G

Problem 12 X X 3 X Y/R G Tower
1 moves S red to S blue peg and S yellow to S green and S red to S yellow

Problem 13 3 X X X Y/R G Tower(4)
1 moves S green to S blue peg and S red to S black peg and S yellow to S green and S red to S yellow

Problem 14 G Y R X G Y/R Flat
1 Moves S green to S blue peg and S red to S orange peg
2 Looks at cups and moves S yellow to to S green and S red to S black peg and S yellow to S orange peg

Problem 15 3 X X X G Y/R Tower
1 moves S green to S blue peg and S red to S orange peg and S yellow to S green and S red to S yellow

Problem 16 G Y R R X Y/G
1 Moves S yellow to S orange peg
2 Looks at cups
3 Moves S red to S green and then S yellow
4 Moves S green to S blue peg and S red to S black peg

Problem 17 3 X X X Y G/R Tower (5)
1 Moves S red to S blue peg
2 Looks at cups
3 Moves S yellow to S green
4 Looks at cups
5 Moves S red to S orange peg then back to S blue peg
6 Moves S yellow to S orange peg
7 Looks at cups
8 Moves S red to S yellow and S green to S blue peg and S red to S black peg and S yellow to S green and S red to S yellow

Problem 18 X X 3 G Y R Tower
1 looks at cups
2 moves S rd to S yellow and S green to S black peg and S red to S blue peg and S yellow to S green and S red to S yellow

Problem 19 G Y R X X 3 Flat
1 Moves S red to S blue peg and S yellow to S orange peg and S red to S yellow and S green to S blue peg and S red to S black peg

Problem 20 R Y G 3 X X Flat

Tower-of-Hanoi - Score sheets

	1 F R/L	2 T R/L	3 F R/L	4 T L/R	5 F B	6 T R/L	7 T L/R	8 F B	9 F R/L	10 T R/L
H1	1	1	1	1	2	2	2	2	1+I 4	3
H2	Ec 3	Ec I IL 1	1	1	2	I I 2	1+I I I 4	2	3	1+I 5
H3	1	1	1	1	2	2	2		1+I 4	3
H4	1	Ec 1	1	1	2	2	2	2	3	3
H5	1	1	1	1	4	2	2		3	3
H6	1	I I 2	1	5	3	2	2	2	4	3
H7	1	1	1	1	2	2	2	2	1+I 1+I 4	I 3
D1	1	Ec 1	1	1	2	1+I 2	I 2	2	I 3	3
D2	1	1	1	1	2	2	2	2	3	3
D3	1	Ec Ec 1	1	1	2	2	2	1+I 3	I I 3	1+I I 1+I 2+I 4
D4	1	Ec 1	2	1	1+1 2	Ec 2	Ec I I 3	2	1+1 1+I I 3	I 1+I 1+I 5
D5	1	Ec Ec I 1	1	1	2	2	2	2	I 1+I I I I 3	I 3

Tower-of-Hanoi Score sheets cont...

	11 F L/R	12 T L/R	13 T R/L	14 F R/L	15 T R/L	16 F B	17 T R/L	18 T L/R	19 F R/L	20 F L/R
H1	4	3	4	5	4	4	8	5	5	5
H2	I 1+I 4	1+I I 3	2+I 8	4	3+I 8	2+I 8+I 12	1+I I 6	3+I 5		
H3	3	3	4	5	6	6	5	5	8	8
H4	4	3	6	4	4	7	5	10	6	7
H5	3	3	4	4	4	6 4	5	5	5	8
H6	1+I 4	1+I 4	4	6	4	4	5	5	3+I 5	5
H7	3	3	3+I 4	6	2+I 5	4	3 5	5	6	2+I 7
D1	3	3	4	4	4	1+I 4	1+I 5	5	2+I 1+I 4+4I 6	
D2	3	3	6	4	4	4	5	5	5 6	8
D3	I I 1+I 3	3	4	2+I 2+I 4	4					
D4	3+I 3	3	2+I 4+1 5	4I 4	4					
D5	I 3	I 1+I 1+I I 3	I I 4		4					

Appendix 11

1. Programme documentation

PROGRAMME NOTES

1. Introduction

The materials consist of a suit of seven programmes. Static or moving dot patterns are generated in a 3 x 3 grid. Patterns may consist of 3, 4 or 5 dots. Response input, which is via a concept keyboard, is recorded on disc along with an identifying pattern number and pattern type (i.e. static or moving).

2. Programmes

"HEAD1" and "HEAD2" produce introduction screens. "PRACSS", "PRACMM", "STATIC3" and "PATERN4" are the main programmes, which generate the memory tests and collect the responses. "READ" allows the data files made in the test programmes to be printed out.

2.1 Running the programmes

When the disc is BOOTed, HEAD1 is run. This initiates a practice session, in which the rules of the 'game' can be explained to the child. A menu allows selection of either static or moving patterns. These are generated by PRACSS (static) or PRACMM (moving) which are CHAINed from within the programme. From within these programmes the user has the option to change the type of pattern or to move to experimental trials.

If the user opts to begin the experimental trials HEAD2 is CHAINed. The user is asked to input the name of the child. This opens a file on DRIVE 1 with the name of the child. A menu allows selection of pattern type and CHAIN's either STATIC3 or PATERN4. These generate the experimental trials and record responses in the opened file in DRIVE 1. Within these programmes the user has the option to change pattern type or to end the session.

Ending the session causes a prompt to "CHECK DATA FILE" to appear on the screen. Once this point is reached the file is closed and the programmes must be reBOOTed.

The READ programme is on the DATA disc and can be BOOTed.

3. Variables

Z$,Y$ - graphics for grid

A$ - Array for grid
D$ - Dot
C$ - erases dot
N$ - name for data file
G$ - get variable

D = number of dots in pattern
P = pattern number
S = response square number
N = cell number of concept keyboard
CK = value from user port
H = 1 sec per dot in pattern
FIN = time lapse of 1sec
A = numeric array holding TRUE/FALSE values for grid squares
T = most recent value of S
F% = channel number for file operations

X,Y control variables

4. PROCeedures

PROCinit - initialises variables, defines characters, text window and colours, dimensions arrays.

PROCdraw - draws 3 x 3 grid and writes pattern type

PROCreset - removes pattern dots after childs responses

PROCtime - sets time dot(s) will remain in square(s)

PROCselect - gets pattern number from keyboard input.

PROCone to PROCnine - draws dot in square 1 to 9. In PRACMM and PATERN4 also erases dot after 1 sec

PROCtrue - resets all elements of array A to TRUE

PROCagain - gets childs response and sets options for next trial or end

PROCCK - gets value of concept keyboard cell from userport

PROCCKS - claculates value of S from concept keyboard cell number

5. Modifications suggested in Chapter 11
PROCck contains the code for handling information from the input device. If a tough sensitive screen is used then the code in this PROCedure would need to be chnaged to that

relevant to the new device. All associted variables will be the same.

To make the dots flash the arguments to the COLOUR command in PROCinit need to be changed e.g.
COLOUR 1
VDU 19, 1,9,0,0,0
will cause COLOUR 1 to be written as flashing red-cyan.