THE ACQUISITION OF LANGUAGE SKILL BY CHILDREN

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Summary

The main purpose of this study was to examine the possibility of improving pedagogical procedures designed to promote language skill by utilising recent developments in psychology and linguistics.

Three experiments were designed to investigate the performance of child subjects on unstructured and structured strings of words using the method of immediate recall.

A first experiment examined the measurement of short-term memory for words by comparing the 'traditional' method of calculation with methods based on informational calculus.

A second experiment investigated the subjects' performance on structured strings which were described in terms of transformational grammar. A developmental trend was suggested by the results and the importance of the frequency of occurrence of words comprising the structures indicated.

A third experiment examined the relationship between structure and vocabulary in greater detail. An interaction effect between structure and vocabulary was found and a developmental pattern confirmed. Vocabulary chosen for low frequency of occurrence in the speech of the subjects was seen to depress performance markedly.

In the second and third experiments, the expected high correlation between memory tasks and the recall of structures was confirmed. In addition, different levels of basic STM capacity were seen to facilitate the processing of structures of differential complexity.

In the conspectus, the findings are here interpreted in

terms of extending basic STM capacity by the active organisation of input through structuring. These learning characteristics point the way to the utilisation of the results in pedagogical procedures and materials.

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1. PEDAGOGICAL APOLOGIA

The main motivating factor behind this study is pedagogical: the desire being to improve, wherever possible, instructional procedures and materials designed for young children in infant schools by a greater understanding of the acquisition of language, by those children. Little consistent research appears to have been done in these departments recently, particularly in the area of the acquisition and development of a first language, and yet surely this should have utmost priority for the school as it is a prerequisite skill, basic to other more complex skills.

To illustrate this primacy, it has been suggested in the past that the teaching of complex skills like reading and writing was dependent for success on maturational factors in the child, who could not begin to read until he was 'ready': what Havighurst (1953) called the 'teachable moment'. This was interpreted by some as a requirement to delay formal instruction until a chronological age of six years had been achieved (Schonell, 1945), because, for example, the child's power of visual discrimination was not sufficiently developed to master the intricate processes involved. Other factors were quoted as being necessary - among them language facility. These accounts of 'Reading Readiness' are now held not to be tenable (Lynn, 1963) for it has been demonstrated that some children can cope with the visual discrimination involved in reading as early as two and a half years, yet it appears that a certain level of spoken language ability is required for success.

These abilities were, and still are, described in broad terms, suffering from inexactitude. To quote, for instance, a Ministry of Education publication (Reading Ability, 1950) which states that reading ability depends on 'a certain state of maturity' and that this 'will depend on home conditions and social environment, facility in spoken language, emotional stability, and upon the level of innate ability'. It was left to the teacher to decide when the child arrived at this 'certain state'. During the decade of the sixties the emphasis for success in acquiring the two basic skills of reading and writing has centred largely on the level of fluency of language achieved by the child, but very little has been done to analyse this achievement in terms of developmental patterns of language competence and performance, or on the psychological mechanisms involved.

A recent report (H.M.S.O., 1967) has pointed out that there are critical periods when the child has a greater sensitivity to various learning processes and it has been thought that there is such a time for beginning to read. To quote,

'It would be surprising if at later ages (early infancy had been discussed) limited periods at least of maximum receptivity did not occur for many skills and emotional developments. A critical period is only the extreme example of a more general class of sensitive periods. It is likely that, in the sphere of learning, periods of maximum sensitivity rather than of critical 'now-or-neverness' exist. More knowledge of the occurrence and nature of such periods from nursery school age onwards would be invaluable for the teacher and the subject is therefore an important one for educational research.'

It has been noticed by many experienced teachers of children in infant reception classes that there are such periods during the early stages of the child's full-time attendance at school, when language facility increases notably.

Biological studies also support a general critical period for language learning; the maturational level, particularly at the lower end of acquisition, being a necessary condition

(Lenneberg, 1967). It is interesting to note also (Herriot, 1950), that studies investigating the recovery of child aphasics, who are between the ages of four and nine years, show that a process of re-learning over a number of years is necessary.

Though, as intimated, little work has been conducted in the school situation to improve pedagogical procedures, a great deal of research has been carried out over the years into the general area of language behaviour so much so that Leopold (1953-1954) complains,

> 'the crushing bulk of data amassed in thousands of studies from many lands and many fields of scholar-ship threaten to overwhelm the student who tried to discover great lines of development in child language.'

Much of this Griffin (1968) points out

> 'has been mainly concerned with such topics as acquisition of the phonological system, mastery of morphology, growth of vocabulary and calculation of egocentricity or socialization in speech.'

Linguistic development is indeed a very old topic for research but recently there have been changes in the conception of the problem and methods of studying it. It is these that appear worth examining and, if viable, using in an investigation aimed at studying language acquisition processes when the child has newly entered school, to try to discover base-lines for instructional sequencies and materials. Alongside this area of linguistic development must go a study of the psychological mechanisms involved in the language processes. It is necessary to heed here, in this introduction, an important distinction first made explicit by the Swiss linguist, Ferdinand de Saussure (1915). From the actual utterances produced when people are speaking, in spite of individual variations between them, a system of rules and relations can be devised as the utterances share, in the main, the same structural characteristics. The utterances are instances of parole, the underlying common structure is the langue. The linguist is interested in the langue or the system, the psychologist mostly in the parole, or language behaviour.

2. INTRODUCTION

2.1 Theoretical Considerations

The new conception of the problems of linguistic development has been brought about by a working relationship established between linguists and some psychologists in the early fifties (Koplin, 1968). Much of this early work was concerned with problems in basic research, but at the same time some work on a considerable range of applied problems was begun using the tools being developed by the 'psycholinguists' as they became called. George Miller (1964) enumerated some of these topics as:

i. the medical diagnosis and treatment of language disorders ranging from stammering to aphasia,

ii. pedagogical applications to the methods of teaching reading, writing and a second language, and

iii. the use of computers for machine translation, making speech visible to the deaf, and making printing audible to the blind.

The methods seemed to be promising and a great deal of work has been reported 'yet the results of basic research have lacked stability and progress in applied areas has been uneven' (Koplin, 1968). The situation is indeed confusing and for various reasons. The coming together of linguists and psychologists is only recent - within the last fifteen years or so - and in addition recently there has been what has been described as 'a revolutionary series of developments in linguistic theory due to generative linguistics'. Moreover, as Herriot (1970) observes,

'Add to this the fact that psychological theory itself is undergoing profound change, and one is left with the sort of situation described by Kuhn (1962): old paradigms are being discarded for new, since they do not adequately describe already observed data nor produce fruitful experimental hypotheses. A further cause for change is the fact that the logicians have abandoned the logical positivist philosophical position and the physical scientists have abandoned the methodological limitations it imposed.'

Prior to the advent of generative transformational grammar - the outstanding contribution of the linguists - language behaviour including the acquisition of language had received considerable attention from the Behaviourist school of psychology. Here attempts were made to give an account of language acquisition in terms of learning theory which followed closely operant and classical conditioning paradigms. There is a deep gulf between the two approaches. Herriot (1970) for instance distinguishes theories as put forward by Chomsky (1965) and his followers as 'linguistic' theories of language behaviour, as opposed to truly psychological theories of language behaviour. Apparently, for the behaviourist there is no room for 'psycholinguistic' theories as such, their basis resting on rationalist rather than empirical grounds. Perhaps one of the clearest expositions of the distinctions involved in the two approaches is given by this passage from Osgood (1963),

'The thing we must avoid, I think, is explaining sentence understanding and creating by simply putting a new homunculus in our heads - in this case a little linguist in every brain. It is true that speakers produce novel sentences all the time, but the semantics and the grammatics cannot both be simultaneously novel, or we fail to comprehend. What is novel is the combination, and this is a familiar psychological problem; ..... let us therefore strive for psychological theories of the sentence which are parts of our theories of behaviour in general.'

The homunculus refers to the hypothesis put forward by the linguists and their associates that acquisition and language processes follow linguistic models, that is, the linguistic model is also a psychological model. Further initial acquisition is said to proceed via a Language Acquisition Device (LAD), which is an innate mechanism responsive to language universals - those abstract characteristics of all languages - in the speech of the community surrounding the child (McNeill, 1966). The behaviourist accepts only a complex central nervous system as being hereditary; language, therefore, has to be learnt. Some of the main features of psycholinguistic theory are discussed further in Section 5 as they relate intimately to the experimental work undertaken with structured strings of words, but for present introductory purposes the contradistinctions involved in the two theoretical positions (taken from a review of Rosenberg (1968)), are quoted by way of summary.

<u>The theory of an innate language-acquisition system</u>

The impetus for this has come from detailed observations and generalisations about language such as:

i. a natural language - a system of enormous complexity - is acquired in a very short period of time;

ii. no special training is needed for language acquisition;

iii. at least within normal limits, language acquisition is independent of intelligence level;

iv. certain linguistic phenomena are universal, i.e., they are found in all languages known to man;

v. natural languages contain features, deep structures, that are not marked in the surface structures derived from overt language behaviour; and

vi. language as we know it is acquired only by man.

The characterization of the innate acquisition system that follows is based mainly on Lenneberg's book (1967) and as expressed by McNeill (1966). It should be noted that McNeill prefers the term Language Acquisition Device (LAD) and this is preferred in this study, whereas Rosenberg uses the term Innate Language-Acquisition System (ILAS).

i. The operation of the ILAS is facilitated by a general cognitive propensity for, as Lenneberg (1967) puts it, 'categorization and extraction of similarities' from sensory inputs.

ii. There is a specific cognitive component to the ILAS that includes, among other things, a predifferentiation of fundamental linguistic categories and relations (linguistic universals). This component of the ILAS results essentially in a set to organise adult linguistic input in a manner that will reveal the structure of a native language.

iii. Although some of the universal characteristics of natural languages appear to be related to the possession by man of a specialized receptor and effector system, the cognitive components (just listed) are the most important components of the system.

iv. The child is an active participant in the process of language acquisition rather than a passive recipient of instruction from the environment. This active participation takes the form, in part, of testing hypotheses about the structural characteristics of the local language. The motivation for this component develops through maturation.

v. The language-acquisition process is activated by the utterances of adults, which then become the raw material for constructing the local language.

vi. If the activation and operation of the ILAS is delayed, difficulties in language development will arise.

In other words there is a critical period of development for language acquisition.

vii. The end result of the language-acquisition process is a phonological, syntactic, and semantic competence that makes possible the comprehension and production of an infinite number of linguistic utterances.

The alternative view of language development

This view owes much to Skinner (1957), and is usually referred to as the stimulus-response learning theory approach. Its characteristics are as the following propositions suggest although there are variations.

i. Although it is generally recognised that damage to certain central and peripheral physiological structures may retard or even make language development impossible, language behaviour (both first- and second-language behaviour) is primarily learned behaviour and is to be understood in the terms of the principles of conditioning (stimulus, response, contiguity, frequency, reinforcement, drive, generalization, discrimination, response, differentiation, and so on), associative learning, transfer, and mediation.

ii. Language behaviour is not qualitatively different from other forms of human behaviour nor from the behaviour of lower organisms. Thus, principles derived from the study of human nonlinguistic behaviour and the behaviour of lower organisms are relevant to language behaviour.

iii. Experience shapes the development of overt language behaviour, as well as the development of the way language is processed internally, through a process of imitation and of successive approximations to adult language behaviour.

In other words, it is primarily the environment that is active in the acquisition of language rather than the child.

iv. Linguistic competence consists of a finite repertoire of learned responses and associatively integrated response chains or sequences whose occurrence (performance) is under the control of specific internal and external environmental events. Linguistic performance, then, is viewed as being prim arily reproductive rather than constructive.

The conceptualization of the development of linguistic competence of the two views differ strikingly, but there is a willingness on the part of the proponents of the biological point of view to accept the importance of certain of the learning principles. It is obvious that the views have far-reaching effects; language disorders, for instance, might be said to result from conditions in the environment if the learning theorists' format is accepted, rather than the biologically orientated innate deficiencies. However, whatever theory is favoured, the controversy between proponents of the two theories has given great impetus to experimentation, and has illuminated some areas in the field of language behaviour. It is this work, its experiments and thought-forms that is exploited in this study.

2.2 Language: the Acquisition of a Skill

There are certain respects in which language behaviour might resemble skilled behaviour and these have been clearly enumerated recently by Herriot (1970) in his book "An Introduction to the Psychology of Language". He lists four major characteristics of skilled behaviour - its hierarchical nature, the processes of feedback, automatisation, and anticipation - showing each of these to be present as an essential constituent of language behaviour. As such this enables the analogy of the highly organised nature of skilled behaviour to act as guide to a study of language behaviour. There are, of course, areas in the perception and production of language which are difficult to separate; they are so inter-related, however, the hierarchical type of organisation of language and the type of analysis for learning skills seems appropriate and is used here as this study has a psychological orientation. As the characteristics of the sub-hierarchies are given by Herriot (1970) in a chapter entitled 'Language as Skilled Behaviour', only a brief résumé is included here.

The lowest level in the language skill hierarchy is the phoneme, which is termed a perceptual constant (that is, despite various physical differences in the sounds uttered, native speakers perceive sounds realising the same phoneme as being the same). Most of the psychological experimentation at this level has been with isolated phonemes, and it is possible to argue, as does Chomsky (1965), that 'analysis into segmental phonemes is unnecessary in situations where adequate syntactic and semantic cues are available.' However, Herriot demonstrates the hierarchical nature of the phonological level from the phoneme through to morphophonemic rules for generating acceptable sequences of sounds and the avoidance of non-acceptable sequences. The evidence discussed by Herriot strongly supports the use of the term 'skill' in the case of phonological performance as it does next with grammatical skill. He deals first with Word and Form classes defining morphemes as 'minimal meaningful forms, consisting of sounds realising phonemes or groups of phonemes.' Morphemes are, in turn, combined into sentences by syntactic rules.

This aspect of grammatical skill is discussed under a sub-heading of 'syntax', the principle by which words are formed into larger constructions. To analyse these principles, the linguists have evolved the techniques of constituent analysis, a constituent being defined as any part of a construction which results from its being sub-divided. Gleason (1961) is quoted as saying,

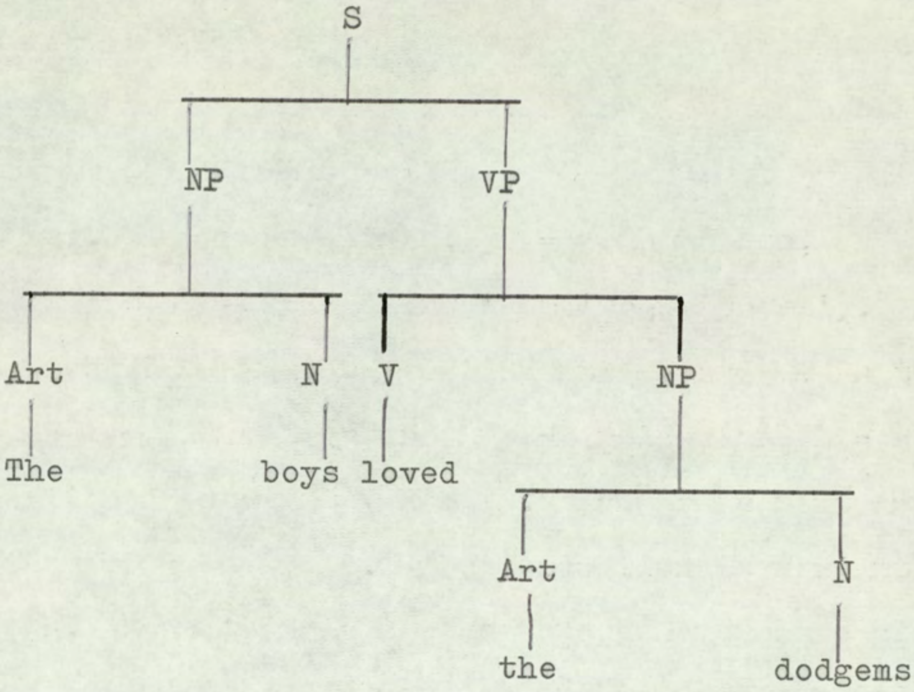
'What a grammar must describe, then, is not sentence patterns, but the smaller units of pattern of which they are constructed. Only thus can a language be described.'

The section of grammatical skills is looked at in greater detail for it is within this area of analysis that the linguists have essayed their most noticeable advances and, moreover, provides the linguistic background for the experimental work to follow in this study.

When analysing a sentence into its constituents, the linguist first sub-divides the sentences into subject and predicate - these are the 'immediate constituents'. That is, an immediate constituent is the segment that results after a construction has been sub-divided. The ultimate constituents of a sentence are individual morphemes (see also example in Section 5.1). These can then be written as fomclasses, e.g., from the sentence 'The boys loved the dodgems': article + noun (plural) + verb (past) + article + noun (plural), thus giving a sentence pattern providing slots into which different morphemes can be inserted. Hence new sentences can be generated from sentence frames. In summary, then, a constituent analysis is a hierarchical procedure sub-dividing sentences into ever smaller units. Immediate constituent analysis has developed into Phrase structure grammar (Chomsky, 1957), which adopts the principle of generation of the finished sentence by rules. Chomsky has called these rules 're-write' rules, which are applied to sets of symbols symbolising constructions of ever decreasing size. The first rule of a phrase structure grammar is usually S ⟶ NP + VP (where S = sentence, NP = noun phrase, VP = verb phrase, and the arrow denotes 'is sub-divided into' or 're-write as'). A rule is then applied to the constituents NP and VP in their turn then NP ⟶ Art + N (where Art = article and N = noun); the derivation is now Art + N + VP. A rule is next applied to VP; thus VP ⟶ V + NP. The derivation is now Art + N + V + Art + N. Here then is the sequence of morpheme classes where inflexions and class membership may be added, giving, for example, Art (demonstrative) + N (plural) + Aux + V + Art (definite) + N (plural) (where Aux = auxiliary). To achieve the final product, transformational rules are applied to give the sentence in English. This final sentence using the actual words is termed the 'surface' structure, whereas the symbols used in the phrase marker tree describe features of the 'deep' structure. Symbols are maintained until a selection is made from the lexical index. A tree diagram is often used to depict the structure starting with a node at the top, sub-dividing into two branches as in Figure (1), which illustrates the analysis detailed above. Phrase structure grammar is characterised by its generative capacity. By using symbols denoting form classes, the number of possible sentences is narrowed down until the specific pattern is generated. The topmost level of the phrase-structure grammar 'S' represents a limitless number

Figure 1

Tree diagram illustrating the process of constituent analysis



of alternatives. The final derivation of morpheme classes still allows an immense number of possible alternatives. It has been pointed out in the last section that there is a difference of opinion between those following the linguistic type of theory of language behaviour and those preferring a learning theory type of exposition, and here is an example of this cleavage. Behaviourist psychology has concentrated on left-to-right dependencies, any temporal sequence of responses being treated as a chain. However, these cannot alone describe adequately the perception, storage, and production of language. As Herriot, himself a behaviourist, points out, 'Grammatical structure must be incorporated into any psychological model', and if the phrase-structure model is accepted then its hierarchical, top-to-bottom nature becomes important. These distinctions are not yet clearly resolved and more work is obviously needed to elucidate them. Herriot summarises his survey of language as skilled behaviour by claiming that the term 'skill' is applicable to the grammatical level and the phonological level.

'Especially noticeable at the grammatical level has been the hierarchical nature of skill; also the preoccupation with response units and their markers, which enable smooth production to occur.'

He comments further about the importance of meaning, so far excluded from discussion, pointing out that it implies a situational context for utterances. Here the definition of language as a skill becomes far more difficult as

'an adequate account of meaning requires the postulation of representational thinking or cognitive categories.'

He comments further that it is probably impossible to separate syntax from meaning, since meaning is involved in every syntactic structure.

Griffin (1968) remarks,

'A language system, it is true, is composed of several interlocking sub-systems - phonological, semantic, and morphological as well as syntactic. But syntax is at the heart of language - it makes possible much of the creativeness of language .....'

To understand then how children develop control over syntax, to discover something of the processes involved and how they are related to one another, would forward this study and raise some fundmental problems for psychology.

2.3 Structured and Unstructured Strings

The distinctions between langue and parole made by Saussure (1.) are re-emphasised by Chomsky (1957), who renamed and further clarified them as competence and performance. Competence is defined as a person's underlying knowledge of his language - internalised rules - reflecting linguistic notions, whereas performance refers to the person's utterances or actual language behaviour. In this study both are of interest if this formulation is accepted, but how are they to be separated? This is a dilemma. If behaviour is observed empirically, and to do so is the intention of this study, then performance is observed. Knowledge of competence is only available via performance; it cannot be observed directly. However, much has been achieved by using performance, as a glance at the learned journals will show. (See for example, "The Journal of Verbal Learning and Verbal Behaviour", which has carried many articles concerning language since the inception of psycholinguistic studies.) Experimentation is to be used then, and in particular, experiments concerning structure. The age of the children selected for study, both from the point of view of language structure and its pedagogical implications, lies between the ages of four and seven. During these years (especially at the age of children in reception classes, as already intimated (1.)), there is probably a period when the child remains quite sensitive to the further acquisition of his language, so the subjects of the experiments will be chosen to represent these age groups.

What is meant when it is said that language is structured? Carroll (1953) declares that

'The central concept of linguistic analysis is structure by which is meant the ordered or patterned set of contrasts or oppositions which are presumed to be discernable in a language, whether in the units of sound, the grammatical inflection, the syntactical arrangements, or even the meanings of the linguistic forms.'

Brown (1958) puts it thus,

'There is a refrain running through descriptive linguistics which goes like this: Language is a system ..... when someone knows a language he knows a set of rules: rules of phonology, morphology, reference, and syntax. These rules can generate an indefinite number of utterances.'

Two ideas seem to be involved, (a) that structure has something to do with inter-related combinations and patterns which are differentially responded to, and (b) that language structure exists at several levels, phonology, morphology, and syntax. However, as Jenkins and Palermo (1964) who make these points, remark,

'What "structure" is, whether the same thing is meant by "structure" at each level, and whether there are general psychological explications of "structure" remain to be explored.'

The purpose behind this study is to explore that aspect of structure which is called syntax or grammar, for it is, at this level, that language acquisition is at its most fruitful and probably of most pedagogic importance. Epstein (1961, 1962) shows, for instance, how syntactic structure also influences learning and he defines syntax as

'the generalized pattern or schema which is imposed upon the reservoir of available words and determines the sequences of these words.'

His experiments show that syntactically structured material is learned more easily than matched, unstructured material when meaningfulness, familiarity and sequential probability were absent or equated.

Epstein's definition of syntactical structure is followed in this study, as the determination of the 'sequencing of the reservoir of words' is particularly apt with the age group with whom this study is concerned.

The overall method adopted is to compare that which is structured with that which is not, to compare performance on unstructured materials and then on structured materials, hence revealing, it is hoped, something of the nature of the structuring process.

This method is particularly appropriate as the immediate recall of the materials - the experimental method by which the performance of the child subjects can be observed - is at the same time akin to the old and well tried teaching method of 'Repeat after me', so often heard in the classroom situation.

The recall of items in this way has a further advantage in that it leads to an examination of the psychological mechanism of immediate or short-term memory, another field of study which, along with psycholinguistics, has flourished of late, and fulfils the second objective to look at the psychological mechanisms involved in language acquisition.

3. MEMORY PROCESSES

Graham's (1968) work has shown that the psychological mechanism of STM is an important factor in children's language performance and he claims that the differentiation of the complexity of the transformation is related in performance to differences in STM capacity. Savin and Perchonock (1965) have also shown that this transformational complexity tends to tax immediate memory. Their subjects were asked to give back tape-recorded sentences and as many as possible unrelated words which were presented immediately after each sentence. This work was also done with E.S.N. children. It was hypothesised that when kernel sentences (the simplest underlying structure before transformations are applied) preceded the unrelated words, the capacity remaining available in immediate memory would be largest. The actual data collected confirmed this as the average number of unrelated words recalled was 5.27 when preceded by kernel sentences, and 3.85 when having the more complex negative-passive-interrogative form (NPQ). Others have reported these relationships (e.g., Mehler, 1963) and as there appears to be a very small increase in the memory span at the age of the children being studied, (3.2.2) and yet a large increase in language facility, it was felt that a review of the characteristics of memory processes was pertinent.

3.1 Dichotomy or Continuum

During the last decade the functioning of human memory has received a great deal of emphasis and experimental scrutiny although, of course, it has received almost continuous attention since Ebbinghaus (1885) made his great contribution to the, then, recently founded Experimental Psychology. Of late, however, interest has been particularly keen. In a recent work, Welford (1968), commenting on areas of controversy, refers as to whether memory is a single process or whether there are two distinct stages - a Short-term store and a Long-term store (STM and LTM). Earlier in an authoritative article, Melton (1963), too, asked whether memory should be considered a dichotomy or a continuum. The most 'acclaimed differences' he states,

'between STM and LTM concern the decay in traces in immediate memory (STM) in contrast to the permanence of memory traces established through repetitive learning.'

Brown (1964), speaking of the physiological basis of the memory trace, records, from among the many possibilities, one suggestion that

'storage of information may involve changes in the structure of ribonucleic acid molecules within the neurons.'

He points out that

'storage involves either changes in synaptic resistances or the creation of reverberating activity within neural loops.'

Lloyd Paterson (1966), the American psychologist, suggests that STM and LTM are indeed closely related but involve separate mechanisms, one an activity mechanism, the other involving structural change. He points out that if the trace in the former (STM) is not continually excited, it will die out, and that in LTM the repetition of experience encourages 'some kind of relatively permanent alteration among neurons.' Here it would seem that the two mechanisms have a common element, 'activity', and are thus related, but perhaps their different functions lead to different characteristics. Baddeley (1966) has shown there to be different types of error for the two stages:

'in STM they tend to be due to confusion between acoustically similar words but not between words similar in meaning, whereas in LTM the opposite tendencies appear.'

However, as Postman and Keppel (1969) point out in the introduction to the section of their collection of papers dealing with STM,

'One source of difficulty is that there are no clear-cut operational criteria for distinguishing between the observed facts of STM and LTM.'

For study of the process, it is clear that separation of the two mechanisms is difficult as they do appear to work so closely together. Keeping this close association in mind, then the Short-term store (STM), either as a separate store or at the end of a continuum, is to receive particular attention as it seems intimately involved in the child's language production and development.

3.2 The Characteristics of the Short-term Store

The short-term storage process is often described as active and 'immediate' - the whole cycle of receiving of information, its retention and recall or retrieval occupying a few seconds or minutes at the very most. It will be seen that memory episodes of about that length of time are of great practical and pedagogical importance, and many illustrations of its use in real life have been cited. For example, its usage in retaining a telephone number just long enough to dial it after consulting the directory, is often quoted, as is Jacobs' (1887) introduction to his report on the first experimental study of the immediate memory span.

'It is obvious that there is a limit to the power of reproducing sounds accurately. Anyone can say 'Bo' after once hearing it; but few would catch the name of the Greek statesman M. Papamichalopoulos without the need of a repetition.' (Quoted by Hunter, 1964)

Jacobs was concerned here with the measurement of the immediate memory span, but the words 'reproducing sounds accurately' remind one of the initial characteristics necessary for the mechanism's 'active' functioning. In this respect an interesting proposal is put forward by Neisser (1966) who, emphasising the temporality of the process, suggests that some kind of 'transient' memory is involved. He points out that auditory input must be preserved just long enough to allow the processes of speech perception to take place, and that this process takes place in an 'Echoic' memory, located, presumably, prior to STM. This 'echo' is akin to the visual after-image which preserves the visual image for a few seconds after the initial stimulus has ceased. This is likened to William James' (1890) 'primary' memory, but Neisser does not use the 'primary and secondary' labels due to the confusion this might cause with Waugh and Norman's (1965) usage. The echoic memory then stores the input for a brief moment whilst analysis-by-synthesis (Neisser's main hypothetical cognitive functioning) takes place. Then an 'organised series of segments' exist which must also be preserved in a non-echoic type of memory - termed by Neisser active verbal memory. He equates this with what is usually called immediate or short-term memory. Neisser's account of the processes involved in language perception is important not only as an explanatory model but for its pertinency to this study. The capacity to hold information for a brief period of time whilst it is being processed, is of great importance for language encoding and decoding. The relationship can be demonstrated when one tries, on reaching the end of a long and complex sentence, to retrieve the earlier part in order to obtain its overall meaning. To unravel the meaning of such a sentence (the last for instance), the beginning of it must be held in some type of temporary storage until the sentence is complete. Neisser states that 'the echoic stage would not be long enough however for this purpose, since many sentences are much too long to be stored echoically.' A longer stage is required - the short-term store.

3.2.1 STM, A Limited Capacity Store

Although STM has a greater capacity than Neisser's echoic store, the capacity is none-the-less limited, and this has been clearly shown over the years by the measurement of memory spans. The immediate memory span has been defined by Postman (1964) as 'the number of discrete units that can be reproduced in correct serial order after a single exposure.' From studies of these spans there appears to be severe limitations on the amount of material that can be processed in this way after one presentation. Jacobs in his early studies found that the maximum number of random digits that could be repeated back accurately after one presentation was about 10 for subjects in their late 'teens. The number correct 50% of times is usually reckoned now as being between 7 and 8. However, other types of material than digits give different estimates. Brener (1940) gave the following results for college students.

Table 1

Average Memory Span for Different Types of Material (Brener, 1940, quoted by Miller, 1951)

Material	Average Span
Simple sentences (whole)	1.75
Simple commands (correctly executed)	2.42
Nonsense syllables (whole CVC)	2.49
Paired associates (whole pairs)	2.50
Abstract words (visual)	5.24
Simple geometric designs	5.31
Abstract words (oral)	5.58
Concrete words (visual)	5.76
Concrete words (oral)	5.36
Colours	7.06
Consonants (oral)	7.21
Consonants (visual)	7.30
Digits	7.98

Miller (1951) comments that the sentences contained 6 words and 8 syllables so that 1.75 sentences corresponded to 10.5 words and to 14.0 syllables of connected prose. It will be seen that the capacity is fixed roughly in terms of discrete units to Miller's (1956) 'Magic number seven plus or minus two'. If the words are in sentence form, given structure, then the amount is extended considerably. None-the-less the store's limited capacity is one of its main characteristics, as is its variation with the type of material presented for recall.

Crannel and Parrish (1957) found immediate memory to be significantly longer for digits than for letters or words, and the span for letters was found to be significantly longer than for words. They conclude,

'That the number of different stimuli with which the subject must contend is not the critical factor. The differences among habits or past experience with digits, letters and words appear to be crucial, but these differences are probably more a matter of the associative trends fostered by the materials, rather than a matter of frequency alone.'

The store, then, has a limited capacity which varies with the type of material presented and the subject's past experience with these materials.

3.2.2 Individual Differences of STM Capacity

It will be appreciated, intuitively at least, that the store's limited capacity will vary from person to person: there will be considerable individual differences and that these will be related to age and intelligence. It is well known that the length of the immediate memory span was treated as a test of verbal ability. In his original enquiry Jacobs noticed that 'as a rule, high span went with high place in (school) form', and further statistical analysis confirmed the relationship with intellectual ability. The span became a standard item in intelligence tests - a typical correlation between memory span and the results of the remainder of the intelligence test being about 0.5, and higher for the child than the adult (Hunter, 1964). Wechsler notes,

'Except in cases of special defect or organic disease, adults who cannot retain 5 digits forwards and 3 backwards will be found in nine cases out of ten, to be feeble minded.' (Quoted by Neisser, 1966)

Another variation observed in the length of the span in earlier studies is the age of the individual. According to large-scale surveys involved in the preparation of intelligence tests (Postman, 1964), the average digit span/age relationship is as the following table taken from Woodworth and Schlosberg (1957) shows:

Table 2

Average Digit Span/Age Relationship

2	digits	at	age	2½	years
3	"	"	"	3	"
4	"	"	"	4½	"
5	"	"	"	7	"
6	"	"	"	10	"

(Taken from the revised Stanford-Binet Intelligence Scale)

The average span increases more and more slowly, to level out at 7 items in the mid-teens. At about the age of thirty the average span begins to decline slightly. The rate of decrease, however, is not so rapid as the rate of increase in the early years of life. By the middle fifties, the span has lessened to 6 digits, roughly equivalent to the ten-year-old level.

3.2.3 Attention and Vulnerability

A further characteristic of STM is its vulnerability to distraction; the system is said to lose information rapidly in the absence of sustained attention. If the subject shifts attention to other material, recall is very liable to be impaired. Welford (1968) quotes the experiment of Brown (1958) where subjects were asked

'to view pairs of consonants on a paper strip which passed behind a small window at a rate of 1 pair per 0.8 sec.'

In one condition the last pair was followed by 5 pairs of digits, all at the same time intervals. The subjects read out the letters and digits as they appeared and immediately afterwards wrote down as many of the letters as they could remember. A control condition was similar except that instead of the digits there was a blank interval of the same length. The letter span in the control condition was between 5 and 6, whilst in the experimental condition it was between 2 and 3: 'presumably the digits had interfered in some way with the retention or retrieval of the letters.'

Table 3

Interference with STM by material presented during the period of retention. Data from Brown (1958) quoted by Welford (1968). The figures are the mean number of letters recalled, based on 9 trials by each of 10 subjects.

Number of letters presented	2	4	6	8
Experimental condition: letters presented, then 5 pairs of digits	1.95	2.72	2.45	2.01
Control conditions; letters presented then blank interval of 4.7 seconds	Not tried	3.98	5.61	5.3

Jacobs had noticed that if people had to write out rather than repeat the items by word of mouth, the span was shorter by about one item. Many other types of interference are quoted by Welford some showing substantial effects from even a simple item, especially upon sequences of 6 or 8 items, for instance when a subject is required to say '0' before recalling a string of digits (Conrad, 1960, quoted by Welford).

This active on-going mechanism of STM is not only vulnerable to disruption by such activities, but is shown to be so through its own internal processes. If the mechanism is analysed into reception (or acquisition) of the stimulus, retention and recall (or retrieval), it will be seen that whilst one procedure is taking place another may well interfere. For example, a subject may have difficulty 'holding' the later items of a 10-digit sequence whilst retrieving earlier ones. In general terms the 'span' is the outcome of competing activities within a person whose capacity for those activities is limited. However, the retention can be improved greatly by rehearsing the material between presentation and recall, although the reasons for the rehearsal effects are not entirely clear. If the neurological model of memory traces is accepted then rehearsal of the material may help to prevent the trace from decaying, 'but this cannot explain the increased resistance to interference from intervening activity.'

3.2.4 STM and Information Theory

Miller (1956) looked into the possibility of the store's limited capacity (see Section 3.2.1) being explained in terms of Information Theory. This type of theoretical orientation regards the human central nervous system as a kind of communication system, and the memory in particular appears to lend itself to this type of concept. Is the limited capacity of STM best measured in terms of the unit of information - bits - and the amount of information entailed? If the span for digits is about 7, then in Information Theory terms this would give a capacity of about 25 bits ($7 \times \log_2 10$). Although attractive this was found not to be so. Miller showed that the store should not be measured in bits but in the number of items stored, whatever those items might be, and because of the recoding process referred to later (Section 3.2.6) the apparent memory span could be increased. Miller called this process of coding, "chunking".

3.2.5 Expanding the Store's Capacity

There have been only one or two investigations into the possibility of extending the span of immediate memory and to some extent it has been shown that the span can indeed be improved by practice. Hunter (1964) reports that two American psychologists, P.R. Martin and S.W. Fernberger, tried to find out as long ago as 1929 whether digit span could be increased by means of daily practice. Sequences of digits of increasing length were read out at a rate slightly faster than one every second and the sequences repeated back. The day's score was the longest sequence correctly recalled. The procedure lasted for fifty days and the span was found to have lengthened by about 36%. The table below gives the average daily score made by the two involved.

Table 4

Days of Practice	Student K	Student R
1 - 5	9.0	10.4
6 - 10	8.8	11.4
11 - 15	9.4	11.0
16 - 20	9.6	11.6
21 - 25	10.4*	11.0
26 - 30	12.8	11.6
31 - 35	12.4	11.8
36 - 40	12.0	11.8
41 - 45	13.0	14.2
46 - 50	13.2	15.4
51 - 55	-	13.6

Table quoted by Hunter (1964). * Grouping starts about day 20.

It is interesting to note that when asked to comment on their recall procedures, the subjects said that the improvement came from their trying to break the digit sequence into groups. Student R became proficient from the start by grouping into fives, but Student K did not attempt grouping until the twentieth day. It will be noticed that at about this time his span increased. This grouping of material results in an increase of the span, not so much from an enlargement of the store itself, as from changed methods of organising the input for storage. It would seem that by grouping the digits, the subject manages to deal more effectively with the concurrent activities of reception, retention and retrieval.

3.2.6 Coding Processes and "Chunking"

This active organisation of the incoming material for economical storage can be viewed as a type of coding process. In the case of the students in Section 3.2.5 this was achieved by a grouping procedure, but recent workers have demonstrated a more sophisticated kind of coding. In a closely reasoned article entitled 'The Magical Number Seven plus or minus Two', George Miller (1956) reports the experiment of S.L. Smith who measured the spans of 20 subjects for binary and octal digits. The spans were nine for binaries and seven for octals. He next gave each recoding scheme to five of the subjects who studied it until they had mastered it. He then tested the span for binary digits while they tried to use the recoding schemes. In every case their spans for binary digits increased; the increase was not as large as expected, however, for the octal digits. The discrepancy increased as the recoding ratio increased. The translation from one code to another has to be almost automatic or the subject loses part of the next group whilst he is trying to recall the translation of the previous group. Ratios of 4:1 and 5:1 are very difficult, so Smith experimented with himself as subject, reporting his results to the Eastern Psychological Association in America in 1954. Having first established his own memory span (about 12) he memorized various methods of recoding binary digits into other forms of notation. After he had learned 'octal' numbering (001 - 1, etc.), his memory span rose to nearly 36. He was, in effect, translating every triad of zeros and ones into a single octal digit and then storing 12 of them.

Table 5

Ways of Recoding Sequences of Binary Digits

Binary Digits (Bits)		1 0 1 0 0 0 1 0 0 1 1 1 0 0 1 1 1 0
2 : 1	Chunks	10 10 00 10 01 11 00 11 10
	Recoding	2 2 0 2 1 3 0 3 2
3 : 1	Chunks	101 000 100 111 001 110
	Recoding	5 0 4 7 1 6
4 : 1	Chunks	1010 0010 0111 0011 10
	Recoding	10 2 7 3
5 : 1	Chunks	10100 01001 11001 110
	Recoding	20 9 25

Table quoted by Norman (1969)

Pollack and Johnson (1965) have obtained similar results also showing efficient coding procedures in memory span experiments.

Neisser (1966) remarks, however, that coding 'which partially protects information against the passage of time must also take a certain amount of time to carry out.' This being so, that is, if time for coding is substantial, recall might be impaired if presentation is rapid. Posner (1963) reviewed a number of experiments with this outcome quoting a study of Yntema et al. (1964) who programmed a computer to 'speak' at the very fast rate of 10 digits per second. When seven digits were presented at 10 per second only three or four were recalled correctly; at 2 per second, the number was nearly six. The conclusion drawn by Yntema et al. was

'..... during the presentation of a slow list the subject performs some sort of process that makes it easier for him to recall the list a moment later, but there is not enough time for him to perform this process when the list is presented rapidly.'

Slow presentation is not always better than fast, however, and contrary results have been achieved under various conditions by Conrad and Hille (1958), Posner (1964, and Mackworth (1965). These studies suggest that

'increased speed improves recall primarily when digit-strings are short and have much internal structure (pauses, rhythms, etc.) or when the order of report is fixed. These are just conditions which minimize the subjects' opportunities for recoding.' (Neisser, 1966)

3.2.7 The Measurement of STM Capacity

Having reviewed some of the characteristics of STM and appreciating further its kinship to language production, it is important to consider ways in which the capacity of the store may be quantified. The experimental procedure which focuses most directly on this capacity is the traditional span of immediate memory. Studies of this, as already intimated, are of long standing. Jacobs (1887) 'read out at a steady rate, sequences of digits of different lengths and arrived at his subjects span by noting the longest sequence he could grasp', that is, successfully recall after a single hearing. Jacobs determined the spans of hundreds of subjects of varying ages keeping his procedure standardised. The immediate memory span became defined as the number of discrete units that can be reproduced in correct serial order after a single exposure.

In 1925 Guilford and Dallenbach proposed that

'the limen of immediate memory or the memory span is defined as that length of series which has the probability 0.5 of being retained, in other words, that length of series which is as likely to be remembered as not.'

For the method - that of constant stimuli - they claimed these advantages:

i. That the measure, the memory span, is thereby equivocally defined and that the definition rests upon the accepted psychological principle of the limen (this term has largely been replaced by the term "threshold").

ii. Exact determination of the span is obtained more readily and more quickly; if groups are to be investigated, the memory span may be obtained by simple presentation of the experimental series; if studies of individuals are undertaken, 5 or 10 trials at every series length may suffice.

iii. All the reproductions, failures as well as successes, are taken into account. A success at a long series is not disregarded because of failures at shorter series.

iv. Complicated rules and weights are unnecessary.

v. Single representative values with their degrees of precision are obtained.

vi. Comparisons may be made between individuals or groups from two points of view: limenal values and the amounts of dispersion may be compared.

It is interesting to note in advantage ii above that Guilford and Dallenbach suggest '5 or 10 trials of every series length'. In Woodworth and Schlosberg (1954), the subjects have only one trial with any one list and that Guilford and Dallenbach's method is in the paragraph referring to 'additional refinements into scoring'.

However, despite the refinements, in order to understand more fully the extent of the capacity of the STM store, one would hope to find a method that would yield a more discriminating measurement especially with child subjects where the incremental growth is reputedly small.

In an article Crossman (1961) comments on the discrepancy between the results of the work of Pollack (1953) and Hayes who were experimenting with the notion of STM being regarded as an information store of limited capacity. Crossman suggests that the conflict between these two experiments which had yielded results at variance with one another on the question of whether or not the span varies with choice may perhaps be resolved by supposing that Pollack's subjects did not receive enough practice to make the restricted choice of items effective. He tried to overcome the problem by using familiar sets of different sizes (Column 2 in the table below).

Table 6

Choice information and memory span for verbal material for different size sets (data from Crossman, 1961)

Vocabulary	No. in Vocabulary S	Information per Item (bits)	Average Length of Span	Selective and Order Information (bits)
Black/white	2	1.00	9.1	27.9
£ s. d.	3	1.58	6.9	22.8
N.S.E.W.	4	2.00	6.8	25.4
Days	7	2.81	5.7	24.6
Digits	10	3.32	7.3	37.3
Months	12	3.58	5.4	27.1
Alphabet	26	4.71	6.8	43.7
States of U.S.A.	49	5.62	4.1	27.9
Playing cards	52	5.70	3.4	23.0
Dates of year	365	8.51	2.9	27.5

Crossman found that neither the 'chunks' nor the 'bits' hypothesis seem to fit the evidence, the spans of the smaller sets being shorter than would be expected. He suggested that the requirement that the items should be in the correct order, 'the origin of much error on lists longer than the span', might be investigated.

'How much information is there in the serial order of a list, irrespective of what the individual items are? With n items,' he suggests, 'there are n! possible permutations of the order, so that the answer appears to be $\log_2 n!$'.

He proposes that the capacity of the store be expressed by the equation: $n\log_2 S + \log_2 n = \text{constant}$, where n is the span and S is the number of choice alternatives. The final column of the table above shows this to be roughly true except for digits and letters (alphabet) whose results are very high. It is probable, as Welford (1968) points out, that this is due to the familiarity of the items. Dale and Gregory (1966) have shown that recall is more accurate for lists composed of familiar words (with high frequency of occurrence) rather than relatively unfamiliar (low frequency) words. It may be that the more familiar the items are the more easily they are coded in some way, and Crossman suggests that 'specific skills perhaps based on coding, are developed for these materials', and to test the hypothesis that increased capacity for digits and letters is due to practice, he used a word frequency count. This, the Thorndike-Lorge count, gave an indication of equivalent vocabulary size because the wide variation of words in common usage would invalidate the information measure. Spans were measured giving an average of 4.8 words or about 73 bits per list, three times the capacity measured for other vocabularies.

Crossman's formulation has been criticised because his formula does not take into account the discriminability of the items as shown so convincingly by Conrad (1964), who demonstrates that acoustically similar material is less well retained than an acoustically dissimilar set. The information analysis used does not take this into account. However, whilst this calls attention to an important factor it does not completely invalidate the Crossman formulation.

Another criticism, cited by Welford (1968), refers to the calculation of order-information in that it is assumed to have already been taken into account in the first part of the equation. This point is made also in the original article in a communication from J. Brown. Crossman proposes that order is not automatically preserved

> 'so that information has to be recorded not only about each item but also about the serial position in which it comes.'

The two experiments described in the Crossman paper strongly support the hypothesis that STM has a measureable, though varying, information capacity but that part of it is used to retain the serial order of a presented list.

3.2.8 Summary

In practice it is difficult to separate the two hypothetical mechanisms, referred to here as the short-term and long-term stores, which comprise memory processes as they seem to work closely together. As Welford (1968) remarks,

> 'Many of the very substantial number of studies which have been made of short-term memory, especially during the last ten years, suggest that long-term as well as short-term stores have been participating.'

He then makes this further interesting comment,

> 'At the same time short-term retention appears to play an important part in the process of learning for long-term retention.'

The characteristics of the short-term store then are of considerable pertinency to this study.

The store's limited capacity has been mentioned, the restriction being about seven, (plus or minus two) items in the adult, and less for the age group being investigated. From the digit spans quoted (3.2.2) we will expect an increase of only one item (from 4 to 5) between $4\frac{1}{2}$ and 7 years. A variation is to be expected also according to individual differences in the subjects' all-round cognitive ability and according to the type of material presented for recall. It is probable too that the spans of the subjects will vary markedly if attention is not maintained throughout experimentation.

Other experiments showing recoding processes designed to extend the limited nature of the store are also noted, together with Miller's concept of 'chunking'. These methods of increasing efficiency shown by experiment are of importance as providing clues to language production and the processing of information.

Finally, the quantifying of the store's capacity was discussed as base-lines for further measurement are required in the study. Therefore, bearing in mind the foregoing characteristics of the store, the problem of how best to measure the store's capacity is dealt with by Experiment 1.

4. EXPERIMENT 1. UNSTRUCTURED STRINGS

A comparison of methods of measuring the STM capacity of children.

4.1 Introduction

It has been shown that STM capacity has been defined by the well established techniques of calculation of the span of immediate memory (Woodworth and Schlosberg, 1954). These calculations are based on an empirical definition of the span based on data derived from the established psycho-physical procedure of constant stimuli (Guilford and Dallenbach, 1925). In addition, the experiments described by Crossman's paper strongly support that STM has a measurable (though varying) information capacity but that part of it is used to retain the serial order of a presented list. By using this formula it was felt that some evidence might be gleaned of the importance of serial order and entail a more discriminative measuring tool.

Recently, the application of Informational Calculus, as distinct from Information Theory itself, has been utilised (e.g., Staniland, 1966) and, as this makes greater use of the available data, it was anticipated that this too might provide a more sensitive measure of STM capacity. Further-more, the use of Information Calculus implies an appropriate information transmission model for the functioning of STM processes, which could be susceptible to further, different, experimental approaches.

It has been suggested (Garner, 1962) that the human being can be looked upon as a communication system, stimuli composing the input, responses the output. In this way the contingent uncertainty is obtained from a matrix in which the stimuli form one variable and the responses the other; in this case the transmitted information becomes a measure of the subject's ST storage capacity.

Garner warns however,

'that we must be able to know rather accurately just how many categories of choice or behaviour there are (as well as the probability of each category); the information concept becomes meaningless when we have an indefinite or unknown set of possible alternatives.' (page 28).

Crossman comments on this point, too, when considering subjective vocabulary size as he feels that

'to abandon objective vocabulary size as an independent variable would be to sacrifice a major advantage of using information theory in psychology, namely that of having a parameter that can link otherwise very different experimental situations where the subjects' expectations coincided as nearly as possible with the situation intended by the experimenter.'

However, he continues thus

'..... with items used unequally in common experience, like words, these conditions do not apply. Here one can estimate from either total vocabulary size or from relative frequency of use.'

Since the size of vocabulary of young children is restricted, it was decided to utilise the relative frequency of usage of certain words from a particular word count to generate the experimental material, thus permitting a valid application of Informational Calculus techniques.

4.2 Word Counts: Burroughs's Lists

It is obviously important for the overall aims of this study to use words rather than digits to discover the capacity of the individual subject's short-term storage as, in the later work into language acquisition, comparisons involving the influence of structure on words will be sought. In addition, as has been shown, the capacity is known to vary with the type of material presented to the subject, the capacity being greatest for words in ordinary use. Dale and Gregory (1966) have shown that recall is more accurate for lists composed of familiar (high frequency) rather than relatively unfamiliar (low frequency) words. Howes (1957) also demonstrated that there was a relationship between intelligibility and frequency of occurrence of English words. In his summary he states,

'The threshold of intelligibility for a word in a wide-spectrum noise is shown to be a decreasing function of the frequency with which the word occurs in general linguistic usage (word frequency). The drop in threshold is about 4.5 db. per logarithmic unit of word frequency.'

This rate is independent of the length of the word, although the threshold for words of given frequency of occurrence is lower for long words.

It was deemed important that the vocabulary to be used should reflect the background culture of the children - Osser's work (1966) (5.3.1) with Negro children has demonstrated this - and to fulfil the requirements of relative frequency just mentioned, needed to be scientifically collected and analysed. Most studies employing word frequencies have relied on American word count studies (e.g., Thorndike and Lorge, 1944) but there appear to be no relevant studies from the United Kingdom. Nevertheless, one such study of potential value is the one undertaken by Burroughs (1957) on the vocabulary of young children in the Midlands, aged from 5 to 6½ years. The design of the Burroughs' collection ensured that not more than four children were selected from any single school and pairs of pupils within each school were randomly selected to ensure that the group was representative of the child population in the Midland counties.

These lists seem to fit the requirements but the frequencies given in this study, however, are not word frequencies as such, but what Burroughs terms 'child frequencies'.

'The recording method adopted ..... was to compile lists which would eventually yield a "child frequency" table.'

Burroughs argues that

'..... an individual child may make constant repetition of a newly-acquired word and that the frequency thus built up may give no indication of the word's generality.'

However, the 'child frequency' has some obvious relationships with the word frequency count in an individual's experience and the child frequency could be used to build up lists which approximate statistically to the limited range of the vocabulary of the children under study.

The total number of words in Burroughs's study after listing was 90,040, the number of different words 3,504. This gave an average word list of 273 words per child, the shortest list being 56 words and the longest 578 words. The words are listed in various ways showing:

i. Birmingham word count showing whether in 1st, 2nd, 3rd, or 4th 500 words.

ii. Percentage frequency of occurrence among the children studied in the Birmingham count.

iii. Percentage frequency of occurrence among children studied in the Scottish experiment (a comparison).

iv. Comparison with the Thorndike lists.

v. Comparison with Doch's lists.

vi. Comparison with Rinsland lists.

vii. Comparison with Gates' lists.

The frequency count from item ii above yields stimulus material of calculable uncertainty using the normal univariate uncertainty formulation, based on the existence of a finite probability distribution.

An experiment was set up to explore and to compare the measurement of STM capacity in three ways:

i. by the traditional method (Woodworth and Schlosberg, 1954),

ii. by using the Crossman formulation (Crossman, 1961),

iii. by Informational Calculus (Garner, 1962).

4.3 Method

4.3.1 Materials

From the lists in Burroughs, List D (p.22) of Food and Drink was chosen as being appropriate to both the task and the subjects involved. The list contains 56 words, 18 of which appear in the first 500 most commonly used words with frequencies ranging from 21% to 72.5%. The word strings presented for recall were arranged so that this range of percentage frequencies was reflected in the total task. It was necessary to increase the number of stimulus presentations over that used in traditional STM experiments, in order to achieve adequate cell values in the information matrix. (Minimum 7, maximum 22 were achieved in these experiments.) This resulted in the use of 270 words which were divided into six sections, each section containing strings of identical word length. Thus each section contained ten word strings, with the first section being ten two-word strings, the second ten three-word strings and so on up to the sixth section which contained ten seven-word strings. The allocation of particular words to the strings was in random order but it must be remembered that the relative frequency of occurrence of individual words in the test material reflected the everyday frequency of occurrence of the words in children's speech, as derived from the child frequencies (see Appendix for specimen sheet of the experimental materials).

4.3.2 Subjects

The subjects were drawn from three classes of a school in the County Borough of Warley. There were 105 children with ages ranging from 4½ to 7½ years in three groups:

Age	Number in group
4½ - 5½ years	40
5½ - 6½ years	36
6½ - 7½ years	29
Total	105

No child had defective hearing, all having received their first medical examination at school, and although intelligence levels were not measured it was the opinion of the staff that they fell within the normal range of ability.

The area from which the children were drawn is a recently redeveloped one of 'high-rise' flats and is largely inhabited by non-skilled and semi-skilled workers.

4.3.3 Experimental Conditions and Procedure

The experimenter was well-known to the children who responded well. The tasks were administered in a quiet room set aside for the purpose. The word strings were given to the children individually in two parts on succeeding days to avoid fatigue and prevent stress. The strings were given in random order so that the longest and the shortest string did not occur in the same position on each occasion. The words were presented aurally at a speed of about one per second, the voice of the experimenter being kept as near a monotone as possible throughout. A preliminary short version of the memory tasks were given about a month prior to the investigation proper so that the children were well aware of the type of response expected of them. The experiment took about two weeks to complete except for one or two subjects who fell ill and were taken later.

4.3.4 Calculations

The responses were recorded on a sheet in such a way that a note of the errors, especially order errors, could be noted thus:

Figure 2

Section of Record Sheet for STM Tasks

string no.						Total
4.5	apple	tea	chocolate	apple	fish	
	2	1				
4.6	fish	salt	pie	apple	jam	
	1	2	3	4	5	

For the string of stimuli (4.5) apple, tea, chocolate, apple, fish, the responses were tea, apple, in that order. In string (4.6) the response is the same as the stimulus.

i. The traditional method of calculation

This method as described in Woodworth and Schlosberg (1954), was followed exactly. Each section gave ten replications of the particular word string length from two to seven words. Thus the maximum possible score is seven for perfect recall of all strings up to seven in length. Where errors occur in particular string lengths the mean value for the ten strings of that length was used in the calculations.

ii. Crossman's method of calculation

a. The formula given for the calculation of selective information is: $n\log_2 S$. This has been interpreted as $\log_2$ of the number of choices of words available, i.e., 18. 'n' is the memory span calculated by method i. above.

b. Order information is given by $\log_2 n!$ Again the memory span is calculated by the first method and substituted in the formula.

c. The total selective information is given by summing the results of a and b above:

$H_t(S) = H_s(S) + H_o(S)$ bits.

The result of each subject's performance was calculated using this formulation.

iii. Informational calculus

A matrix was set up for each subject, one axis representing the stimulus (x), the other the response (y) (Garner, 1962). The results of an individual subject's performance were plotted on the matrix and the frequencies summed at the margins. For this calculation it was necessary to insert a 'no response' category at the foot of the x variable to fit the empirical findings. The matrix thus became a 18 x 19 matrix, an example of which is shown below in Figure (3). Intrusions, of which there were few, were not entered. No attempt was made here to apply a correction for small samples.

Figure 3

A typical information transmission matrix for a single subject. The matrix is obtained from all responses of an individual subject

	Tart	Jelly	Porridge	Chocolate	Pie	Salt	Pear	Potato	Banana	Bread	Cabbage	Tea	Jam	Milk	Apple	Cake	Fish	Egg	$\Sigma(y)$
Tart	4						1							2				1	8
Jelly	1	4								2									7
Porridge		1	4							1							1		7
Chocolate				4								1						1	6
Pie					6	1									1				8
Salt						3	1							1				1	6
Pear	1						4				2								7
Potato								3					1			2		1	7
Banana					1				5		1		1						8
Bread									1	6				1		1			9
Cabbage											9	1						1	11
Tea			1	1					1			8			1		1	1	14
Jam			1			2		1	1				8		1		1		15
Milk					1		2						1	9	2		1	1	17
Apple				1	1						1		2	3	13		1		22
Cake															1	12			13
Fish					1						1		1		2	2	12	1	20
Egg							1	1		1			2	1	1		1	15	23
no response	5	3	2	2	1	4	2	2	4	4	2	5	5	5	3	4	5	4	62
$\Sigma(x)$	11	8	8	8	11	10	11	7	12	14	16	15	21	22	25	21	23	27	270

After this procedure the uncertainties, U(x) and U(y), were computed and a joint uncertainty U(x,y) calculated for each subject's performance. The contingent uncertainty U(x:y) is the difference between the maximum joint uncertainty (given by U(x) + U(y) and the actual joint uncertainty, U(x,y). Thus $U(x{:}y) = U(x) + U(y) - U(x,y)$. This value of the contingent uncertainty was taken as a measure of STM capacity.

4.3.5 Measurement of Reading Progress

Alongside the comparison of Chronological Age (CA) and STM capacity, it was decided to include a measure of the reading progress attained by the subjects as a rough indication of educational attainment related to the main area of the study but not directly with STM. This was done by simply ranking the amount of progress made by the individual in the school's reading scheme, which was based on the 'Janet and John' series of reading primers. It should be emphasised that this was a rough measure intended to give an approximation of the educational attainment of the subjects since they began schooling.

4.4 Results

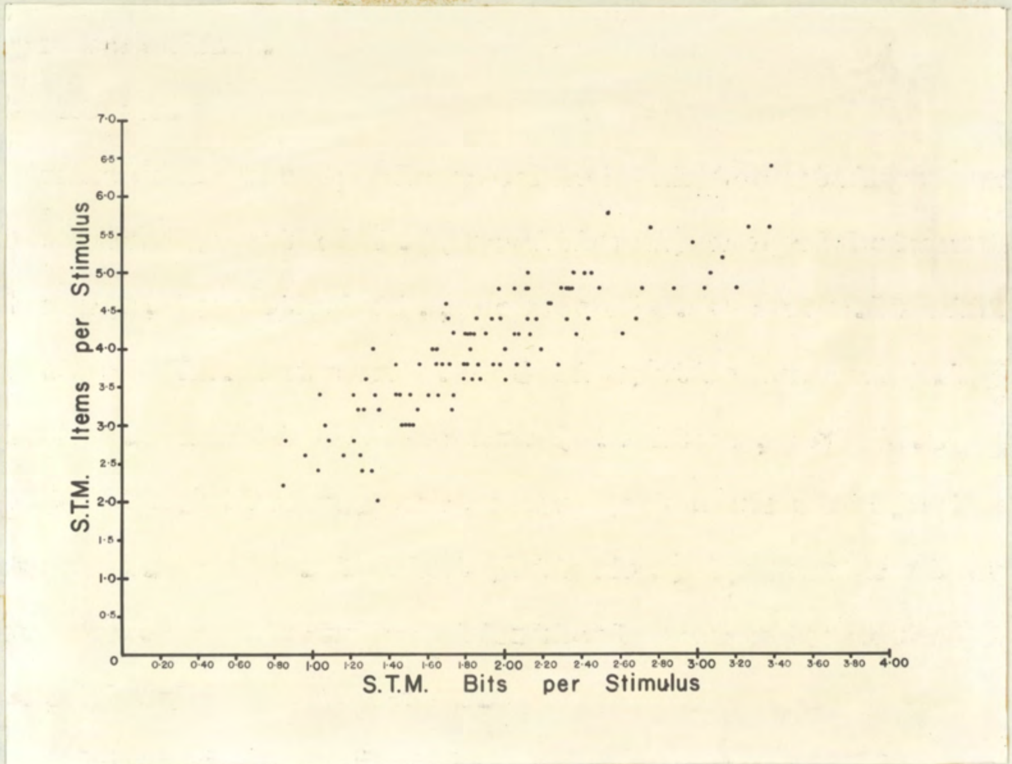
No subject in the sample recalled all the strings perfectly. The scores by method i. (traditional) ranged between 2.0 and 6.4 words, by method ii., between 36.60 and 9.34 bits, and by method iii. between 0.8486 bits/stimulus and 3.4036 bits/stimulus. The highest scores (6.4 items, and 36.60 and 3.4036 bits/stimulus) were made by the same subject but the lowest (2.0 and 0.8486 bits/stimulus) by different subjects. A number of subjects had identical scores by method i. scoring:

e.g., 13 subjects scored 4.8
13 " " 3.8
12 " " 4.2, and so on,

but by methods ii. and iii. there were no ties. However, very significant correlations were found between the various measures. Figure (4) is a scattergram showing the relationship between method i. and method iii. ($r = 0.948$, $p < 0.001$).

Figure 4

Scattergram showing the relationship between STM measures calculated by traditional techniques (method i) and informational calculus (method iii).



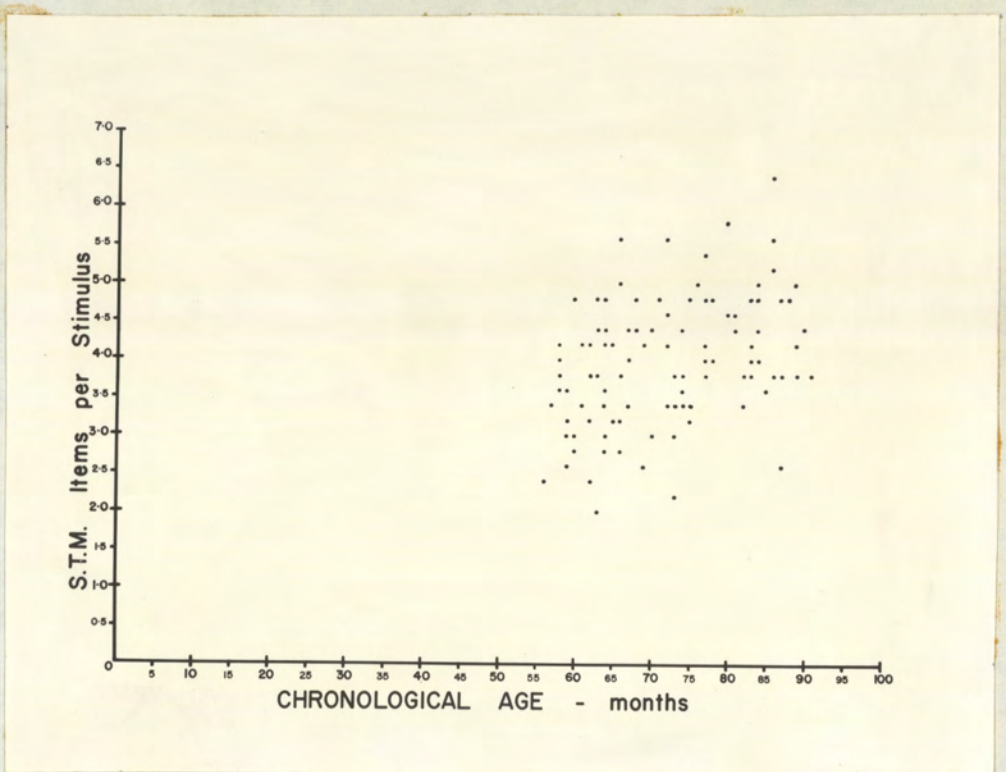
The relationship between the age variable and STM did not prove significant, as illustrated in Figure (5). (r = -0.008 (methodi), r = 0.077 (method iii).

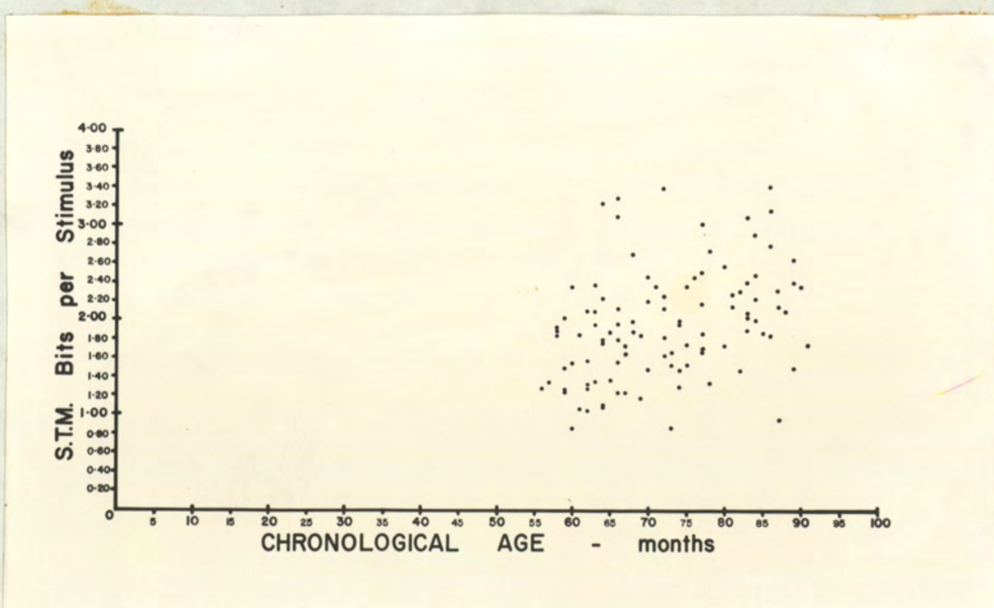
Figure 5

Correlation between age and STM as derived from the two different methods of determining STM

(a) traditional techniques

(b) information calculus





A significant correlation was found between STM and reading attainment but not between CA and reading attainment. The results of the correlations are given in the matrix below, Table (7), by way of summary.

Table 7

Correlation matrix for CA, STM (three methods of calculation) and Reading Age

Methods of Calculation

CA	i	iia	iib	iic	iii	Reading
1.000	-0.008	-0.018	0.001	-0.007	0.077	-0.065
	1.000	0.988*	0.975*	0.998*	0.948*	0.380*
		1.000	0.958*	0.993*	0.945*	0.382*
			1.000	0.971*	0.911*	0.360*
				1.000	0.950*	0.384*
					1.000	0.370*
						1.000

* indicates significant results

4.5 Discussion of Results

If the results of the measuring techniques are considered first, the almost perfect correlations between methods i. and iia, iib, and iic are understandable for the calculation of method ii depends, in part, on the memory span as calculated in method i ('n' in the formula). The correlation between method iii and the other methods is, however, interesting as this appears to indicate that the traditional method of calculation is as reliable as the more complex mathematical methods employed. Nevertheless if it is required to utilise mathematical methods to discover further relationships of a multivariate nature, it is useful to know that method iii calculates STM capacity effectively; it is shown to be no less sensitive than traditional techniques. Looking next at the absence of correlation between age and STM capacity, it is surprising that this well-known relationship (Section 3.2.2) did not occur in this sample. If comparison is made with Table (2) quoted from Woodworth and Schlosberg (1954), it will be noticed that between $4\frac{1}{2}$ and 7 years only one digit is added to the memory span. Although there is difficulty in comparing a digit span with one of words it was hoped that the Informational Calculus techniques would detect this increment as they make more use of the data available.

An important variable not measured in this study was the intelligence of the subjects involved. It was considered at the time of the design of the experiment that this would be difficult and perhaps not worthwhile as the results of intelligence tests are often unreliable at this age and often contain, as indicated earlier, a STM sub-test as part of the test itself. It was felt that this might well confound the results when relationships involving STM are being sought. That the span varies with intellectual ability (3.2.2) is a well documented factor (Hunter, 1964) so a few enquiries were made about the sample. It was suggested by the school 'end-of-the-year' assessments that the overall ability of the three groups concerned may be higher the younger the age group, i.e., intelligence in this sample happens to be inversely proportional to age. It could be then that the effect of difference in ability within the sample nullified the incremental effects expected from the age variable. However, this proposal is tentative, as there may well be other explanations.

The significant correlation between STM and reading attainment ($r = 0.380$, $p < 0.001$) is another interesting feature of this experiment. It must be recalled that the measurement of reading progress was only roughly performed, but the results require further investigation for it would appear that reading progress has a closer relationship to the psychological mechanism of STM than to the maturational process shown by CA. If, as has been indicated already, STM may be an important factor from composite general intellectual ability that enables the child to make progress with the development of intricate language skills, however, it is necessary to seek further clarification of the details within these relationships.

Two further points, perhaps of a minor nature, need comment. Firstly, the words selected from Burroughs's vocabulary, listed as child frequencies, are usable in the context of the experiment when the subjects are young children and provide a source of experimental material for the next stage of the work. The shorter test given as a preliminary was found to have a significant correlation with the main set of STM tasks ($r = 0.9$, $p < 0.001$). Secondly, as Atkinson et al. (1964) reported, the results of these experiments confirm that orderly data can be collected from young subjects and that STM processes are consistent.

4.6 Summary

A short-term memory (STM) experiment was devised with a 'child frequency' word count being used to define the statistical properties of the stimulus material. This statistical definition of the stimulus material enabled informational calculus methods using contingent uncertainty to be applied to the measurement of STM, as well as the more traditional methods of measuring STM. In addition, Crossman's formulation was used for further comparison of the calculation techniques. The practicability of using the 'child frequency' word count was established and the experimental results yielded a high correlation between traditional methods, the informational calculus method, and Crossman's formulation ($p < 0.001$).

The feasibility of using children as subjects in this type of experiment was established and the consistency of STM within the age group (4½ - 7½ years) of the experimental sample was demonstrated. An educational measurement, that of reading progress, was also found to be associated with STM capacity.

5. STRUCTURE

Experiment 1 has revealed something of the ability of the child subjects to handle unstructured material; the next step is to investigate the processing of structured material. In some ways, as shown by the review of memory processes (3.0), much can be learned about the recall of unstructured material from the literature, but the next stage concerning structure is not so well documented. This is especially noticeable when methods of describing and thence quantifying structure are entailed. In this respect, it is hoped that the new descriptions and theories of the generative linguists will assist the work, so a further discussion of their proposals follows.

5.1 Generative Linguistics

It is important to look further into the position taken by the linguists if the basis for much of the recent work in this area is to be understood, and one cannot proceed very far in this without meeting the name of Chomsky. A comprehensive linguistic theory has been formulated by Chomsky (1957, 1965) and his colleagues (Katz and Postal, 1964), who raise no objections, as do the behaviourists, to the concept of specific innate ideas. Chomsky and his colleagues are rationalists, not empiricists, and they gain their linguistic descriptions from their own intuitive analysis of the language. Here their approach differs from the empirical in that they do not derive inferences from observing behaviour. The now well known, meaningless but grammatically correct, sentence 'Colourless green ideas sleep furiously' is an example of production by intuitive judgment. This "sentence" they have concocted themselves: it has not been observed within the speech community. They formulate rules which describe the grammar and distinguish them from semantic rules. These rules are said to be internalised into the speaker as his competence. The grammar proposed by Chomsky in Syntactic Structures (1957) and as amended in Aspects of a Theory of Syntax (1965) is not only a theory for 'a range of phenomena', the sentences of a language, but also a programme for generating sentences. It is the development in children of this kind of sentence generating skills that is to be explored.

The child is said, by the linguist, to be exposed to the utterances of those around him - his family, his friends, the radio and television - and from these he 'induces from the regularities in the sample an implicit grammar'. Each child is said to re-discover language. Long before he is taught grammar at school, the child operates with syntax, and it will be noticed in modern techniques of second-language learning that the system relies, after presentation of the same sentences again and again by film and tape recorder, on this important step into automatic construction of novel sentences. The learner develops competence then in second-language learning as he has earlier in his own native language. It is thought by some, particularly Chomsky (1957) who emphasises the point, that this competence precedes and makes possible performance of language. Here there seems to be an unresolvable difficulty, the separation of competence and performance, for we need performance to study competence. This underlying competence for Chomsky carries certain other far-reaching implications for language acquisition. For him the process cannot be explained in terms of learning since the behaviour necessary for acquisition is supposed to be dependent upon its previous existence. The conclusion reached, therefore, is that competence is based on innate features, and a Language Acquisition Device (LAD) (Chomsky, 1965) is proposed. D. McNeill (1966), in an article entitled 'The Creation of Lanuage', carries Chomskian thinking to its logical conclusion, arriving at the following position as paraphrased by Fraser (1966):

'It is now proposed that, first, children are born with a biologically based, innate capacity for language acquisition; secondly, the best guess as to the nature of the innate capacity is that it takes the form of linguistic universals; thirdly, the best guess as to the nature of linguistic universals is that they consist of what are currently the basic notions in a Chomskian transformational grammar.'

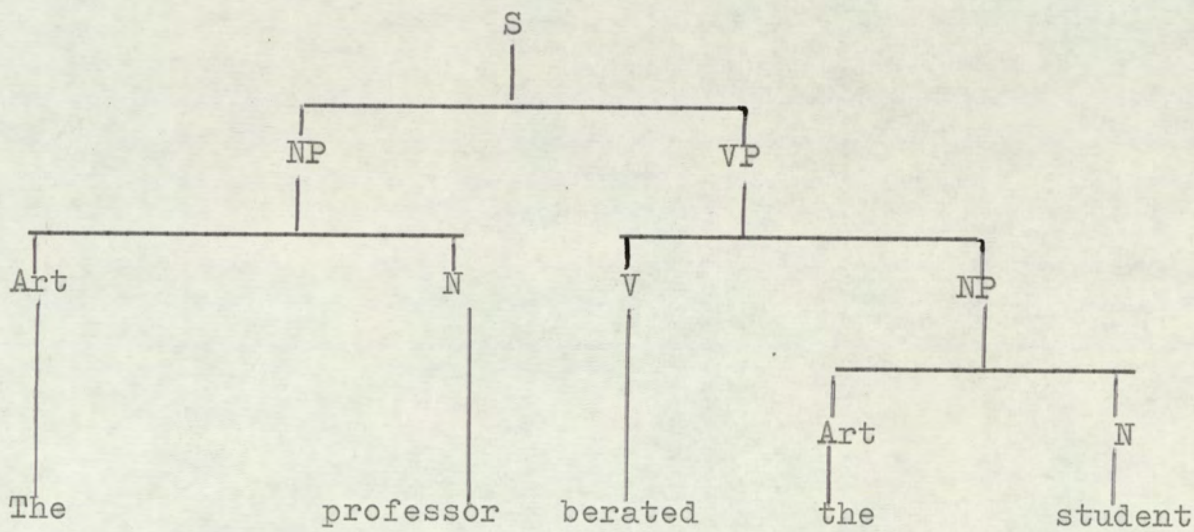
McNeill (1966) points out that the child acquires in slightly more than two years the full knowledge of the grammatical system of their native tongue and that

'The process behind this stunning intellectual achievement is essentially one of invention.'

A second feature of the Chomskian account of language acquisition concerns the differentiation of deep and surface structure and the transformations that convert one to the other. A sentence contains words in a particular order, it has what we call structure, that is, the words fall together in a certain way. Furthermore this structure appears to be hierarchical in type. A sentence often quoted as an example to illustrate this is 'The professor berated the student'. Here the sentence is made up of two major constituents, the professor and berated the student; this latter is itself made up of two constituents, berated, and the student. Here it will be seen that the pattern is one in which some constituents contain others; one can progress from higher-order constituents to lower-order ones. This can be expressed by means of a tree diagram. A simplified version for the above example looks something like this:

Figure 6

Phrase-structure tree diagram

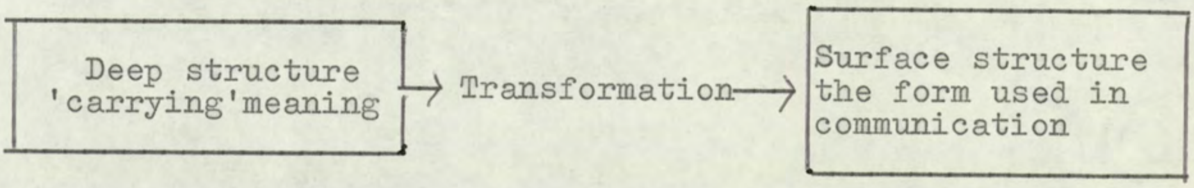


This linguistic notation gives the pattern of the hierarchy and has, for some, psychological as well as linguistic significance. However, this particular sentence does not show up the deep surface structure which Chomsky deems so important to his descriptive linguistic theory. Examples often quoted for this purpose are: 'John is easy to please', contrasted with 'John is eager to please'. The constructions of the two are similar at least on the surface, but they differ fundamentally in meaning. In the first sentence John is the object, in the second, the subject, of the sentence. The distinction is understood by the native speaker of the language and yet the difference is not represented in the surface structure. The difference is said to lie in the deep structure which carries abstract linguistic features. Even the simplest sentence has an underlying abstract structure. As McNeill (1966) remarks, however, 'The problem for a theory of language acquisition is to explain the development of such abstractions.'

So far, the competence/performance differentiation, the deep/surface structure distinction have been mentioned, and now the third important area of the theory of generative grammar, that of transformations, requires discussion. A transformational rule of grammar relates deep to surface structures. Without these transformations all linguistic knowledge would have to be manifest in the surface structure, and a sentence like 'John is easy to please' would not be possible. If the general theory sketched above is accepted for the moment, then it is important for a theory of language acquisition to include the acquisition of deep structure and the associated transformations. If the earliest utterances of children show evidence of this deep structure the rest of the Chomskian account becomes plausible for it supposes that transformational processes act upon deep structure to produce surface structures in adult sentence production. This part of the process has been described diagrammatically as:

Figure 7

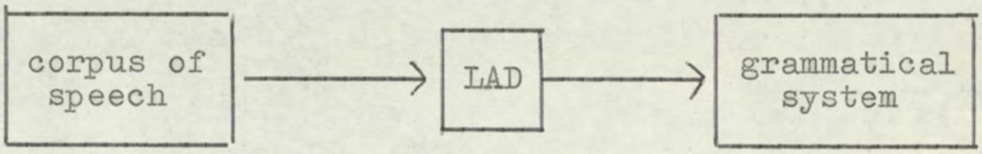
Diagram showing the Deep-surface structure relationship via transformations



The three main features of generative transformational grammar as proposed by Chomsky (1965) are intimately related to language acquisition through an innate mechanism, the 'Language Acquisition Device' (LAD) which is said to receive a corpus of speech and 'creates a grammatical system'. The corpus contains sets of utterances, some grammatical, some not, the type of utterance usually heard by the young child. McNeill gives the following diagram:

Figure 8

The (diagramatic) relationship of LAD to speech and grammatical systems (after McNeill, 1966)



The input to the 'black box' (LAD) is a corpus of speech and its output a grammatical system. LAD's internal structure must be able to deal with any natural language, its contents must be universally applicable. 'The theory of LAD will be (in part) a theory of linguistic universals.' That this must be so is evidenced by the fact that a baby born of English parents can acquire, as successfully as the native, Bantu, or Russian or Chinese, if exposed to the language of those people. It is further suggested that the abstract grammatical relations of subject-predicate and verb-object, examples of linguistic universals, are features which must be imposed on, and evidenced in, the earliest speech of the child.

5.2 The Acquisition of Deep Structure

There is not, as yet, overwhelming evidence to support the hypothesis that the child's early speech shows these abstract characteristics. McNeill (1966) quotes the work of Roger Brown and some of his own work with a small Japanese girl. From these studies Brown and Fraser (1963) and together with Bellugi (1964) concluded that the two-year-old child they were observing possessed three grammatical classes, two resembling adult English. (In parenthesis it might be observed here that some workers in this field repeatedly point out that the child's grammar must not be taken a priori as an adult grammar in embryo, rather they regard children's grammar as specific to the child.) The three classes detected were nouns (boot, tractor, truck, mommy, Adam, tower, gas), verbs (hear, see, make), and a third class of 'modifiers', (two, a, in the 'sentences' below as well as adjectives this, that, other and 'nother). This latter class contained several adult classes and the other classes, nouns and verbs, were not entirely distinctive. Some of the 'sentences' aptly called 'telegraphic' by Brown and Fraser were:

Two boot

Hear tractor

See truck, mommy

Adam make tower

A gas

It was found that in eight hours of recorded speech, involving some 400 sentences, 'there were examples of every admissable combination but no examples of inadmissable ones'. This could be interpreted as evidence that basic grammatical relations were being observed from the first. The authors go further, not only is there evidence of rule-governed utterances, but at this early stage sentences involving transformations were missing. This restriction of the variety of sentence-types is put forward as evidence that children include abstract relations in their earliest speech. Some further work by Slobin (1966) supporting the appearance of abstract grammatical relations in the early speech of children exposed to Russian may be quoted as well as McNeill's (1966) own observations of a Japanese girl. Although the conditions surrounding these children, American, Japanese and Russian, were so different yet they were found to do similar things - 'They do so because of their shared inborn capacity for language' - is the conclusion. Ruth Weir (1962), a trained linguist, discovered that her son, Anthony, appeared to experiment with language when he was alone in his crib. A microphone had been placed close to him and on eighteen evenings when the child was between twenty-eight and thirty months old, she made recordings of his 'monologues'. Weir classifies the sequences in his corpus as 'buildups', 'breakdowns' and 'completions'. They appear to be exercises to discover syntactic unity and exploration of hierarchies.

An example of a 'buildup' is given as:

Block,
Yellow block,
Look at all the yellow block (Weir, 1962, p. 82)

and breakdowns:

Another big bottle
Big bottle
Anthony jump out again
Anthony jump (ibid., p. 82)

Buildup and breakdown concatenated:

All gone
It's all gone
It's not all gone
It's not all (ibid., p. 82)

The completion episodes involve the sequential production of units that would later form adult-type sentences.

Look at those pineapple
In a pretty box

and,

Anthony take the
Take the book (ibid., p. 82)

The following is reported as being very suggestive:

What colour
What colour blanket
What colour pillow
What colour are this room
What colour map
What colour glass
What colour TV. (ibid., p. 82)

Miller in the Foreward to this study writes that he was

'completely unprepared to encounter a two-year-old boy who - all alone - corrected his own pronunciations, drilled himself on consonant clusters, and practised substituting his small vocabulary into sentence frames ..... The gap between the child's reported behaviour and all I had been led to expect from the books of Pavlov, Watson, Thorndike, Hull, and other association theorists was more than I knew how to cope with. If you read Dr. Weir's report with an eye for how you might build an explanation in terms of rewarding or punishing stimulus - response connections, you may get some feelings for the difficulties that young Anthony poses for the psychological theory on human learning.'

This passage is quoted by Griffin (1968) in his chapter on children's development of syntactic control demonstrating for him the child's insightful 'awareness of syntactic options and obligations'.

Through studies of the child's own utterances like those quoted above, the distribution of different items were analysed and certain types of words found to have certain privileges of occurrence: they could only occur in certain positions in the utterance, and not in others. It is fairly clear that we do get patterning in speech of this type from about eighteen months; the child begins to produce pairs with a pattern, dropping those words that are, presumably, not approved. Braine (1963) found that a considerable proportion of sequencing fell into rudimentary patterns:

i. Pivot + Open (P + O), and ii. Open + Open (O + O) patterns.

Figure 8

Braine's suggested rudimentary patterns

i. P	+ O	ii. O	+ O
*there	dog	proper noun	ordinary noun
my	table		
a	chair		
this	dog		
this	blue		

*These are called modifiers (different workers use different terms); not many are found in the second position.

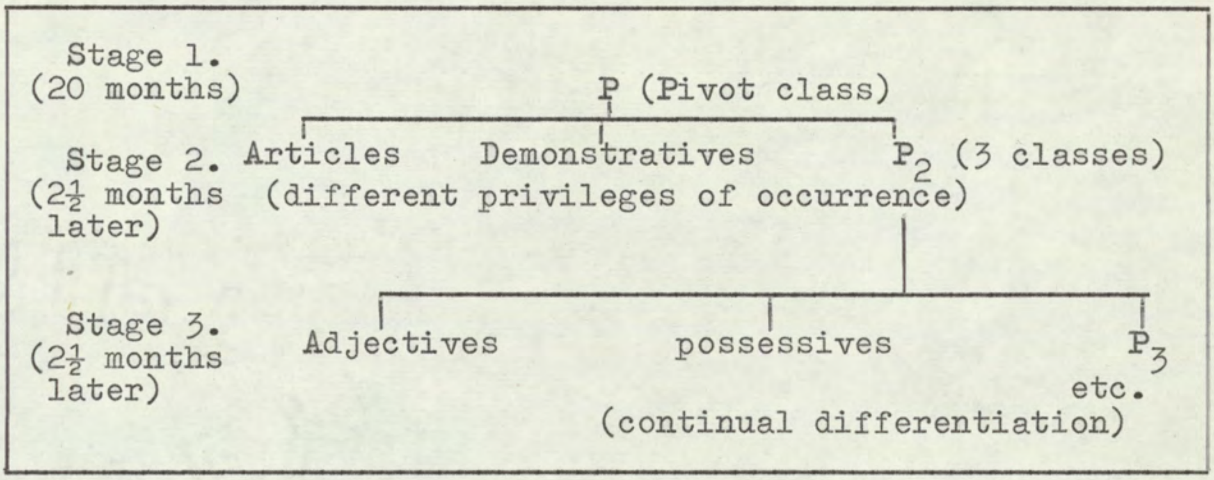
In the first type, the pivot word (P) always occurs in one of the two positions, whereas open (O) class words are not so restricted. These pivot words are further divided into sub-classes depending on their function (see Figure (9) below). In other words, pivot words are said to be in the same sub-class if they have the same privilege of occurrence. Pivot words are less in number than open class words and consequently used more frequently than individual open class words. Herriot (1970) points out that

'this statistical imbalance is a very important feature of two-word sentences. (For) If the pivot words were function words, it would parallel the greater frequency of function words in adult usage.'

However, pivot words are not usually function words, and therefore, it must be inferred that the child has imposed his own structure. Braine's (1963) behaviouristic account suggests that children hear sentences and classify them by the relative positions the words occupy by 'contextual generalisations'.

Figure 9

The beginnings of structure



He further suggests that two-word sentences grow into three-word sentences (see Figure (9)) because the child learns this relative word position and thence by increasing complexity learning which word comes first in a phrase and then which phrase comes first in a sentence. Hence the child learns that sentences are hierarchically organised. McNeill (1968) finds contextual generalisation doubly limited for

'It denies the possibility of transformations on the one hand, and it reduces the power of phrase-structural grammar to the level of a finite-state grammar on the other.'

He prefers what he calls the nativist account of language acquisition (2.1). The advantage of this is that it takes into account the abstract structure of language which applies where an S-R theory does not. He concludes, however, that

'At best, it states (i.e. the nativist account) what in language is acquired and so offers a reasonably clear formulation of the problem of language learning ..... however, it omits many details and ignores certain large issues, the mechanism of acquisition perhaps being the most conspicuous among the latter.'

McNeill maintains that all the child's utterances are rule governed and based on innate linguistic universals. The difference between the two approaches - the nativist (or generative linguistic) and the behaviourist (or learning theorists) - has been reviewed in detail by Herriot (1970), who although he rejects most psycholinguistic interpretations of language acquisition and behaviour, nonetheless, recognises the psychological reality of deep structure whatever its method of acquisition. He states (p. 165),

'However, perhaps the major discovery of psycholinguists has been the psychological reality of deep structure. Any theory which claims to describe language behaviour adequately must account for it.'

This being so, then how is the semantic component within deep structure realised at the surface? How is meaning expressed (translated) by the phonological component? The psycholinguist would answer that this is the role of the transformation.

5.3 The Acquisition of Transformations

The linguists show that transformations appear in all languages, but the particular transformations of each language are peculiar to that language. How a particular grammar is acquired then, if this hypothesis is followed, rests heavily on the acquisition by the child of a transformational system. It is suggested by some, McNeill (1966) particularly, that this is by a process of hypothesis, similar to scientific inference, by the child, who is said to propose certain hypotheses based on the regularities of the adult speech surrounding him and then to try out these by experiment. This is interesting as something like this can be observed in parent-child dialogue. The parent will repeat the child's utterance, enlarging it to a more acceptable form, 'Doggie bite' being returned to the child as 'yes, he is biting'. Brown (1964) calls this process expansion, and reports that approximately 30% of what children say is expanded by parents. It is important to note that one profound dimension of English grammar is preserved in the child's telegraphic type of speech, that is word order thus enabling the adult to discern the sentence form from the child's reduction.

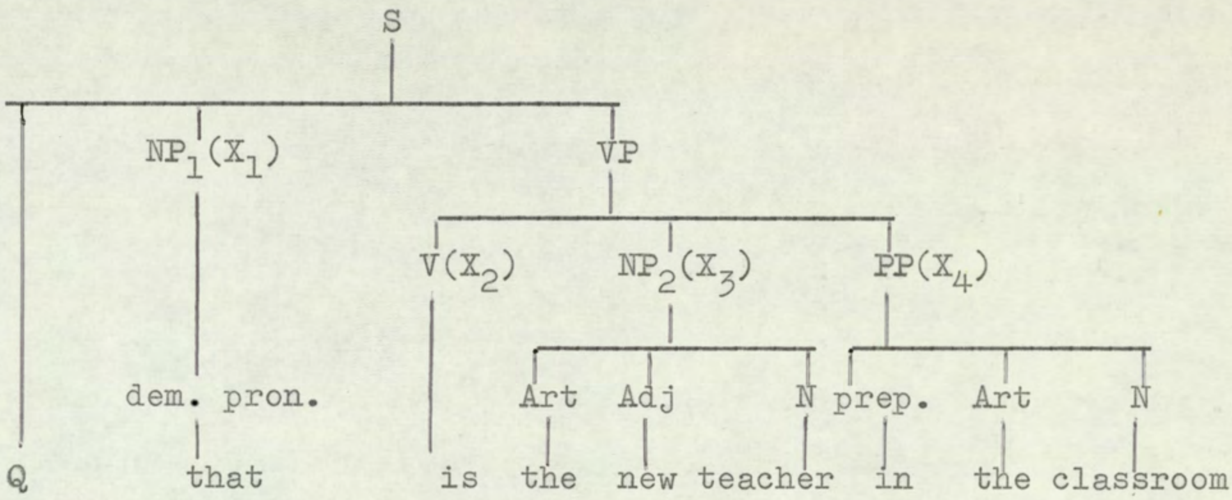
'If children's earliest syntactic competence comprises the deep structure of sentences, then obviously the major portion of syntactic acquisition after this point will be taken up with the growth of transformations.'

This quotation from McNeill (1966) is very important if language acquisition is thought to follow the generative transformational grammar model. It is thought that at the stage when transformations are about to be learned, sentences derived from deep structure should be in evidence with the element of transformation prefixed to the sentence. Bellugi has concentrated on this aspect of the acquisition of transformations and a report of her findings on the negative and interrogative transformations can be found in Klima and

Bellugi (1966). The structure of such transformations is seen to function according to Chomskian rules. A simplified version is shown in the following diagram. The analysis is of one of the Question transformations taken from the experimental material used later in the study (see Appendix).

Figure 10

Structural Change by Transformation

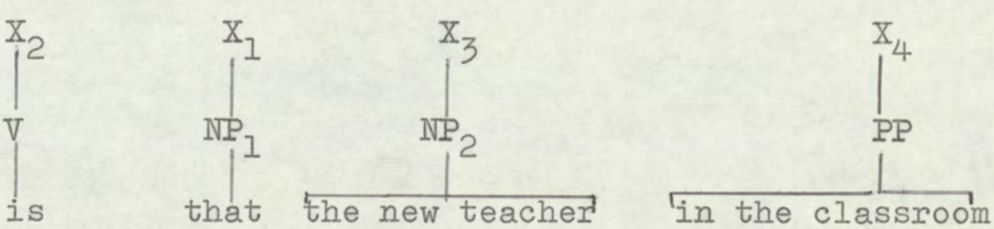


The structural analysis (Chomsky, 1957)

$X_1 - X_2 - X_3 - X_4$ (- stands for concatenation)

The structural change

$X_1 - X_2 - X_3 - X_4 \longrightarrow X_2 - X_1 - X_3 - X_4$ ($\longrightarrow$ rewrite as)



Here the deep structure is changed by the 'Q' transformation to the surface structure form. In this example the notion of the transformational prefix is seen quite clearly signalling the change. Other transformations are analysed and will be found in the Appendix. It has been shown by Bellugi (in Klima and Bellugi, 1966) that the negative and interrogative word is placed, in the early stages, in front of the sentence or implied by intonation. Examples given are: 'no singing song', 'no play that', 'no fall', 'who that?', 'where kitty?', 'ball go?'. It will be noted in these examples of early utterances that the word order is preserved, and that the transformational element is at the beginning of the sentence, and that, with the negative, not only is the negative morpheme placed at the beginning of the sentence rather than within or after it, but it is also reported that a negative, uttered late in a mother's speech (i.e., late in the position in a sentence) is not understood. Auxiliaries make their appearance later and earlier they are omitted. In the next stage in the case of the interrogative sentences (e.g., 'Where my mitten?', 'What the dolly have?', 'What me think?') it is understood that the object of the question is a N or NP. This perhaps reflects that the child expects such questions to require an answer. At a later stage still the auxiliaries are used freely, their position in the sentence now only needing correction (e.g.s, 'Did I saw that in my book?', 'Why kitty can't stand up?'). When these are corrected, the result of the transformational operation becomes identical to the adult. Roger Brown (1968) in a summary of his article 'The Development of Wh Questions in Child Speech', states that in general there is evidence that children in pre-school years do develop a grammatical structure underlying Wh questions that is much like the structure described in current transformational grammar.

'Because the abstract underlying structure is not strongly suggested by the surface form of Wh questions,'

he continues,

'it is difficult to see how it can be learned.'

We are left to assume then, that the abstract structure is related to an innate mechanism. (This study, it is interesting to note, is termed by the author 'naturalistic' rather than experimental.) It must not be assumed, however, that the stages as outlined above occur precisely one after the other; clearly this is not so, for at any time elements may be there and at other times, not.

In the early stages of the development of transformations it is suggested that the child attempts to reduce the number of individual rules to two or three transformational rules. For instance, there are at least five rules in the second stage of the negative types mentioned above (Herriot, 1970). These rules may be derived by an inductive process producing such sentences as 'I digged in the yard', or 'I saw some sheeps', or 'Johnny hurt hisself'. Here the mistake is not a random one and it is unlikely that it is the result of imitation. Many verbs ending in voiced consonants form the simple past by adding /-d/ and many nouns ending in voiceless consonants form the plural with /-s/. For example the set of forms me, my, myself, and you, your, yourself strongly suggest he, his, hisself. English, however, prefers himself. By performing in this way the child shows his tendency to induce rules. This is shown clearly by the work of Berko (1958).

5.3.1 Later Acquisition of Transformations

There have been many studies now using generative transformational grammar with adults, but those dealing with the exploration of the development of the child's syntactic control beyond the early acquisition phase are less frequent.

Some of the work that has been reported seems promising, pointing to the possibility of tracing patterns of development of transformational acquisition.

Paula Menyuk (1963a) carried out a research programme with children in nursery school and kindergarten in America. Her subjects' mean ages were 3.3 years for the nursery children, 5.6 years for the kindergarten, a girl nearly seven, a boy of eight and a half, and a male adult. Her experimental method relied on the ability of her subjects to repeat sentences backwards and in ordinary sequence, within a nine-word limit. The method then included repetitions of the rule-governed items and those same items in reversed order. There seemed to be no critical effect of sentence length even by the three year olds when normal order was maintained, but with reverse order, the inability of the subjects to repeat the items was correlated significantly with their length, even with the adult. Menyuk interpreted the ability to repeat the sentences in normal order as evidence of mastered rules and not merely the power to imitate. A pattern of development was seen: the nursery-school children's correct repetitions did not reach the 0.05 level of significance for question, present perfect verb phrases with the participal 'got' or with adverbs after the contracted auxiliary 'have', subordinations with 'so' and 'because', and various nominalisations; yet among the kindergarten children the only significant non-repetitions of such transformations were those involving 'got' and 'have'. It is interesting to note that individuals among the groups were able to repeat sentences with transformations and other patterns which were correct that they did not use in their own language. In a further piece of work, reported in the same year (Menyuk, 1963b), with a nursery-school group, all the basic structures used by adults to generate their sentences were found and in comparing a number of children in the two age levels investigated (i.e., 48 nursery children aged from 3 years 1 month to 4 years 4 months, and 48 first-grade children from 5 years 11 months to 7 years 1 month) structures that were used at the early age were used consistently. The structures that were being acquired at the nursery stage were also still being acquired by the first-grade group. There were few significant differences in the use of structures between males and females or between children above and below the mean I.Q. It is important to notice the high level of these groups, however: the nursery group had a mean I.Q. of 130.3 (SD: 11.2) and the first-grade group had a mean I.Q. of 132.0 (SD: 13.4).

From other investigations, Menyuk (1964), again with upper-middle-class children with better than average I.Q.s ranging in age from 3 years to 7 years, found indications of certain clear developmental patterns. There was a general but fluctuating progress towards adult norms, and she concluded that

'language acquisition and development cannot be explained merely by an imitative process since there are systematic levels of behaviour in language production that cannot be accounted for by imitation of a model.'

Another pertinent study is that of J.B. Brannon (1968) who compared the syntactic structures in the speech of three and four-year-old children. From these group comparisons, Brannon found that his subjects differed in ten of the twenty-six transformations observed. There was a very large increase in the number of times the group of four-year-olds used the negative, contractions, Auxiliary 'Be' and conjunctions. The last two suggest that the four-year-olds are expanding their sentences more than the three-year-olds. There was a lesser, but still significant increase in the number of questions, the use of 'got', the auxiliary 'have', 'so', relative clauses, and infinitival complements. Brannon also reports a second analysis apart from the frequency of usage, that is by the number of children actually using transformations. Although nearly all three and four-year-olds used a particular transformation, the four-year-olds used it much more frequently. He suggests that children

'mature towards a fairly differentiated linguistic competence in stages or hierarchies of advancement:

1st stage sentence rules relating to phrase-structure are learned by two to three years,

2nd stage rules governing generation of sentences seems to be that of simple transformations.'

It was found that the mastery of double base or generalized transformations were among the most difficult ones to learn and they were not acquired completely until six or seven years. (Lists of Transformations used by Brannon will be found in the Appendix).

Osser (1966) finds that Menyuk's statement that her subjects used 'all the basic structures used by adults' difficult to assess as there is no agreement as to what these basic structures are. His own work looked into the language of twenty 'grossly deprived' Negro five-year-old children in Baltimore. It was found that this sample exhibited a much narrower range of syntactic structures than did Menyuk's white middle-class children in Brookline, Massachusetts.

Furthermore a great deal of difference was found within the group and Osser is quoted as saying

'a theoretical position that downgrades experiential factors in favour of maturational factors in language development'

must take account of very great intergroup and intragroup divergences in language patterns. The work is quoted by Griffin (1968).

5.3.2 Transformations and STM

The divergencies between individuals within the group are brought out in the work of Graham (1968) who investigated Short Term Memory (STM) and Syntactic structure in E.S.N. children. In this study the children were tested on STM tasks (unstructured strings) and twenty-four sentences manifesting different transformational rules. Seven levels of STM were identified and the degree of facilitation provided by sentence structure was related to these levels. The main finding in this work was the differential effect of sentence types at different levels of STM. Graham concluded that STM limitation may well account for some language deficiencies in that some subjects will fail to process such sentences as make demands beyond their STM capacity.

Graham's methodology is of interest. He chose twenty-four major transformational rules 'from the literature on generative grammar' and composed eight-word sentences for each rule. The following were the transformations used:

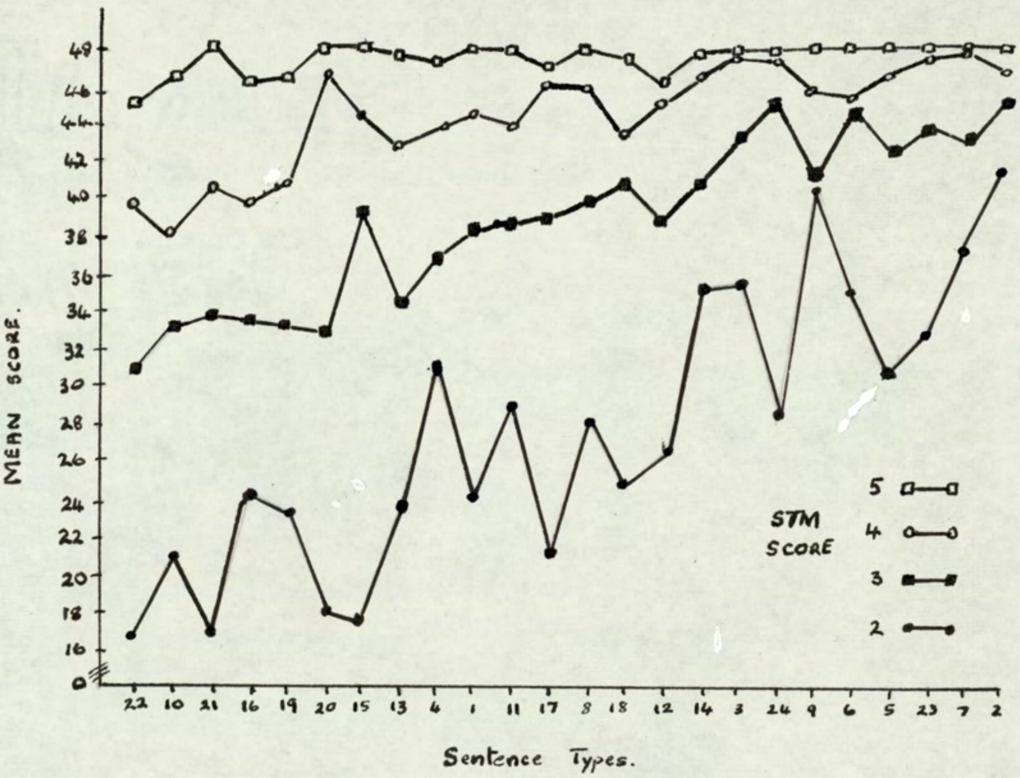
1.	Passive	13.	Conjunction 'And'
2.	Negative	14.	Conjunction 'If'
3.	Question	15.	Conjunction 'So'
4.	Adverbial Inversion	16.	Iteration 'And so'
5.	Relative question	17.	Conjunction 'Because'
6.	Imperative	18.	Adjective
7.	'There' transformation	19.	Relative clause
8.	Separation of particle	20.	Nominalized subject 'To -'
9.	Auxiliary 'Be'	21.	Nominalized subject '-ing'
10.	Auxiliary 'Have'	22.	Possessive nominalized subject ''s -ing'
11.	Possessive ''s'	23.	Complement '- to -'
12.	Reflexive	24.	Compliment '- ing -'

Parallel versions of the list of sentences were made so that some control over incidental differences of structure and content were obtained. Dale's 769 Easy Words and Mein's Vocabulary of Severely Subnormal Children (1961) were used 'as guides to the choice of vocabulary for the sentences', and the unstructured strings (STM tasks) ranging in length from two to six words were drawn randomly from a pool created by taking every fifth word reading through the sentence lists. The sentences were presented singly in a normal speaking voice with an interval of approximately seven seconds between sentences. The subjects responded by repeating the sentences as best they could. Subjects had four sessions of twelve sentences and at the end of the second session they were tested for immediate recall of unstructured strings. The STM score for these was given by the average length of the longest string in each set which the subject was able to recall without error.

Graham's results given in graphical form show sentence types in a descending order of group means on one axis of the graph and four STM groups on the other. Figure (11) shows the differential effect of transformational complexity with STM.

Figure 11

Transformational Complexity and STM



Mean scores per sentence type of four STM groups.

Sentence types are ranked by group harmonic means in descending order from left to right. (After Graham, 1968)

The highest STM score is shown to facilitate the repetition of all the sentences, the lowest being geared to poor performance - especially the greatest overall difficulty. Correlations between the various factors showed that sentence recall and STM had the closest relationship and that I.Q.

and Chronological Age (CA) had lesser coefficients. The actual matrix is shown below as Table (8).

Table 8

Matrix of Correlations from Graham (1968)

	STM	IQ	CA
Sentence recall	0.82	0.54	0.55
STM	1.00	0.59	0.45
IQ		1.00	0.46
CA			1.00
All coefficients were significant at the 0.01 level			

Graham ends his discussion thus,

'Ultimately, an adequate language performance model based, presumably, on a transformational theory of competence must precede the development of reliable and valid measures of language for educational and clinical purposes. Performance on the task of immediate recall of sentences of known structure and controlled length has been shown here to reliably reflect differences between subjects and to scale sentences in an empirical order of difficulty related to STM capacity. ..... It remains to be seen whether it is not only reliable but also valid.'

Experiment 2 was designed to look more closely at this order of difficulty, and at the same time as comparing subjects' performance on structured strings, make other relevant observations.

6. EXPERIMENT 2. STRUCTURED STRINGS

It has been said (Griffin, 1968) that 'syntax is at the heart of language': it follows then that the mastery of syntactical operations by the child will carry it a long way towards the full acquisition of that language. However, to determine the progress made by children at different ages and developmental stages requires carefully controlled experimental techniques and measurement. Furthermore it would seem that the amount of basic STM capacity available is also an important consideration. Its functioning, therefore, affected as it is by such variables as age, intelligence, attention, speed of presentation and word familiarization or frequency (3.2) will need to be taken into account as important variables. In the experiment to be described, attempts were made to control some of these factors, and to collect other data thought to be relevant in the school situation. Again, particular interest is taken of the reception class group, aged between 4½ - 5½ years.

6.1 Method

As already reported, Graham's (1968) work pointed the way when he investigated the E.S.N. child's performance with syntactic structures, 'as it were in slow motion'. But what of the normal child; how are the characteristics of STM related to the growth of the perception of syntax? Experiment 2 was set up to try to find some of these relationships using the method of immediate repetition of a sentence. Neisser (1966) has commented that this method reflects the ability to perceive a sentence.

'We deal with sentences we hear by reformulating them for ourselves - we grasp their structure with the same apparatus that structures our utterances.'

Graham (1968) and Menyuk (1963) also found this method successful, but Graham worked with sub-normal subjects, and it must be borne in mind that his method of scoring reached a ceiling. As the subjects of this study have, presumably, greater ability (being educationally normal), it was thought necessary to introduce 'white noise' as a factor to increase the discriminability of the material with the older subjects.

6.1.1 Syntactic Materials

The syntactic materials were structured by using Chomskian type transformations as a basis for the linguistic definition of syntax, and by controlling the vocabulary employed it was hoped that a trend of transformational acquisition might be detected amongst the subjects.

Some fourteen transformations were chosen from recently reported work using transformational grammar, and in particular that work concerned with the ages chosen for investigation. The fourteen transformations selected are shown in Table (9), together with the works from which they were derived.

The vocabulary chosen as being most appropriate is the word count already used in Experiment 1 (Burroughs, 1957).

Vocabulary has always been an important feature in language acquisition (McCarthy, 1954) and as STM varies according to the familiarity of the items presented for recall (Dale and Gregory, 1966), it was regarded as a major variable in this experiment. The literature shows that it is occasionally referred to but rarely strictly controlled. It was decided to use only those words appearing in List 1, the first 500 (containing the 'core' vocabulary) of Burroughs's lists,

Table 9

List of Transformations used with works from which they were derived.

No.	Identity of Transformation	Author employing Transformation
T 1	Negation	1. 2. 7.
T 2	Relative Question	1. 2.
T 3	Auxiliary - 'Be'	1. 2.
T 4	Question	1. 2.
T 5	Reflexive	1. 2.
T 6	Because. A.	2.
T 7	'So'	1. 2.
T 8	Nominal Subject ... 'ing'	2.
T 9	Auxiliary 'Have'	1. 2.
T 10	Nominal Subject-possessive- ... 'ing'	2.
T 11	Passive	2. 3. 4. 6. 7.
T 12	Negative Passive	4.
T 13	" " past	6.
T 14	" " 'might'	6.
T 15	Because. B.	2.

Note: Transformation T 6 'Because' A., and T 15 'Because B. are the same structure but with different vocabulary levels.

Key to Authors

1. Brannon (1968)
2. Graham (1968)
3. Slobin (1966)
4. Hayhurst (1967)
5. Menyuk (1963 a. b.)
6. Fraser et al. (1963)
7. Savin and Perchonock (1965)

except where the character of the transformation demanded otherwise (e.g., the 'reflexives' himself, herself, themselves occur in lists 2, 3, and 4 respectively). Also, so that some assessment of the relationship of vocabulary with structure can be made, one of the transformations - 'Because' - was replicated using words from the lists made up of lower frequency words.

Another variable, sometimes controlled and sometimes not, is sentence length. Graham kept his sentences to eight words but Menyuk (1963) found 'no critical effect of sentence length' with the normal order preserved within a 9-word limit. It should be remembered, however, that increasing sentence length is a main performance criterion in many studies of language development (Templin, 1957) and that Menyuk's subjects had high average I.Q.s (Mean I.Q. = 130.3). Due to these different findings it was decided to control sentence length to a point just beyond the longest unstructured string correctly recalled in the STM experiment, that is, 8 words. Examples of the materials generated by these procedures are shown below. First (Figure (12)) the comparison between the two versions of the 'Because' transformation, and secondly examples of Reflexive transformations (Figure (13)).

Figure 12

Two examples of 'Because' transformation illustrating different vocabulary levels.

T	eg.	Because transformation							
6	2	The	baby	laughed	because	she	saw	the	kitten
Vocab.		1.	1.	1.	1.	1.	1.	1.	1.
15	2	The	ambulance	rushed	because	of	the	awful	accident
Vocab.		1.	4.	3.	1.	1.	1.	3.	4.

Figure 12

Vocab. 1, 3, 4 refer to Burroughs's List, 1, 3, 4 being the first '500', third '500' and fourth '500' word count lists.

Figure 13

Examples of 'Reflexive' transformations

T	eg.	'Reflexive' transformations							
5	1	The	girl	looked	at	herself	in	the	Mirror
Vocab.		1.	1.	1.	1.	3.	1.	1.	1.
5	3	The	boys	and	girls	bought	themselves	some	sweets
Vocab.		1.	1.	1.	1.	2.	4.	1.	1.

Note: Some of the 'key' reflexive words appear in the less frequent lists.

Each of the fifteen syntactical structures was represented by six differently worded examples, and the ninety resulting structures were arranged in three sets of thirty, each set containing, in random order, two examples of each structure. These three sets were tape recorded, using a male voice, at normal speaking speed and intonation, and so that presentation might be identical for each subject, the material was heard through head-phones. (Copies of the three sets of material used will be found in the Appendix.)

6.1.2 Assessment of mental ability

It was decided to include a measure of mental ability for, traditionally, intelligence has been associated with language ability.

The following table shows the intercorrelations between Mental Age, Vocabulary and Language, found by Sampson (1959)

Table 10

	Language	Vocabulary
Mental Age	+0.74 (±0.045)	+0.73 (±0.044)
Language		+0.69 (±0.049)

Data from Sampson (1959)

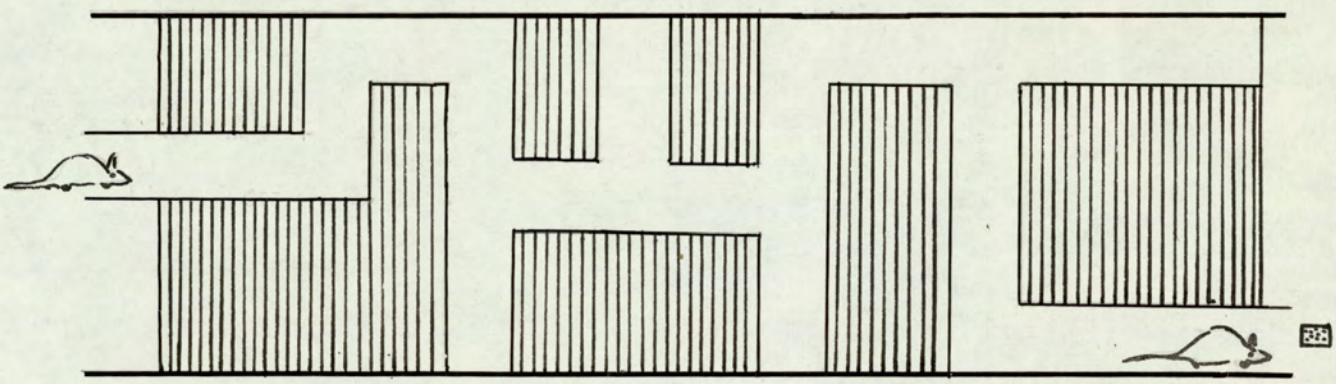
However, these details are not always reported in the literature, and as Griffin (1968) remarks,

'..... most of the investigations (of syntactic control) have dealt with middle-class children, and it is remarkable that so many investigations have reported subjects as of average or above-average intelligence.'

On the other hand, Graham has employed E.S.N. subjects to show the process with below-average children, as he puts it 'in slow motion'. Osser's (1966) subjects, it will be remembered, were culturally deprived Negro children and he demonstrated linguistic differences due to environment. For these reasons it was thought that some measure of mental ability would be interesting and provide a further dimension. A suitable test to assess intelligence proved difficult to find as the following conditions needed to be met so that the results of the experiment would not be confounded. Firstly to avoid contamination of the main experimental variables of syntactic structure and STM, the measurement should not include these types of tasks as sub-tests as do many intelligence tests. Jackson (1968) comments, for instance, on 'the high verbal content' of the Stanford Binet Scale of Intelligence, and its unsuitability with certain school populations. Next the age of the subjects has to be considered: there are few suitable tests for the age range involved, $4\frac{1}{2}$ - $7\frac{1}{2}$ years, and testing is known to be full of uncertainties at this age (Updegraff, 1932). One of the few procedures to meet these requirements was a performance type test, a series of mazes designed by Prof. Porteus (1952). These are graded mazes to be negotiated by the subject by pencil tracing, starting at a level suitable for a fourteen year old. It is claimed that the mazes reflect planning capacity and that the results are positively correlated with such intelligence tests as the Stanford-Binet Revision.

Figure 14

Example of maze. Level Year V.



The highest correlation (r = 0.77) reported was for 263 normal children examined by the Stanford-Binet Revision (Porteus, 1952). The Porteus test is one of the earliest kinds of performance test (originally published in 1914), relying very little on verbal skills. Its most useful contribution in recent years has been its sensitivity to brain damage, and use with primitive peoples (Butcher, 1969). However, its purpose here is to give the study another dimension so that the subjects may be described in other terms than verbal abilities.

6.1.3 Sex Differences

Older studies have often noticed that girls were superior in language skills to boys and that there were many regional variations (Templin, 1957). In many reports in later years the sex differences are, however, said to be negligible. Sampson (1959), pointing out the boys' superiority at five, on vocabulary, nonetheless confirms Templin's (1957) findings that girls have superiority in language tests when 'precision and fluency' are considered, though 'on the whole, differences between the boys' and girls' scores are not great'. Griffin (1968), commenting on this, suggests that

'It would be worthwhile to settle the question of whether reported differences are tied to biology (sex) and culture or to culture alone.'

From this work of Griffin and other reports, the question of differences in the performance of boys and girls is still unclear. In this study, therefore, the differences will be recorded and analysed by age group and by sex.

6.1.4 STM Tasks

It has been shown (4.4) that the measurement of STM by the comparatively lengthy test involving mathematical procedures did not appear to be superior to the traditional methods of calculating the memory span. It was decided, therefore, that the shorter test, designed primarily as introductory material for the longer test but constructed in the same manner, should be used for this purpose. The short version of the test (see Appendix) was found to have a high positive correlation with the longer test ($r = 0.900$, $p < 0.001$).

6.1.5 Description of Subjects

It has been noted in the literature (e.g., Osser, 1966) that environmental differences affect the developmental pattern of language acquisition: it is important, therefore, to note that whilst the subjects used in the experiment are in a normal school situation, the socio-economic levels of the district are those of lower or semi-skilled workers. The area is one of recent redevelopment and many families are housed in 'high-rise' flats. The school is near to the one used in Experiment 1, reflecting similar educational levels. There is, however, a range of ability represented in the school, shown by the 36% selected annually at eleven years for grammar school, the rest going to non-selective schools.

6.1.6 Summary Table of Observations

The following data was collected during the experiment.

i.	Chronological age of the subjects	(CA)
ii.	Sex of the subjects	(S)
iii.	STM Capacity	(STM)
iv.	Performance of the Maze test	(PM)
v.	Length of Schooling (younger subjects)	(Sch)
vi.	Transformation scores	(T)

6.1.7 Experimental Conditions and Procedure

The subjects were introduced to the taped transformations by the experimenter, who was known to them, in a quiet room set aside for the purpose in the school by the Headmaster. The subjects were taken through the sets of material individually although initially they came in pairs for an introductory session. The introductory tape contained instructions and simple 'messages' for immediate action and repetition to allow subjects to settle and to ensure correct mode of response. This worked well and the children enjoyed the tasks. To avoid fatigue only one set of structures was given on any one day. The subjects heard the structures through head-phones to prevent distraction and preserve some control of 'attention'. This procedure was necessary also for the addition of white noise. The three sets of material were presented as follows.

Table 11

Method of Presentation of Structured Materials to the Groups

Age Group	Set A	Set B	Set C
1	Level 1	Level 1	Level 1
2	Level 1	Level 2. B(N)	-
3	-	Level 2. B(N)	Level 3. C(NN)

Key:

Level 1 = No noise added (arbitrary value)

Level 2 = Signal/noise ratio decreased by 3 db.

Level 3 = Signal/noise ratio decreased by a further 3 db.

Scoring Procedure

The transformations were scored as correct, only if the whole structure was accurately recalled word for word.

6.1.8 Administration of the STM Tasks

The presentation of the transformational structures was followed by the STM tasks, but not on the same day for any subject.

6.1.9 Administration of the Porteus Maze

The subjects were taken through the maze tasks individually by the experimenter, the instructions in the administration manual (Porteus, 1952) being strictly observed.

6.2 Results

The results are given in the order shown by the Summary Table of observations (6.1.6).

6.2.1 Chronological Age of the Subjects

The subjects were in three age groups, Group 1 were between 4½ and 5½ years (mean age 63.7 months), a middle group, Group 2, between 5½ and 6½ years (mean age 75.5 months), and an older group, Group 3, between 6½ and 7½ years (mean age 88.1 months). There were 31 in Group 1, 33 in Group 2, and 27 in Group 3. Tables (12) and (13) give the details of the groups by age and sex.

Table 12

Numbers in Age Groups

Group	Boys	Girls	Total
1	15	16	31
2	16	17	33
3	13	14	27
Total	44	47	91

Table 13

Mean Ages by Group and Sex

Group	Mean Ages in Months			
	Boys	Girls	Group	SD
1	64.50	63.00	63.70	3.128
2	75.40	75.70	75.50	3.524
3	89.30	87.07	88.10	3.399

6.2.2 Sex of Subjects

It will be seen from the Tables above that the number of boys in the three groups was 44 and the number of girls was 47, making 91 subjects in all. The mean ages of the subjects by sex show that the boys were slightly older in Groups 1 and 3.

6.2.3 STM Results

These results are given in the summary table below, by group and sex.

Table 14

Mean STM Scores by Age, Group and Sex

Group	Boys	Girls	Group	Group S.D.
1	3.49	3.67	3.58	0.573
2	3.97	4.01	3.99	0.681
3	3.18	3.81	3.49	0.566

The results show that the girls have a slightly higher mean score on the STM tasks, but the incremental increase expected with age is not shown. Group 3's mean score in particular being below that of Group 2, a year younger.

6.2.4 Maze Performance

These results are presented in the form of a summary table below. It will be seen that there are both age and sex differences in this measure and that the results of the girls in Group 2 are significantly lower ($p < 0.01$) than the boys and the other groups of their own sex. In these results the scores are 'corrected' for age so that comparisons can be made between groups, but as there is a considerable difference in the performance of the girls in Group 2 it was decided to compare raw scores.

Table 15 (PM 1)

Mean PM Scores by Age and Sex

Group	Boys	Girls	Group	Group S.D.
1	109.93	100.87	105.40	24.034
2	111.12	85.88	98.50	24.773
3	112.1	110.00	111.05	25.534

Table 16 (PM 2)

Mean PM Scores (Raw Data) by Age and Sex

Group	Boys	Girls	Group
1	6.566	5.937	6.25
2	7.65	5.85	6.75
3	8.90	8.50	8.70

The boys' scores are seen to be superior on these tasks in both Table (15) and Table (16).

The boys' scores shown in Table 16 for 'uncorrected' data show a proportional increase with age, but the girls in Group 2 still have a level of means below that of the girls a year younger.

6.2.5 Length of Schooling (Group 1)

As environmental conditions in general are believed to affect the level of language acquisition of the subjects (Lewis, 1969), it is suggested that a changed of the intimate environment experienced by the child at home to that of the school might also be observed. As these subjects began school at different times, the number of weeks each subject had attended school were extracted from the attendance register and the mean number of weeks calculated. For the boys it was 19.46, and for the girls it was 17.65 weeks; the total mean for Group 1 being 18.55 weeks with a standard deviation 8.9. The boys had been in school longer than the girls.

6.2.6 Performance on Transformational Structures

Three sets of material were presented for immediate recall to Group 1 and the mean scores for these are set out in Table 17 below.

Table 17

Mean Transformation Scores for Group 1 by Sex

Group 1	Set A	S.D.	Set B	S.D.	Set C	S.D.
Boys	17.33	7.3	17.40	6.4	15.13	6.5
Girls	18.81	6.5	16.43	7.2	16.00	7.0
Group	18.07	6.9	16.91	6.3	15.56	6.3

Group 1

The performance of the girls in this age group is slightly above that of the boys except for Set B, but there is also a difference between sets. It could be said that Set A was the more easily perceived as more subjects had correct scores, and that Set C was the most difficult to perceive, and that this was reflected in the lower scores. The spread of scores on one set was from a score of 3.3 to 27.0, and the maximum score possible was 30.

Group 2

The results for Group 2 on the Transformational tasks are given in Table 18. It should be remembered that the transformations in Set B(N) were given under conditions of noise.

Table 18

Mean Transformation Scores for Group 2 by Sex

Group 2	Set A	S.D.	Set B(N)	S.D.	Mean T.	S.D.
Boys	20.5	5.9	10.75	3.5	15.35	4.2
Girls	19.58	6.6	10.58	4.0	15.08	5.0
Group	20.4	6.3	10.67	3.8	15.26	4.8

The following comparison can be made with Group 1 with Set A results. An increase in the mean score by Group 2 over Group 1 can be seen.

Table 19

Mean Transformation Scores for Groups 1 and 2 on Set A

Group	Boys	S.D.	Girls	S.D.	Group Total	S.D.
1	17.33	7.3	18.81	6.5	18.07	6.6
2	20.50	5.9	19.58	6.6	20.04	6.5

Group 3

The transformation scores of Group 3 are shown in Table 20. Here Set B (N) has been given with noise level 2 and Set C (NN) with greater noise at level 3.

Table 20

Mean Transformation Scores for Group 3 by Sex

Group 3	Set B (N)	S.D.	Set C (NN)	S.D.	Mean T.	S.D.
Boys	13.7	4.4	3.8	2.7	8.75	2.7
Girls	16.6	4.8	2.3	2.3	9.45	2.8
Group	15.25	4.6	3.05	2.5	9.10	2.8

Again, as with the comparison between Groups 1 and 2, Table (19), the comparison that can be made next is between Group 2 and Group 3 at noise level 2. Table (21) gives this comparison.

Table 21

Mean Transformation Scores for Set B(N), by Sex, for Groups 2 and 3.

Group	Boys	S.D.	Girls	S.D.	Group Total	S.D.
2	10.75	3.5	10.58	4.0	10.67	3.8
3	13.7	4.4	16.6	4.8	15.25	4.6

Here there is an increase in the overall mean scores by age even when noise is applied to decrease the discriminability of the materials.

6.2.7 Correlations of Group 1 Observations

Having reported the measurements for individual groups and, in some cases made comparisons, an exploration of the way in which the measurements vary together within groups was next carried out. The results are reported in detail for Group 1.

Table 22

Correlation Matrix of the Various Observations of Group 1

CA	STM	PM(1)	PM(2)	T(A)	T(B)	T(C)	$\bar{T}$	Sch.
1.000	0.247	0.187	0.345	0.258	0.337	0.366 *	0.340	0.841 ****
	1.000	0.252	0.290	0.686 ****	0.653 ****	0.717 ****	0.725 ****	0.185
		1.000	0.985 ****	0.377 *	0.391 *	0.386 *	0.407 *	0.314
			1.000	0.410 **	0.440 **	0.436 ***	0.435 **	0.445 ***
				1.000	0.776 ****	0.913 ****	0.949 ****	0.242
					1.000	0.833 ****	0.919 ****	0.212
						1.000	0.968 ****	0.323
							1.000	0.273
								1.000

Levels of significance indicated by: $p < 0.05$ * $p < 0.02$ ** $p < 0.01$ *** $p < 0.001$ ****

<u>Key to abbreviations</u>

CA	=	Chronological Age
STM	=	Short-term memory
PM(1)	=	Porteus Maze ('corrected' scores)
PM(2)	=	Porteus Maze ('raw' scores)
T(A)	=	Transformation scores Set A
T(B)	=	" " Set B
T(C)	=	" " Set C
$\bar{T}$	=	Mean transformation score
Sch.	=	Length of schooling

The relationships between the various measures for Groups 1 and 2 are given below in Table (23).

Table 23

Correlation Matrix for Groups 1 and 2

CA	STM	PM	T(A)
1.000	0.286 *	-0.065	0.194
	1.000	0.164	0.647 **
		1.000	0.266 *
			1.000
Levels of significance:	$p < 0.05$ *	$p < 0.001$ **	

6.2.8 Analysis of Transformation Scores for Group 1

Table (24) shows the mean transformation scores for Group 1 arranged in an empirically derived order of complexity. This is based on the results of 31 subjects on the means of the three sets of material.

Table 24

Transformations arranged in Rank Order by Mean Scores

Rank	Transformation No.	Identity	Mean Score
1	T2	Question	23.8
2	T4	Relative Question	23.0
3	T3	Auxiliary 'BE'	22.5
4	T1	Negation	22.0
5	T6	Because A	20.5
6	T8	Nominalization	20.2
7	T11	Passive	18.1
8	T9	Auxiliary 'Have'	17.5
9	T5	Reflexive	17.3
10	T7	'So'	15.2
11	T12	Neg. Passive 'Future'	14.7
12	T13	" " 'Past'	13.3
13	T15	Because B	8.1
14	T10	Poss. Nominal Subject	6.8
15	T14	Neg. Passive 'may'	5.1

Rank Order Correlation

This rank order is correlated positively and significantly with the original order given on p. 86 ($r = 0.85$, $p < 0.01$). This would suggest that the rank order derived from the experimental results has a fair measure of agreement with the earlier order derived from the literature and based, in part, on the transformations' underlying complexity. It is interesting to note the considerable difference in the order of T6 'Because A' (mean 20.5) and T15 'Because B' (mean 8.1). Here the difference must be attributed to the vocabulary as the structure was held constant. The finding is brought out clearly when the results are put in histogram form. The effect of vocabulary is seen to give a drop of 12.4 in the mean scores (see Figure (15)).

6.3 Discussion of the Results of Experiment 2

The discussion is divided into two sections for convenience of presentation, though, of course, there are inter-relationships between them. The areas are:

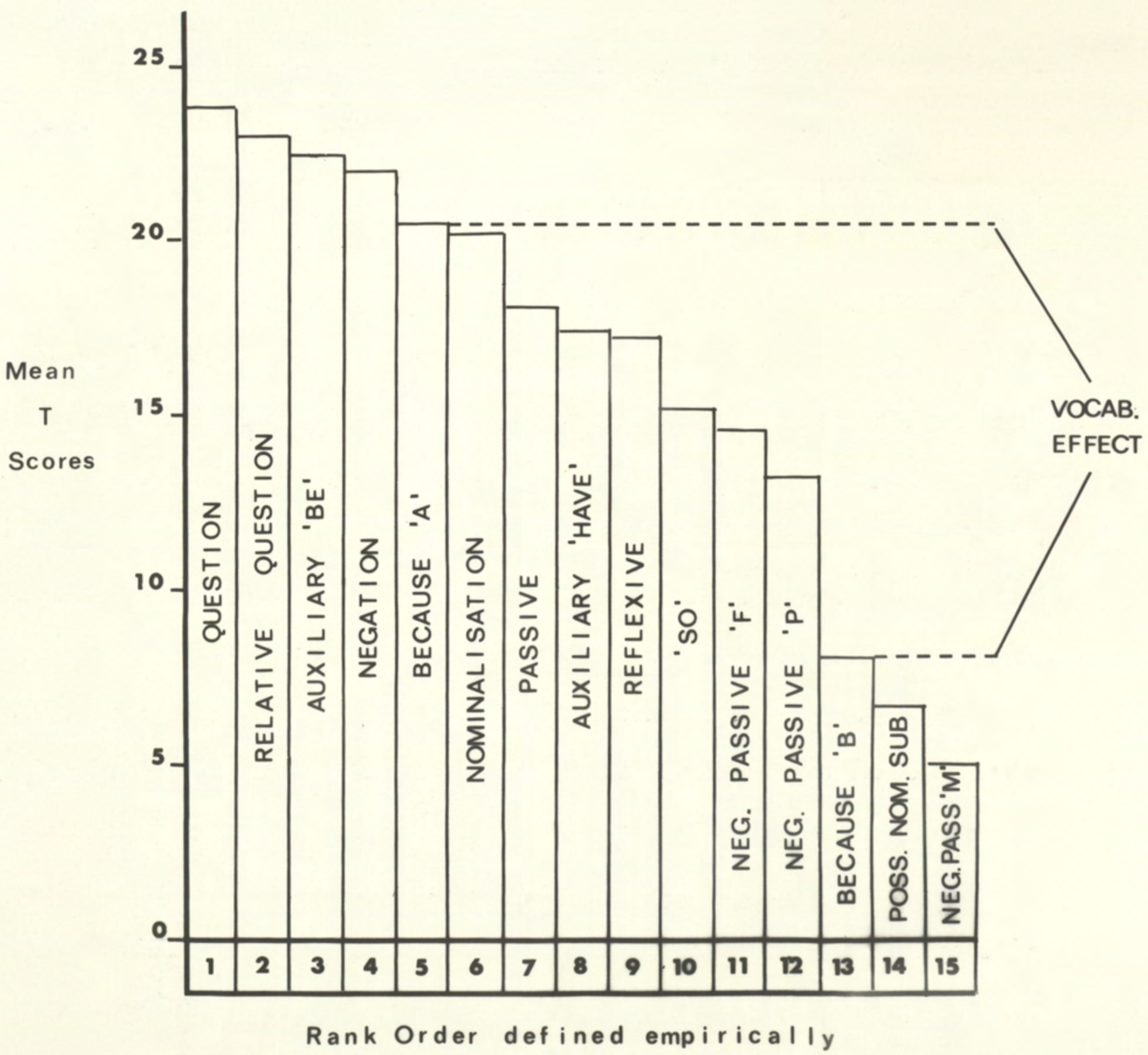
1 Development trends in the control of syntax, and

2 The association of the other experimental observations.

6.3.1 Developmental trends in the Control of Syntax

It was feared that if the transformational sequences were presented without the addition of 'white noise' the materials would not be sufficiently discriminative to discern trends in acquisition and that a ceiling would be reached with the oldest group. Although there were grounds for thinking this might not be so (after all sentences varying in length are given successfully as sub-tests of Intelligences scales), nonetheless Graham's results with a similar method showed a tendency to reach a ceiling especially with those subjects who were in the group with a STM capacity of 5.0. Furthermore Graham's subjects were drawn from E.S.N. schools; the subjects of this experiment were drawn from an ordinary school where an even greater range of ability might be expected. However, the materials were discriminative. Taking the youngest group's performance (the group of most interest in this study) to illustrate this, where the three sets of material were given without the addition of 'white

Figure 15


Mean T Scores
25
20
15
10
5
0
QUESTION
RELATIVE QUESTION
AUXILIARY 'BE'
NEGATION
BECAUSE 'A'
NOMINALISATION
PASSIVE
AUXILIARY 'HAVE'
REFLEXIVE
'SO'
NEG. PASSIVE 'F'
NEG. PASSIVE 'P'
BECAUSE 'B'
POSS. NOM. SUB
NEG. PASS 'M'
VOCAB. EFFECT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Rank Order defined empirically

noise', no subject had a set completely correct, the highest score for one set being 28 out of the maximum of 30. The scores, however, ranged from 1 to 28, reflecting the extent of individual ability within the group, with a mean for all subjects over the three sets of material of 16.85, and a standard deviation of 6.8.

Graham claims to have shown that the complexity of the syntactic structure can be defined by transformational grammar and when thus defined, the transformations can be graded. It follows, one would suppose, that the differential difficulty of the structures would be reflected in a pattern of acquisition, the less complex transformations being acquired early in the development, those of greater complexity later. In performance, those acquired earlier would obviously display greater practice effects and be perceived more readily. Again this pattern would most probably be hierarchical in character, following the hierarchical pattern of the constituents of the language (Herriot, 1970). From the results of the experiment the transformations have been arranged empirically in a rank order by a descending order of mean scores (Figure (15)). This order shows the structures of less syntactical complexity being recalled more frequently than those of greater complexity, but apart from the analysis and details of structural change required by the transformation theory of Chomsky (1965), this complexity is not as yet quantifiable although many attempts have been made to measure it. It is not possible, therefore, to show the nature of the complexity except in terms of the structural analysis which is coarse especially when transformations are similar, as the examples in the Appendix show. However, that there is a gradation of complexity may be inferred, by way of hypothesis, from these empirical results and this may be supported by comparison of these results with others, particularly Graham's.

To illustrate, the Question transformation (T2) and the Relative Question (T4) have the greatest mean scores and the Negative Passive construction (T14), the lowest in this study (Rank order No. 1, 2, and No. 14) and in Graham's study exactly the same positions are reported, the Question and Relative Question transformations having the highest scores. The lowest mean score in this study was for T14 Negative Passive with 'may' but this was not used by Graham. However, next in this study was T10 Possessive Nominalization which again agreed with Graham being the most difficult. In addition, the type of transformations used here reflected those found in the productive speech of children of the age groups being investigated (Brannon, 1968).

Tentatively summing the findings so far then, the experiment supports the notion that there is an order in which transformations, as defined by the generative-transformational-grammar of Chomsky (1965), can be graded according to their complexity of structure, but it should be remembered that this complexity has not been satisfactorily quantified.

The next question to be posed needs to be: Is this order of complexity related in any way to chronological age? Does the child's ability to process these structures increase with age?

If one compares Tables (17), (18), (19), and (21), there is an overall increase in the mean scores as the groups increase with age. The mean scores in Set A for Group 1 is 18.07 and for Group 2, a year older, 20.04. This difference, however, does not reach acceptable significant levels ($p < 0.20$). This increase may be an underestimate as the performance of the girls in Group 2 appears to be on a level with those a year younger. Comparing Group 2 with Group 3 on Set B, this time with 'noise' added (B(N)), there is an increase in mean score from 10.67 to 15.25. This result was significant ($p < 0.001$). In these terms the subjects' ability to recall the transformations increases with the age of the subject. That is, the older the child, the more transformations are recalled correctly and the better able the child is to process the more complex transformations. However, when we consider the correlations within Group 1 there is only a significant correlation of CA with T scores and that only in one set. The correlation between CA and T(C) reaches the 0.05 level of significance ($r = 0.366$). It is interesting to note that this (Set C) was the most difficult to process, having the lowest mean scores, and yet its relationship reaches significance. The correlation coefficients are low, however, compared with other observations.

Summarizing then, it could be claimed that the results support the notion that there is a developmental trend in the acquisition of transformations, in that the more mature the subject the greater is the number of the transformations correctly recalled.

6.3.2 The Association of the Other Experimental Observations

As the structures appear to be graded according to complexity, the significant positive correlation between STM and the transformation scores T(C) shown in Table (22) ($r = 0.717$, $p < 0.001$) can be interpreted as indicating that, the greater the basic STM capacity possessed by the subject, the more capable he is of processing structures of increasing syntactical complexity. It is hardly surprising that this correlation is high as the measurement of STM was accomplished by presenting unstructured strings for recall and the transformation scores achieved by the immediate recall of structured strings. One would expect that the structuring would indeed enhance performance and lead to a significant result when correlated. However, the structures were graded by the complexity of their transformations, so perhaps STM capacity facilitates the processing when complexity is increased. In other words, the greater the subject's basic STM capacity the better able he is to perceive the more complex transformational structures. This result suggests that STM is a major psychological mechanism in the normal child's ability to process sentences, and strongly supports similar findings with E.S.N. subjects by Graham (1968). But is it only the structural complexity that is being examined here? In this study the level of vocabulary was controlled as well as the length of sentence and syntax. Dale and Gregory (1966) have shown that recall is more accurate when the material presented is composed of high frequency (familiar) words than low frequency (unfamiliar) words, and a similar effect has been found here. By using words of low frequency of occurrence from Burroughs's lists, performance has been affected as much as it was by levels of greater complexity of syntactic structure. This is illustrated by comparing the significant differences of the mean scores of T6 (20.5) and T15 (5.1) ($p < 0.01$) for the effect of the difference in word frequency counts, with T2 (Question 23.8) and T10 (Possessive Nominal Subject 6.8) for syntactic complexity.

There is a further hint of this vocabulary effect in T5, the reflexive transformation. In the rank order this transformation is found in the 9th position, showing it to be more difficult to perceive than such transformations as nominalisations and passives. It should be recalled here that some of the reflexive words themselves are to be found in the less frequent lists. It may be that the difficulty of the transformation lies not only in the complexity of the transformation per se but is related also to the lower frequency of some of the reflexive words used.

However, apart from the 'Because' transformations A and B, the word frequency variable has been controlled to high frequency words only (unless as just reported, the key transformation word was from a lower frequency list), so much of the differentiation of T scores must be attributed to the demands made on STM by increasing complexity of the structures themselves. That the processing of transformations require basic STM capacity has been demonstrated effectively by Savin and Perchonok (1965) and by Graham (1968) in similar conditions to this experiment. If the ability to handle increasingly complex syntactical structures is a feature of language acquisition, and if this ability is related to STM capacity, then the slow incremental growth of that capacity in the young child must be an important factor. As already intimated (3.2.2) only one increment is added to the digit span between the years of 4½ and 7, and yet, during this time the language capacity grows rapidly.

The results shown by the Porteus Maze tests in the younger group are of interest because examination of the table of correlations reveals a significant result between the ability to thread a maze and the ability to process transformations ($p < 0.05$) (Table (22)). This relationship is, at first, difficult to explain, but if, as the author claims, the tests assess 'planning' capacity then there may be a connection to, as it were, 'plan ahead' or 'look ahead' as one processes a sentence. However, this is highly speculative but may be an interesting avenue to explore. Another, perhaps more obvious relationship is that the child's perceptual-motor functioning is maturing quite rapidly at this age and facilitates the subject's ability to trace through a maze with a pencil. This growth of perceptual-motor functioning is probably associated with the length of time the child has been in school as the requirement to put pencil to paper now grows rapidly; indeed we find that the correlation between the maze-threading and length of schooling reaches significance ($r = 0.445$, $p < 0.01$), yet the performance in the transformation tasks and length of schooling did not reach significance ($r = 0.323$). The latter explanation of maturation is probably therefore the more likely.

The slight superiority of the boys in the maze tests agrees with many of the findings of those using the tests in the past; men having a higher score than women (Butcher, 1969). In contrast to this, it is interesting to note that the mean scores of the girls on the STM tasks are superior to the boys, and this may perhaps suggest a reason for their oft reported language proficiency compared with boys.

6.3.3 Summary and Conclusions for Experiment 2

Firstly, the experiment supports the notion that there is an order in which transformations, as defined here by the generative-transformational-grammar theory of Chomsky (1965), can be graded according to their complexity of structure, although as yet, this complexity has not been quantified satisfactorily.

Secondly, the results support, tentatively, the notion that there is a developmental trend in the acquisition of transformations as defined above, in that the more mature the subject, the greater the number of transformations correctly recalled.

Thirdly, further to the expected finding of an overall close relationship between STM capacity and the recall of structured strings, was the support of the work of earlier investigators (e.g., Graham, 1968) showing that the greater the basic capacity, the better the more complex structures were processed.

Fourthly, it was shown that there was a lesser, though significant, relationship between maze performance and sentence recall. This was interpreted primarily as an indication of the growing maturity of the subjects. However, if, as is claimed by the author, 'planning' ability is shown and that this 'planning' ability is related to intelligence, the experiment has a useful additional dimension.

Boys showed superiority in the maze tests, whereas the girls' superiority was evidenced in STM performance.

Some progress has been made towards achieving the aims of the investigation, but further exploration is called for by these results, especially the relationship between complexity and the frequency of occurrence of the actual words being structured.

7. EXPERIMENT 3. INTER-RELATIONSHIPS

Further exploration of some of the factors investigated in Experiment 2 (6.1) are obviously required, and for the main purposes of the study, the relationship between STM, Vocabulary levels and Structure is the most important.

7.1 Vocabulary Effects

In Experiment 2, the performance of the subjects differed markedly on T6 and T15. Here the structure of the sentence was held constant as far as possible within the definition of transformational grammar, but the vocabulary was varied for word frequency. In T6 the vocabulary was taken from the list of most frequently used words and for T15, from lower frequency lists. It should be noted, however, that although these words have lower frequencies, the frequencies are relative to the 'core' vocabulary, the words being taken mostly from lists 3 and 4, and still within the main listings. It would seem then that the variation in vocabulary is quite sensitive. However, Experiment 2 contained only two examples of each of the fourteen transformational types, so the further investigation of vocabulary effects with selected transformations was made a main feature of Experiment 3.

7.2 STM Capacity

Another variable achieving overall significance and of interest with the age group concerned, was the STM capacity of the subjects. This was greater than any of the other factors involved and must remain a major consideration, and is again used to compare performance.

7.3 Method

The method used in this experiment resembles that used in Experiment 2 (6.1), but instead of concentrating mainly on the younger group, it was decided to try to establish an overall pattern of acquisition within an infant school with subjects' ages ranging from 4½ to 7½ years.

7.3.1 Syntactic Structures

Syntactic structures reflecting different transformations as defined by the generative-transformational grammar of Chomsky (1965) were again used as the basic independent variable of the experiment. From the results of Experiment 2 five transformational types were selected for the following reasons. Firstly, to discover a pattern of acquisition, the transformations had to be graded in complexity, and to ensure that such a gradation achieved sufficient spread, a transformation of simple construction was chosen to provide a base-line, the interrogative transformation, and a complex construction involving difficult tenses to give discrimination, a negative passive with 'might'. It was envisaged that these two would give a 'top and bottom' to any scale being sought. There is some evidence that the interrogative transformation figures early in the acquisition pattern. For instance, Roger Brown (1968) has investigated this particular transformation thoroughly showing its presence in pre-school years, and that this is so is demonstrated by the high mean scores in Experiment 2. The more difficult construction (that is the structure less readily perceived by the subjects), the negative passive with 'might', received the lowest mean score in Experiment 2. Comparing the mean scores of the two transformations, T4 Question had a score of 23.8 and T14, the Negative Passive with 'might', had a score of 5.1. Three further transformations were selected, 'Because', 'So', and the Reflexive types. The 'Because' and 'So' transformations were chosen because of their interest in the previous experiment and for their conjunctive qualities. In earlier studies of language acquisition following traditional methods of data collection (Templin, 1957) (McCarthy, 1954), progress in language acquisition is often shown to be from simple to complex sentences. One of the ways of achieving this is by conjunctions, 'Because' and 'So' being two possible early types.

The Reflexive transformation was chosen as the fifth type as this has an inherent quality which appears, perhaps from the adult standpoint, to be simple - the replacement of the object by '... self' when subject and object are the same person(s) or thing(s). However, this may not be so simple for the child. It has been already stated when this was cited as an example of underlying structure, from the transformational grammar point of view, the 'deep' structure refers to the notion of subject-object identity, whereas the surface structure, the result of the transformation, uses the overt form '... self'. The vocabulary frequency of the reflexive words is another indication of the suspected difficulty for the child as most of the reflexives, apart from 'myself' are in the 'less frequently used' lists (e.g., 'himself, List 2; 'herself', List 3; 'itself', List 4, and 'themselves, List 4). These, then, were the five transformations and the rationale behind their selection for the experiment: T1 Question, T2 'Because', T3 'So', T4 Reflexive, T5 Negative Passive 'might'.

Having chosen the syntactical structures, it was decided to vary systematically the vocabulary used. Two lots of material were generated. The first set was made up of the five transformations at vocabulary level 1. For this the words were taken, as far as possible, from List 1 - the first 500 words in Burroughs's lists. Again, occasionally a word from other lists was included when the character of the structure made this necessary. However, wherever possible the more frequently occurring words from the first 500 were employed. The second set of materials used the same five transformations as the first set but the vocabulary was at level 2. The words this time were, as far as possible, taken from lists 3 and 4 of Burroughs count. Again, in the same way that words from later lists became necessary in the first set, so words of more frequent occurrence were used here when it became necessary; such words as 'the', 'a', serve as examples.

Summarising the description of these materials, then, we have two sets of 5 structures of different syntactical complexity, with vocabulary strictly controlled. In order to get an adequate measure of the differentiation between these five structures, seven examples of each were composed; thus each set contained 35 transformations (copies of the two sets of material appear in the Appendix). The order of the structures within each set was randomised, and six sets of different randomisations were prepared.

7.3.2 Technical Data of Recording Procedure

During the previous experiment, a certain amount of difficulty was found in matching the signal through different pairs of head-phones. Great care was taken in this experiment to ensure that the head-phones were matched for output. A technical description of the apparatus and its lay-out will be found in the Appendix.

7.3.3 STM Tasks

The measurement of the subjects' STM capacity was by the short version of the test from Experiment 1 as used in Experiment 2. This proved an efficient test and can be administered fairly speedily. It has the advantage, too, that the words used are from the same vocabulary count.

7.3.4 Description of Subjects

Another school was chosen in the same area as used in the two preceding experiments. The socio-economic levels of the district might be described as that of lower or semi-skilled workers, but it was estimated that a full range of ability would be found among the subjects involved. It should be noted that this school has a nursery department attached, so some of the children may have received some compensation for any deprivation that might accrue from their socio-economic status.

7.3.5 Experimental Conditions and Procedure

The design of the experiment required at least 30 subjects for each of the three age levels ($4\frac{1}{2}$ - $5\frac{1}{2}$ years, $5\frac{1}{2}$ - $6\frac{1}{2}$ years, and $6\frac{1}{2}$ - $7\frac{1}{2}$ years) found in infant schools to discern a developmental pattern (if any) of acquisition. Each subject was to have at least two sets of material for repetition, so the experimental procedure was organised so that a set could be presented to five subjects at once, (7.3.2). This arrangement needed four assistants. These were students from a College of Education in the second year of their course. They had already had two Teaching Practices with the same age group as the experimental subjects and were soon trained to record accurately the subjects' responses. This procedure proved economical of time and had the advantage of individual presentation. The subjects came in groups of five to a spare classroom and after some preliminary conversation with the experimenter and the students, were introduced to the procedure expected of them, by an introductory tape. The subjects settled quickly to the conditions and responded well. As before the introductory material consisted of simple 'messages' to be repeated back to the recorder until the stimulus reached experimental length. A short rest was given to the subjects when this point had been reached. After this the group was taken through a complete set of materials, though only one set was given to any one subject on any one day. The STM tasks were given to the subjects individually by the experimenter on a different day to the syntactic structures.

7.4 Results of Experiment 3

7.4.1 Details of Subjects by Age and Sex

As in Experiment 2 there were three age groups covering the same age range. Group 1 was between 4½ and 5½ years (mean age 62.03 months), Group 2, 5½ to 6½ years (mean age 76.78 months), and Group 3 between 6½ and 7½ years (mean age 85.68 months). The details of subjects' ages and sex are shown in Tables (25) and (26).

Table 25
Number of Subjects in Groups

Group	Number of Subjects		
	Boys	Girls	Total
1	17	21	38
2	20	13	33
3	33	38	71
Total	70	72	142

Table 26

Mean Ages of Subjects by Groups
(in months)

Group	Boys	Girls	Group	Group S.D.
1	62.18	61.91	62.03	3.488
2	75.45	77.31	76.78	3.391
3	86.34	85.13	85.68	4.126

7.4.2 STM Results

These results are given in the table below by group and sex. There is significant correlation between CA and STM ($r = 0.2743$, $p < 0.01$).

Table 27

Mean STM Scores by Age and Sex

Group	Boys	Girls	Group	S.D.
1	3.482	3.666	3.54	0.612
2	3.52	4.25	3.793	0.736
3	4.03	4.20	4.12	0.659

7.4.3 Length of Schooling (Group 1)

As in Experiment 2, a record of the length of schooling of the youngest age group was made. The mean number of weeks for the boys was 18.31 and for the girls it was 20.50 weeks; the total mean for Group 1 being 19.53 weeks.

7.4.4 Performance on Transformational Structures

Two sets of material, Set A and Set B, were presented to all the subjects for immediate recall: the mean scores for the three groups are set out in Table (28) below, by age group and sex. The girls' scores are superior in Groups 2 and 3 to a significant level.

Table 28

Mean 'T' Scores by Age Group and Sex

Group	Sex	Set A	Set B	A + B	p <
1	Boys Girls	15.882 11.857	7.294 4.667	23.176 16.524	NS
2	Boys Girls	13.650 23.92	6.550 14.530	20.200 38.461	0.01
3	Boys Girls	20.000 23.973	10.33 16.08	31.757 40.236	0.02

The total mean scores for the groups for Set A and Set B are recorded in Table (29). The scores indicate a significant increase with age. The correlation (all subjects) between CA and 'T' scores was significant ($r = 0.3457$, $p < 0.001$).

Table 29

Mean 'T' Scores by Age Group for Set A and Set B

Group	Set A	Set B
1	13.87	5.86
2	18.00	9.76
3	22.12	13.42

A summary table of the correlations (all subjects) between CA, STM, and 'T' scores is shown below.

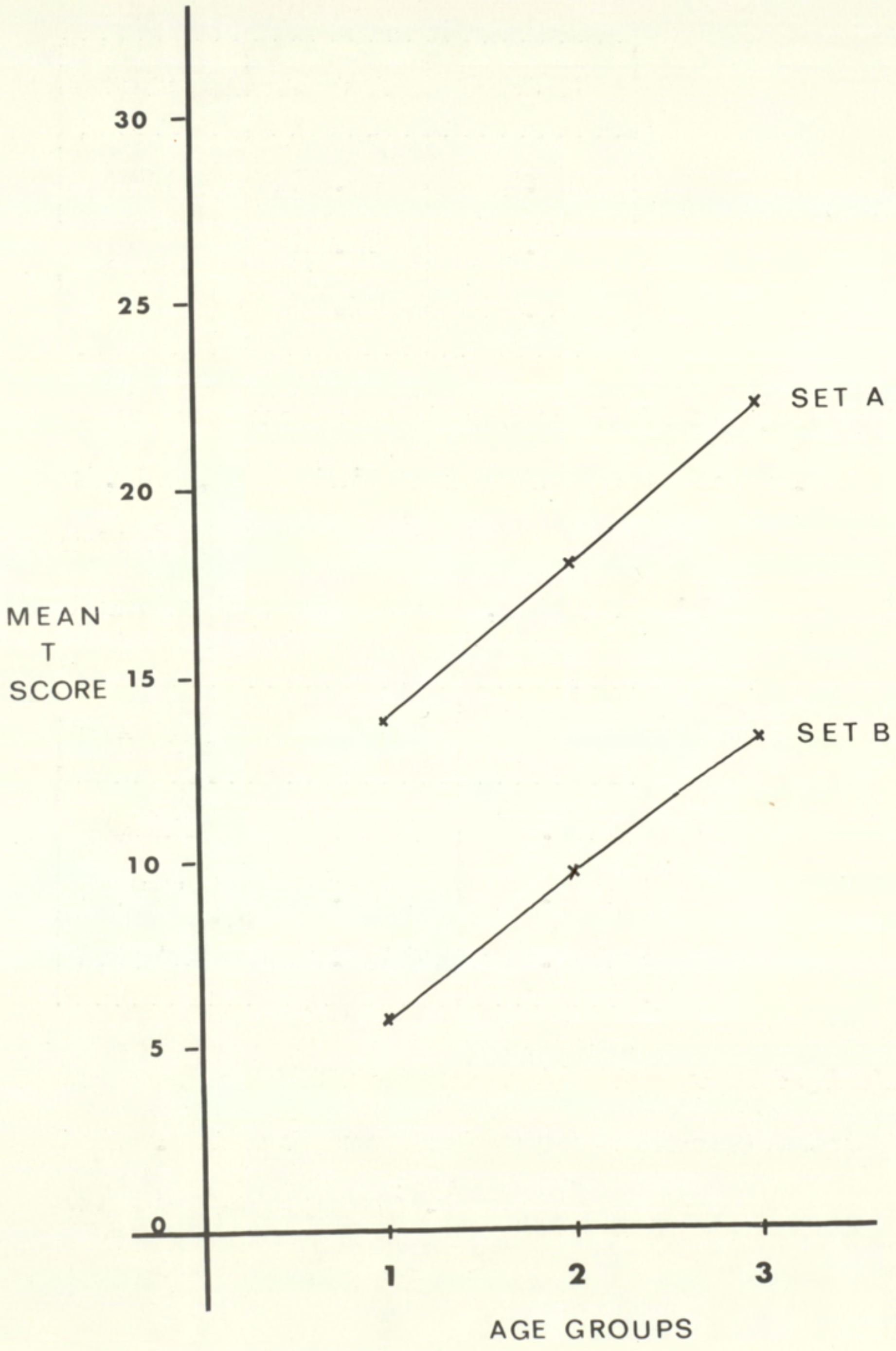
Table 30

Correlation between CA, STM and 'T' Scores

n = 141	r	p <
CA/STM	0.2743	0.01
CA/'T'	0.3457	0.001
STM/'T'	0.9704	0.001

Table (29) data is presented in graphical form in Figure (16) below. The increase in mean scores on Set A, and Set B can be clearly seen.

Figure 16.



7.4.5 Analysis of Transformational Scores

The mean scores for each transformation in Set A is given in Table (31). The increase in scores with age is again shown as is the decrease in score with increasing complexity of syntactical structure.

Table 31

Mean Scores by Age Group for Each Transformation in Set A

Transformation	Group 1	Group 2	Group 3
T1	4.158	4.969	5.565
T2	1.763	4.363	5.568
T3	2.342	3.393	4.315
T4	2.737	3.303	4.354
T5	0.710	1.666	2.256

In Table (32) the mean scores for each transformation in Set B is given by age groups. The marked effect of the low frequency vocabulary of Set B can be observed, the means in each cell being smaller than in Set A. However, the age pattern is clearly defined by increasing means. The decreases in mean scores are apparent as the structure increases in complexity.

Table 32

Mean Scores by Age Group for Each Transformation in Set B

Transformation	Group 1	Group 2	Group 3
T1	1.473	2.030	3.185
T2	0.763	2.121	2.753
T3	1.078	1.939	2.528
T4	1.631	2.757	3.541
T5	0.632	0.848	2.593

The data from the above Table is presented graphically in Figure (17) below. The age effects are shown, the decreasing scores for complexity of structure, and the marked effects of vocabulary control.

The shapes of the graphs show clearly some of the relationships existing between the various mean scores for the transformations. The mean score in Set A for each age group starts, in each case, at a higher point than Set B scores, for each transformation. The empirically derived overall descending pattern of the individual transformations reveals differences in T2 for Group 1 for Set A, and T4 in Set B. Looking at the detailed scoring of T2 for an explanation of this, it was found that a large number of subjects responded with the diminutive 'cos' instead of using the complete word 'because'. Consequently they were not credited with correct recall. The scripts were, therefore, re-marked crediting the use of 'cos' when it occurred, to make the following comparisons. Table (33) gives these details.

Table 33

Revised Mean Scores for T2 by Age Group for each Set

	Group 1		Group 2		Group 3	
	n/c	c	n/c	c	n/c	c
T2 (Set A)	1.763	3.711	4.363	5.788	5.568	7.000
T2 (Set B)	0.763	1.026	2.121	2.515	2.753	3.188
T2 (A + B)	2.526	4.737	6.483	8.303	8.309	10.188

<u>Note</u>: n/c = 'cos' not credited correct

c = 'cos' credited correct.

Figure 17.

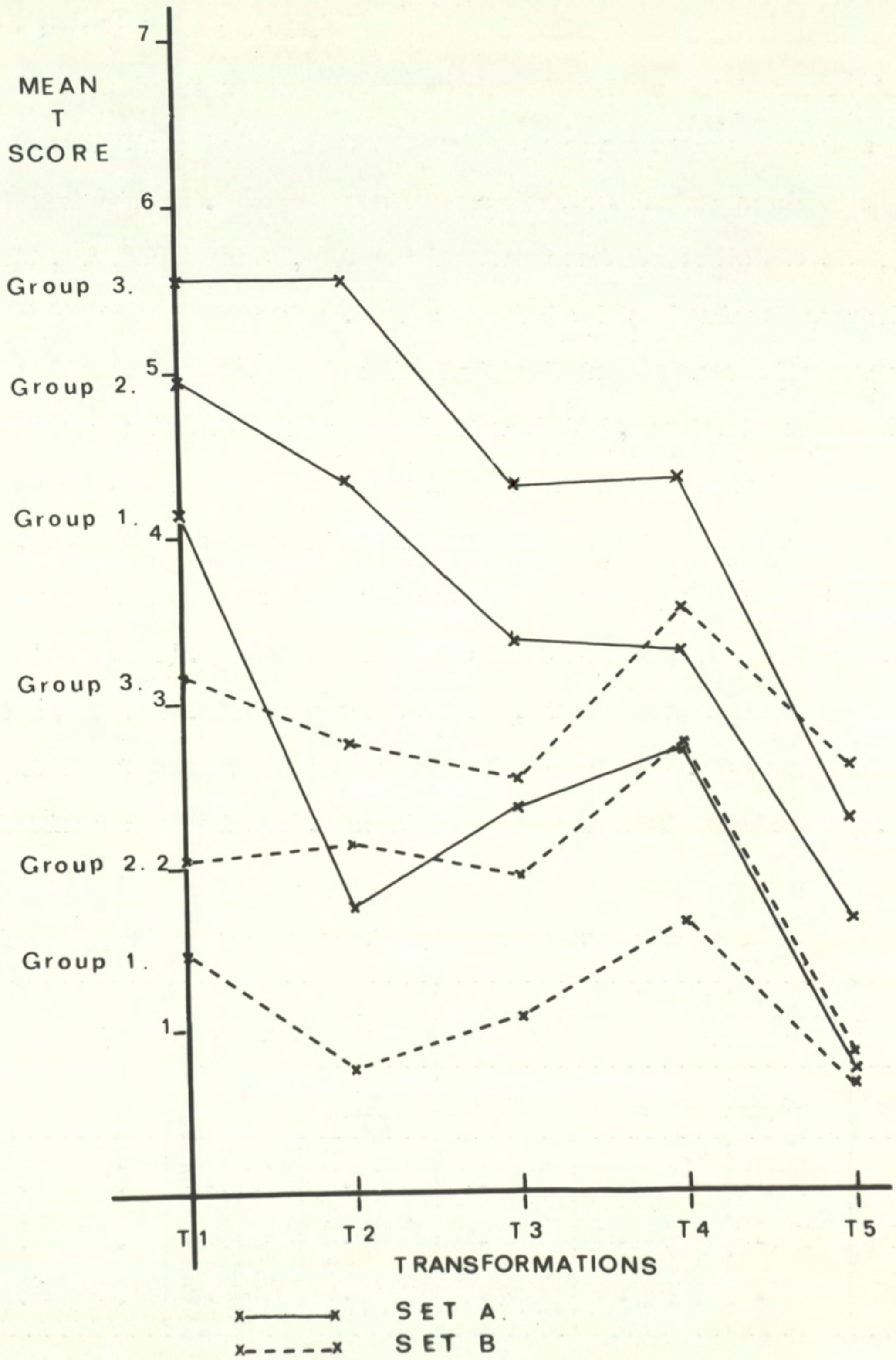
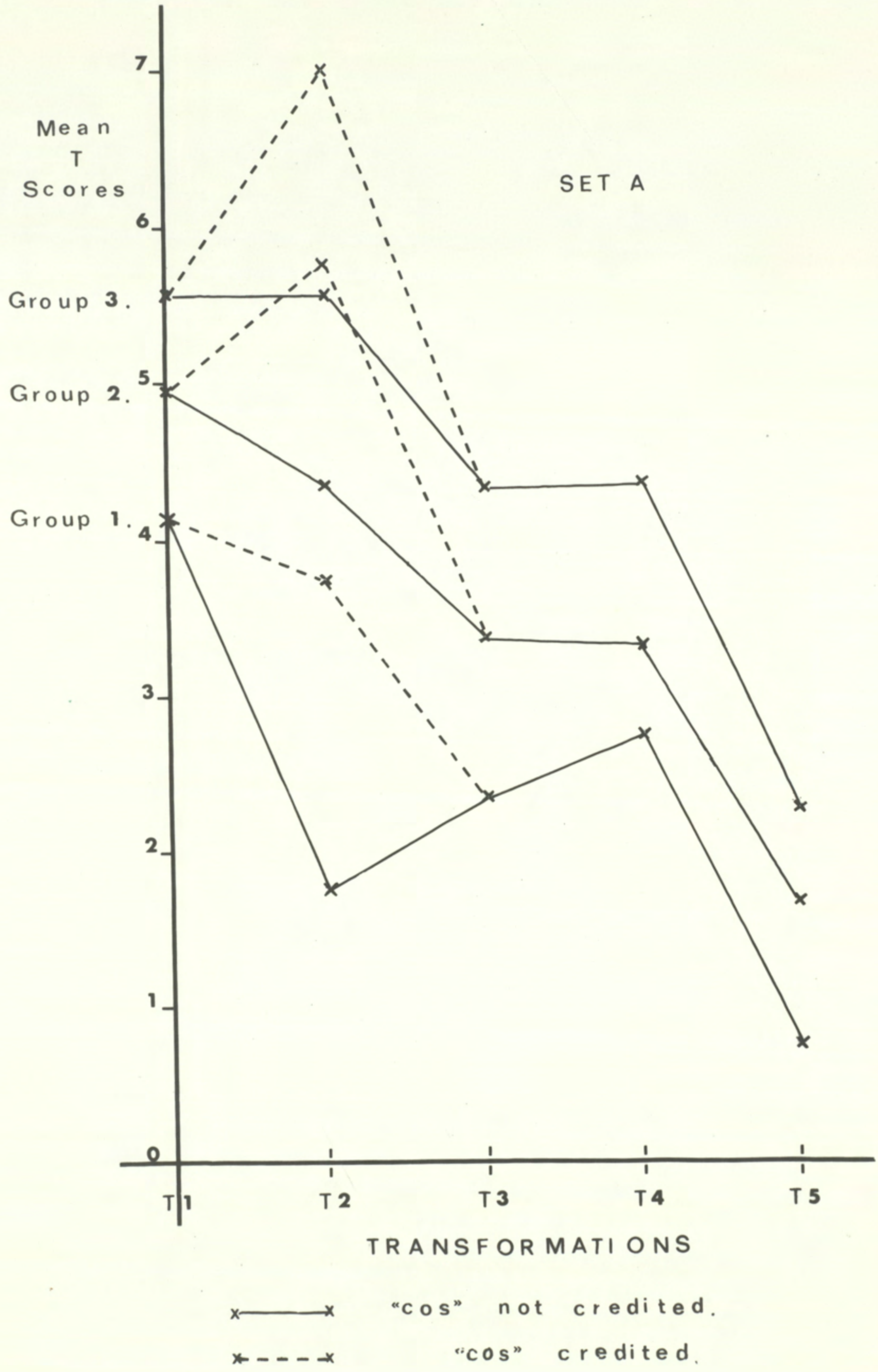

7
MEAN
T
SCORE
6
Group 3.
5
Group 2.
Group 1.
4
Group 3.
3
Group 2. 2
Group 1.
1
T 1
T 2
T 3
T 4
T 5
TRANSFORMATIONS
SET A.
SET B

Figure 18.


Mean
T
Scores
SET A
Group 3.
Group 2.
Group 1.
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6
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4
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2
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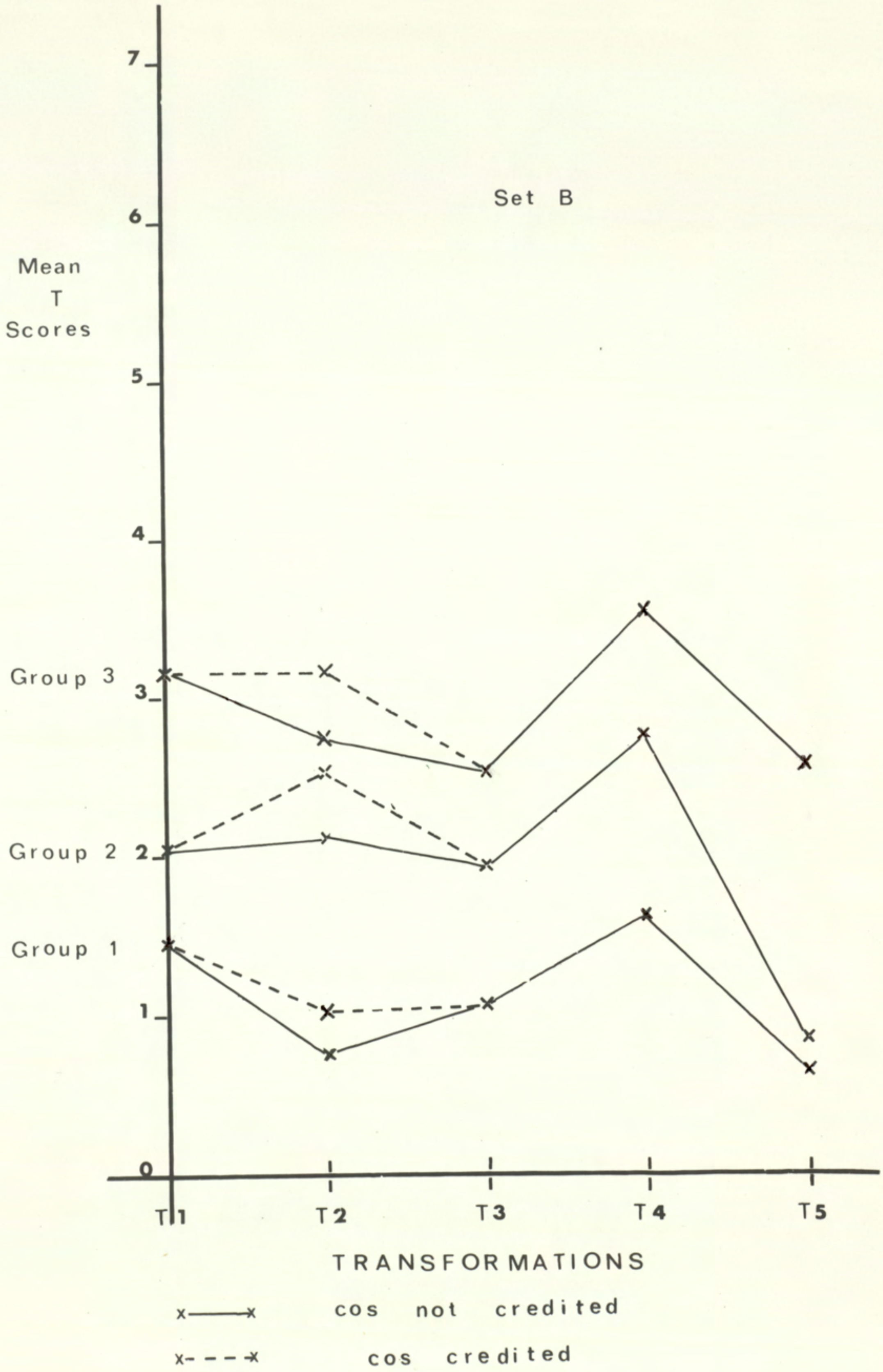
T1
T2
T3
T4
T5
TRANSFORMATIONS
"cos" not credited.
"cos" credited.

Figure 19


Set B
Mean
T
Scores
7
6
5
4
3
2
1
0
Group 3
Group 2
Group 1
T1
T2
T3
T4
T5
TRANSFORMATIONS
cos not credited
cos credited

The data in Table (33) is recorded in graphic form in Figures (18) and (19) above. The decline in scores for transformational complexity is indicated by the shape of the two graphs; the marked effect of vocabulary in the difference between the two, and the effect of crediting 'cos'.

When the results of the two Sets are put together, the graph of the individual transformations shows the acquisition pattern by age group. Figure (20) below gives these patterns.

It will be noted from this presentation (Figure (20)), that the crediting of the term 'cos' brings the results of T2 into line with the general acquisition pattern. However, the pattern also shows that T4 is more readily recalled than T3, and this is especially marked when the vocabulary is of low frequency (Set B). Due to these variations within the overall pattern, it was decided to apply an Analysis of Variance to the results to establish whether or not there are interaction effects between the three main variables of age, structure and vocabulary, and whether they are of significance.

7.4.6 Analysis of Variance

The design followed for the statistical treatment was a three-factor model with repeated measures on two of the factors, adapted from Winer (1962). A schematic representation of this model is given below, Table (34).

Figure 20

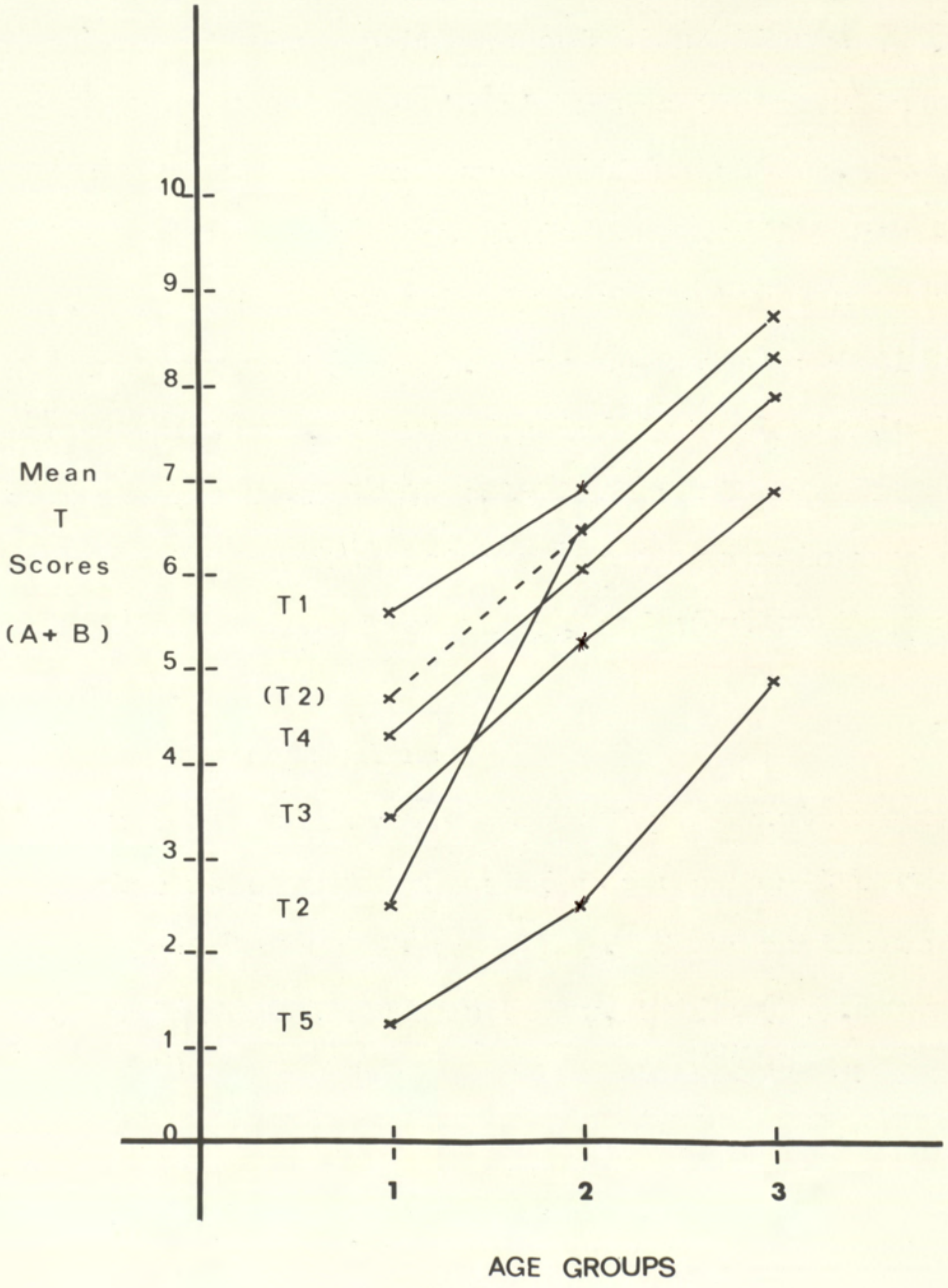


Table 34

	B1					B2				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	G_1	G_1	G_1	G_1	G_1	G_1	G_1	G_1	G_1	G_1
A2	G_2	G_2	G_2	G_2	G_2	G_2	G_2	G_2	G_2	G_2
A3	G_3	G_3	G_3	G_3	G_3	G_3	G_3	G_3	G_3	G_3

In this experiment A1, A2, and A3 are the three age groups, B1 and B2, the two levels of vocabulary, and C1, C2, C3, C4, and C5 the five levels of transformational complexity. Each subject in each age group has been observed under each combination of B x C. The original plan of the experiment called for equal group sizes; however, in this particular instance for reasons unrelated to the treatments this did not happen in the completed study. The procedure for unequal group size was followed (Winer, 1962), an unweighted means solution being the more appropriate.

The analysis gave the following results.

Table 35

Analysis of Variance of the Factors, Age, Vocabulary and Structure

	SS	df	Variance	Variance Ratio	p
A	15.7113	2	7.85567	20.540	<0.01
B	16.7648	1	16.76478	43.834	<0.01
C	16.7097	4	4.17741	10.923	<0.01
AB	0.338677	2	0.16934	1.411	NS
AC	1.60987	8	0.20123	1.677	NS
BC	5.50537	4	1.37634	11.467	<0.01

This analysis (Table (35)) confirms that the three variables chosen as important in the experiment are significant ($p < 0.01$) and that there is a significant interaction effect between B and C, that is between Vocabulary and Structure.

7.4.7 Analysis of Variance (2)

Table 36

Analysis of Variance of the factors, STM, Vocabulary and Structure

	SS	df	Variance	Variance Ratio	p
A	58.2218	2	29.11089	87.073	<0.01
B	15.0620	1	15.06200	45.052	<0.01
C	14.6188	4	3.65471	10.932	<0.01
AB	0.632383	2	0.31619	9.587	<0.01
AC	1.00804	8	0.12601	3.821	<0.05
BC	5.45090	4	1.36272	41.319	<0.01

In this analysis A = STM; B = Vocabulary, and C = Structure. All the factors and the interactions gave significant results although the significance of the STM/Structure interaction is less than the others.

7.5 Discussion of Results

7.5.1 Developmental Trends in the Control of Syntax

The experimental results demonstrate that the three main factors of age, vocabulary and structure are significant variables in the tasks chosen to illustrate the subjects' ability to handle syntactic structures of differing complexity. The effect of this complexity is in evidence when the results of T5 in particular are instanced. In both sets of material T5 is consistently less readily recalled than the other transformations and grammatically is by far the most complex including negatives, passives, tense difficulties and 'might', yet this complexity is better controlled as the age of the subject increases. Although there is some variation of position within the overall pattern of the transformations when the age group results are compared, the graphs nonetheless show an overall steady fall (in line with complexity) with mean scores (Figures (18) and (19)). This again could be interpreted as showing that the chosen structures do indeed exhibit differing levels of syntactical complexity and that this is reflected in the subjects' perception of the sentence. However, due to the change of position within the pattern there is reason to think that the grading of the degree of complexity is not reliable. It could be stated, of course, that the structures are more readily perceived and therefore recalled more easily, simply because of their frequency of occurrence, but this in itself may again only reflect this differential complexity in that the less complex structure is the more employed (and thus more familiar) in the early speech of the child.

The choice of vocabulary, drawn as it was in Set B from the less frequently occurring words depresses the mean scores, but the pattern of acquisition by age remains consistent. However, it would appear that, not only does this variation of vocabulary make perception of the structures in total more difficult, but also reveals important interaction effects between vocabulary and structure. This interaction has the effect of altering the positions of the individual transformations in the acquisition pattern. The two main factors of vocabulary and structure cannot then be regarded as separate; they must be considered together in acquisition. Illustration of this is seen in the graphs (Figures (18) and (19)) where T4 is more readily recalled by each age group than T3 in Set B, but not so markedly in Set A though there is indication of the process with Group 1. When the results of the two sets are combined T4 results are superior to T3 (Figure (20)). The descending order now becomes T1, T2, T4, T3, T5, and this is maintained through the age range.

7.5. 2 Individual differences

The results indicate again the wide range of individual differences to be found in the performance of the subjects on the three tasks. The scores of the girls in Groups 2 and 3 show superiority (Table (28)) in recalling the Transformations, but not in Group 1. These differences (i.e., in Groups 2 and 3) were significant. Again the girls have higher STM scores (Table (27)), Group 2 having a whole unit difference. As the experimental task was one of immediate recall, the superiority of the girls' transformation scores is to be expected if their STM capacity is greater than the boys. Without further corroboration it is difficult to follow this point further, but it is interesting to note that the girls' superiority with the language processes in these studies may be linked with their superior STM scores. Further work might show, therefore, that this association underlies the superiority of the girl with verbal materials in the school situation.

8. FINAL SURVEY

This final discussion has the following format.

Firstly, there is a re-statement of the aims and purposes of the investigation; secondly, a summary analysis of the three experiments, and thirdly a synthesis of the results of these three phases in a final conspectus.

8.1 The Purpose of the Study

The aim of the study has been pedagogical (1), that is, the work has been so designed as to provide fundamental background knowledge of language processes for the design and improvement of teaching procedures and materials especially for the first years of schooling.

Language is a prerequisite skill, yet it is still in the process of acquisition during the primary school years. New ways of looking at the structures comprising this skill, the systematic organisation of its fundamental rules and the acquisition of those processes, have been recently put forward by the science of linguistics in such a way as to resemble psychological models. It was hoped that these formulations would be of assistance in the investigation of language acquisition and at the same time enable a further study of the psychological mechanisms involved.

8.2 Review of Experiment 1

This was designed to look at the characteristics of STM and its quantification. Here it was found that the traditional method of measurement was highly correlated with the methods based on Information Theory. Although there was no theoretical reason for not using these mathematical techniques further, it was decided to employ the traditional method as it is more economical in time. Although the informational techniques did not appear to be superior in any way, the matrices (Figure (3)) demonstrated an interesting example of the concept of an information transmission model. Pont (1963), in a study of the effects of age on channel capacity, has shown that it increases steadily with age. His subjects' ages ranged from 10 years to adult, the channel capacity approaching asymptotic values at particular ages, and the greatest increase being between 10 and 12 years with his particular material. Although the stimulus material of word frequencies used in the present experiment were quite different (Pont used the subjects' ability to judge the position of dots on a matrix), these results support Pont's finding of a measurable channel capacity increasing with age. His results, as did those in this study, gave clear indication of the amount of individual difference in this channel capacity, pointing to the possibility of further work using similar quantitative techniques. Pont concludes further that methods of increasing channel capacity are learned.

The study of the characteristics of the STM store, bearing in mind its alleged intimate relationship with language processes, enabled variables to be further controlled in Experiments 2 and 3. In addition to this, a successful attempt was made to use words that were appropriate to the subjects under investigation, remembering both their chronological age and environment. The viability of the materials thus confirmed gave opportunity for those same word counts to be used confidently in later work. The result of the measurement of reading progress was also of interest as it gave encouragement to the notion that the close connection posited by some between STM and language processes was being reflected in reading skill.

8.3 Review of Experiment 2

In contrast to Experiment 1 with unstructured materials, Experiment 2 looked at the subjects' performance on structured materials using the immediate recall of transformations. In addition other relevant factors were recorded. Developmental trends in the subjects' increasing control of syntax was observed and some notion of the position of the individual transformation within a grading of complexity was gained.

A very recent book with a linguistic background (Chomsky, C, 1970) shows that children between the ages of five and ten are still acquiring syntax surprisingly late - especially when the syntactic structures are complex. The structures used in this study were:

1 John is easy to see

2 John promised Bill to go

3 John asked Bill what to do

4 He knew that John was going to win the race.

Considerable variation was found in the ages of the children who knew the structures and those who did not. Structures 1, 2, and 3 are strongly subject to individual rate of development. Structures 1 and 2 are acquired between the ages of 5.6 and 9 and are known by all children 9 and over. Structure 3 is still imperfectly learned by some even at age 10, and Structure 4 is acquired fairly uniformly at about 5.6. Active syntactic acquisition is taking place up to the age of 9 and perhaps beyond. This work substantiates the findings of Experiment 2 and Experiment 3, that the child's ability to process structures increases with age and that there is a developmental trend when material is characterised by transformational grammar. During this experiment, hints were given of the importance of the vocabulary chosen for structuring, especially by the reflexive transformation. This factor of inter-dependence is taken up more fully in Experiment 3, and is discussed there. However, the drop in mean scores for the 'Because' transformation shown by the marked effect of the low frequency word count, underlines the great importance of the semantic component, as emphasised in the work of Herriot (1970).

The importance of STM was discussed as the developmental trend of acquisition is apparently one of increasing control of complexity, and the amount of STM capacity available has been shown to facilitate this processing by Graham (1968). Remembering, of course, that the experimental task was one of immediate recall, STM was seen to be of importance in this study. A correlation between the immediate recall of unstructured strings (STM tasks) and structured strings (transformation tasks) was expected, but the high correlation, considering the complexity differential, suggests that STM is indeed an important psychological factor in the control of syntax.

The other measure of maze threading and its correlations is also of interest. Porteus (1941) claims that this measure of 'planfulness' is essential to every intelligent act.

'Until the activity becomes automatic through repetition, this prehearsal and choice of alternatives is characteristic of speech, literary composition, ... and so on through the whole list of humanly adjusted conduct.'

In the discussion following Experiment 2 (6.3.2), it was stated that the maze was most probably reflecting increasing maturity of the subjects and with it the level of performance on the transformation tasks. There is the possibility, however, that the maze detects the ability to 'look ahead' in the way that speakers look ahead to the completion of a sentence, but this needs much further investigation.

The other interesting factor to be noticed in this review is the difference in performance of the sexes. The boys have a slight superiority on the maze and the girls on STM tasks. The maze, it should be recalled, gives superiority to the male but the findings are in accord with another set of results. McCall (1955) carried out a study into the sex differences in Intelligence employing three intelligence tests comprising 31 sub-tests. The boys' mean scores were significantly higher than the girls' in 15 of the 31 sub-tests and 11 of these 15 tests were non-verbal. The Porteus maze test was a non-verbal performance test. Furthermore, in the McCall study, the girls were shown to be superior on the verbal tests. In this work girls' scores are shown to be slightly superior on Set A and Set B in Group 1 (Table (7)).

The low correlation with the length of schooling was also noted with interest as this could be interpreted as showing that the experiences provided by the school situation were not enhancing (or speeding) the subjects' ability to recall structures of this type, or that other factors were prohibiting progress. However, this is very speculative as much more control of experimentation with larger numbers of subjects is needed to isolate the many factors involved.

The experiment then investigated the possibility of measuring the acquisition of transformations during early schooling in terms of immediate recall. Other data was also collected due to the inconsistency of reported results (Griffin, 1968).

8.4 Review of Experiment 3

Experiment 3 took the investigation of the main findings from the performance on structured materials, and the relationship of basic STM, a stage further.

The structure of the word strings in this experiment was again in transformational terms; the words were strictly controlled by their frequency of occurrence, and STM measured by unstructured strings of words selected from the same word counts. The results demonstrated the following factors. Firstly, the structures had a differential effect reflecting the differences of their syntactical complexity. This, in turn, can be observed as a developmental trend, assuming the least complex to be acquired more readily than the most complex. Secondly, the effect of varying the vocabulary, shown by the comparison of words selected from a high frequency list on the one hand, and a low frequency list on the other, was to depress the mean scores. Interdependence between structure and vocabulary was also shown. This might be interpreted as the interaction between the syntactic and semantic components. Again, STM was measured and seen by the correlations to be an important psychological mechanism in this processing. The CA/STM correlation for all the subjects was significant ($r = 0.274$, $p < 0.01$), and the CA/T score more so ($r = 0.346$, $p < 0.001$).

The interaction of the variables is demonstrated in the analysis of variance (1). Here the main variables of Age, Structure, and Vocabulary are found to be significant beyond the 0.01 level, with Structure and Vocabulary interacting. In the analysis of variance (2) looking at Structure and Vocabulary in terms of STM, further evidence of relationships was demonstrated. STM interacted with the other main factors of Vocabulary and Structure, and Vocabulary and Structure themselves also interacted to a significant level.

8.5 Conspectus

In this study a pattern of transformational acquisition with age has been demonstrated empirically, and it has been shown in linguistic terms what has been acquired. Transformational grammar has moved the description of syntactic structures a step nearer objectivity, although it is still far from a quantitative description. Many attempts have been made to quantify syntactic complexity. For example, Yngive (1960) referred to the depth of a sentence; Miller and Chomsky (1963) tried a node/terminal node ratio; Schlesinger (1966), the degree of nesting; Graham (1968) hints at yet another method and Sheldon and Osser (1970) have recently put forward what they call a psycholinguistic model based 'on the fundamental logical operations underlying phrase - and transformation - rules.' The authors claim that their model has so far been successful, but further corroboration is awaited. This work has further pertinent interest, for in their discussion they state

'... we have observed that both the average complexity scores and the number of different transformations used, as well as the proportion of double-based transformations generally increase with age ...'

But how does this process take place? What are the information-processing skills and strategies that the child must possess in order to acquire such linguistic knowledge when exposed to the speech of his language community?

The basic design of this investigation was a comparison of the performance by young children with either unstructured or structured word strings. The words used for immediate recall (the method chosen to observe performance) are consistently controlled in all three experiments, (by their selection from Burroughs's word counts) and in this way, more information about structure per se was exposed.

Language activity is structuring activity, and whilst there is no agreed definition of structure, nonetheless it is shown to exist at specific levels of language - the phonological, the morphological and the syntactical levels. This study has concentrated on the syntactical level as most requiring observation and understanding at the age chosen for investigation. The performance of the subjects on the unstructured material was observed to be of a limited nature, the highest score for a subject in Experiment 1 being 6.4 items, thus demonstrating their limited short-term storage capacity. It should be remembered that the capacity of basic STM is shown to increase only very slowly with age, yet it hardly needs an experiment to show that the child is able, from a very early age, to process sentences far longer than his basic STM capacity. The difference between the performances, then, is the facilitation provided by structure.

This leads one to suspect that the answer to 'How' the child is able to process sentences of greater length than his memory span, may be found among the characteristics of STM reviewed earlier (3.2), especially among ways shown to exploit more effectively basic STM capacity. It has been shown by Graham (1968) and is supported here, that the greater this basic STM capacity, the better able the subject is to deal with the actual complexity of the structure. In a recent review of work that has been done investigating STM, Belmont and Butterfield (1969) report on its relationship to development and intelligence. How much a person remembers is a complex measure, they point out, determined partly by the amount he acquires at the time the material is presented, the rate at which he forgets what he acquired, and the accuracy with which he retrieves what he has not forgotten. Changes in any of these determinants might underlie increases in STM as a function of age and intelligence. They conclude however, that forgetting rate decreases neither with age nor with intelligence. The great superiority of older and more intelligent people is due, apparently, to differences in acquisition or retrieval, or to some combination of these factors. Older and more intelligent subjects are said to employ more active acquisition strategies. Differences between child and adults of average intelligence may, however, be due both to differences in acquisition strategy and to children's use of less effective retrieval strategies. From this review of research, it follows that the child may well have to learn economical methods of promoting successful acquisition and retrieval to overcome what Miller has called the 'bottleneck' of STM. Growing efficiency may be achieved perhaps by active organisation of the stimulus being presented, by perceiving its syntax, thus promoting both acquisition of input and retrieval for output. (Reference has been made already to Pont's (1963) study where it is also suggested that increases in channel capacity are learned.) It is hypothesised here that the observed rule governed behaviour fits this formulation, the rule being a syntactical rule (a transformation) perceived in the incoming speech and re-applied during repetition.

Looking further at STM as the major cognitive mechanism involved, we saw earlier (3.2.6) that, although little experimentation supports it, one method of exceeding the span of immediate memory was by the process known as 'recoding' or to use Miller's terminology, 'chunking'. If we compare the performance of the two students to increase their memory spans for instance (3,2.5), longer spans were achieved when a process of grouping was employed. This could be looked upon as actively organising acquisition. Crossman (1961), commenting on the higher spans of his subjects with digits and alphabet, goes further when he states,

'However, these two vocabularies are most certainly more often used for immediate recall in daily life than the others, and so receive more practice. It may be that specific skills, perhaps based on coding, are developed for these materials.'

The result of an early experiment to increase memory spans with child subjects (Gates and Taylor, 1925), did not lead to a permanent enlargement, however, and the spans shrank when the practice sessions ceased. There was, however, an increase during the practice. It would seem that the span is indeed limited in the amount that it can retain but that variations can be made to increase the basic capacity, but these require considerable learning and practice. Unfortunately, there is no report on Martin and Fernberger's (1928) students after their practice sessions; perhaps their digit

span decreased also when experimentation ceased.
Intuitively, it might be expected that if the experiment was repeated with the same subjects, the ability to extent their spans by grouping would be revived quicker than it took originally. Smith's coding experiment (with binary coded numbers) did not succeed with his student subjects with the most difficult ratios, but did prove successful when he learned the coding procedure himself. The learning of the codes had to be such that they could be applied almost automatically - a skill characteristic - to attain his impressive results, a span equivalent for 36 digits.
Applying the knowledge gained from these investigators, we might expand further the hypothesis that the child subject actively organises the input into familiar 'chunks' and that a process of learning (or familiarisation) with rules has gone into the formation of these units.
Miller's (1956) propositions are similar. He suggests that, since the memory span is a fixed number of 'chunks', the number of bits of information that it contains can be increased by building larger and larger 'chunks', each 'chunk' containing more information than before.

'The operator recodes the input into another code that contains fewer 'chunks' with more bits per 'chunk'. There are many ways to do this recoding but probably the simplest is to group the input events, apply a new name to the group, and then remember the new name rather than the original input events.'

It will be remembered that one of the methods hypothesised for the recall of transformations was that the underlying abstract structure (called the kernel in Chomsky's earlier theory, 1957) of the utterance would be stored along with the transformational 'tag' (Mehler, 1963). Here the tag (or Crossman's (1961) random-address model might be also considered), could be the new 'name' (of a group) to be remembered. The suggestion of a transformational 'tag' is preferred here, as evidence has been provided by the study of Bellugi (Klima and Bellugi, 1966) who attempted to show this tag preceding early transformational utterances. Accepting this model for discussion, we have to ask next how this transformational tag is acquired? The tag would appear to accompany the sentence, signalling the application of the transformational rule. The trends in acquisition shown by the study point to the subject learning these transformational rules, together, presumably with the associated 'tag'. Some support to the rule learning is given by the errors of the younger subjects when their responses contained simpler forms than those presented. When, in order to recall the complete stimulus, the subject had to perceive a combined transformational operation (e.g., T5), some of the younger subjects often recalled part of the structure in such a way that a rule governed process was observed, although the total response was incomplete. Often a word was omitted (evidence of insufficient STM capacity), revealing part acquisition of the transformational rule or inability to cope with the complexity involved with double transformations. The older child was able to cope with the rules involved, pointing to familiarisation (or overlearning) reaching a further skill characteristic - automatisation of performance.

Next, consideration must be given to the 'signal' provided by the tag, which triggers the transformational rule. The results of the Analysis of Variance provide interest here as perhaps certain key words, and their (word) associations are involved. Interaction effects between word and structure might support this, but this remains speculation at the moment though certainly vocabulary and structure are intimately connected.

Summarising the proposals, then, it is suggested that with the adult the process of organisation of the input and its retrieval has reached automatic levels (skill has been acquired) but the child is still in the process of acquiring these skills. This acquisition takes the form of increasing competence at organising the input so that memory processes may facilitate even longer and more complex utterances far in excess of the basic memory span which is so limited and slow in growth. It is further suggested that the input is organised in terms of grammatical rules, and that the scheme of generative transformational grammar describes these rules in a systematic fashion allowing experimentation. Hunt (1970) makes these observations about these rules,

'The concepts of transformational grammar suppose that the number of different syntactic shapes of the elementary sentences themselves is relatively small. Secondly, it supposes that the number of different combining transformations is also relatively few. But the number of possible combinations and permutations of these relatively few transformations is vast. In this way, the richness of language production is built up.'

This organisation of rules does not imply, however, that the innate mechanisms hypothesised by some psycholinguists are thereby accepted, but that, at the moment, the theory posited by Chomsky (1965) best describes the material being acquired and gives some hints to the acquisition programme.

There are indications in this study, supported by the clear developmental trends shown in the acquisition pattern, that sentence structuring is learned, and that, furthermore, the material being structured (the words) is an integral part of the process. This intimate connection between words and structure may be obvious at first sight (one can hardly learn structuring without something to structure) but the exact nature of this relationship is apparently very intricate. It is suggested that the words and the structure are learned together, in such a way that certain words, essential to the transformation, signal the application of grammatical rules, described here by Chomskian transformations.

For language production, then, it could be said that the notion to be communicated is contained initially in the semantic component, which lies within the deep structure. This abstract object is then translated by the transformational organisation into the surface structure, which is the overt structured string of words.

The mechanics of this transformational process may be explained perhaps in terms of learned associations of certain key words within the vocabulary being employed, with their appropriate structure of grammatical rules. This is, as stated, hypothetical; there is still much to be investigated and many ideas for future research and experimentation are to be found in this summary.

The individual differences noted in the study are in line with many other educational studies, showing the girls' superiority in language activities. A recent longitudinal study by Moore (1967), for instance, exploring the part played by language in early mental development, found indications that 'it is more salient in girls than boys.'

It is suggested that girls may be more interested by nature in communicating; boys on investigating the properties of objects. The findings of Experiment 2 are in accord with this, for the boys' results showed superiority on the non-verbal performance task (Porteus Maze), whereas the girls had higher results in the main on verbal tasks (transformations). There is a need here for more work establishing these relationships, in particular the relationship between the girls' STM capacity and performance on language tasks.
The pedagogical implications of the investigation are important, for if the processes are learned, then it should be possible to build up relevant teaching procedures and materials to assist learning. An example of materials concerning the utilisation of language sequences may be clearly seen in early reading instruction. It is only in the last few years that any attention has been given to the adequate matching of the vocabulary used in these materials with the age of the child for whom they are intended.
Of the available reading schemes there is only one, the Ladybird Scheme of Reading primers (published by Wills and Hepworth) that bases the choice of words used on a scientific count of those most frequently used by children of the age for whom it is designed. No reading scheme, among the many published, has yet graded the syntactic structures employed for complexity, or matched them to acquisition patterns.
And yet, according to Goodacre (1968), 96% of the schools in her survey were using published reading schemes and four out of five said their instruction was based on a single scheme.
There is much room for improvement for there is still considerable failure (Cox, 1968), and materials matched to

the child's state of transformational acquisition might well ease the task for those who have difficulty. It is abundantly evident that language is a prerequisite skill and its nature and continued acquisition of fundamental importance in these early years. A considerable amount of attention has been given to early acquisition in the literature prompted by psycholinguistic studies, and lately a few works concerned with the age groups being studied here (Griffin, 1968). It is important that these advances should be employed to illuminate further the characteristics of what is being acquired and the psychological mechanisms involved in language acquisition, so that teaching may become the more efficient.

More information is, of course, needed (only a few structures have been looked at here for instance); however, the study encourages the idea that more of the pattern of acquisition awaits to be uncovered. Furthermore, deeper insights into the psychological mechanisms involved in these processes would also assist the teacher. The finding suggested by the experiments, and supported by Chomsky, C (1970), that the process of acquisition of syntactic structures continues late into the primary school (till at least nine years) suggests that the sensitive period discussed earlier (1.) lasts for a considerable number of years and is not restricted to the early infant years. This agrees with the aphasic studies also referred to in Section (1.)

One is left with the impression that much of the theory provided by the psycholinguists is pertinent for a full understanding of these problems, but yet again there are strong hints of processes more readily explained by behaviouristic learning-theory. Perhaps the closing words of an article, appropriately entitled, "Toward a Wedding of Insufficiencies", by Osgood (1968), might make a fitting closing observation:

> 'The demonstration of psycholinguistic relevance of syntactic structure is not in itself a refutation of behaviour theories. It poses problems for any theory of the language-user, those deriving from transformational grammars as well as those deriving from S - R constructs and associationistic principles. None of us is very close to an understanding of how people create and understand sentences. We will be wise to learn what we can from each other.'

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10. APPENDIX CONTENTS

10.1 Experiment 1. Specimen Sheet of Unstructured Strings

Name .... Date .... Age .... yrs .... mths

1.0	banana	pie						
1.1	apple	jam						
1.2	milk	milk						
1.3	pie	choc'te						
1.4	cabbage	tea						
1.5	tea	bread						
1.6	banana	por'ge						
1.7	cabbage	banana						
1.8	tart	jam						
1.9	bread	banana						
2.0	pear	milk	milk					
2.1	salt	tart	jam					
2.2	jam	jam	jam					
2.3	fish	apple	apple					
2.4	cake	cake	egg					
2.5	egg	egg	apple					
2.6	apple	bread	bread					
2.7	cabbage	egg	fish					
2.8	fish	tea	pie					
2.9	fish	milk	milk					

3. 0.	apple	egg	jam	potato			
3. 1.	potato	jam	potato	egg			
3. 2.	cake	milk	egg	milk			
3. 3.	cabbage	apple	pear	salt			
3. 4.	pear	egg	egg	tart			
3. 5.	salt	pear	cabbage	apple			
3. 6.	apple	cake	cake	fish			
3. 7.	fish	cake	cake	cake			
3. 8.	cake	pie	potato	choc'lte			
3. 9.	fish	fish	egg	egg			
4. 0.	fish	cake	cake	cake	fish		
4. 1.	porridge	choc'	tea	banana	tart		
4. 2.	cabbage	jelly	bread	jelly	jelly		
4. 3.	bread	jelly	porridge	por'ge	tea		
4. 4.	egg	egg	egg	apple	apple		
4. 5.	apple	tea	choc'te	apple	fish		
4. 6.	fish	salt	pie	apple	jam		
4. 7.	milk	milk	pie	choc'te	cabbage		
4. 8,	tea	tea	bread	banana	porridge		
4. 9.	cabbage	banana	tart	jam	banana		

5. 0.	bread	pear	milk	milk	salt	tart	
5. 1.	jam	egg	jam	fish	apple	cake	
5. 2.	cake	egg	bread	cabbage	egg	fish	
5. 3.	fish	tea	pie	fish	milk	apple	
5. 4.	egg	jam	potato	jam	cake	milk	
5. 5.	egg	milk	cabbage	apple	pear	salt	
5. 6.	pear	egg	egg	tart	salt	pear	
5. 7.	cabbage	apple	cake	cake	fish	fish	
5. 8.	cake	pie	potato	fish	egg	porr'ge	
5. 9.	choc'te	tea	banana	tart	cabbage	jelly	
6. 0.	bread	jelly	jelly	bread	jelly	porr'ge	tea
6. 1.	egg	apple	apple	tea	choc'te	apple	fish
6. 2.	fish	salt	pie	apple	jam	milk	milk
6. 3.	pie	choc'te	cabbage	tea	tea	bread	banana
6. 4.	porr'ge	cabbage	banana	tart	jam	banana	bread
6. 5.	pear	milk	milk	salt	tart	jam	jam
6.6.	jam	jam	fish	apple	milk	cake	bread
6. 7.	cake	egg	apple	cabbage	fish	tea	pie
6. 8.	egg	jam	potato	cake	milk	egg	milk
6. 9.	cabbage	apple	pear	salt	pear	egg	tart

Memory Span: ....

Score p. 1
p. 2
p. 3 ________

10.2 List of 26 Transformation types used by Brannon (1968) in his Study.

Transformation number and Designation	Example
1. Passive	They might get locked up.
2. Negation	They wouldn't like him.
3. Question	Do you think she'll be mad?
4. Contraction	He's watching.
5. Inversion	Sometimes I help my sister.
6. Relative Question	What's her name?
7. Imperative	Get out of the house.
8. Pronominalization	There was a big daddy dog.
9. Separation	He says, "Take it off the grass."
10. Got	We've got a toy monkey.
11. Auxiliary	
(a) Be	They might be fighting.
(b) Have	I've been thinking about that.
12. Do	It doesn't have wheels.
13. Possessive	There's poppa's house and there's momma's and baby's and sister's.
14. Reflexive	She feeds herself.
15. Conjunction	A monster was there and it was terrible.
16. Conjunction Deletion	It's soft and easy.
17. If	We'll stay home if they don't have turtles.
18. So	I posted it so I get another one.
19. Because	You can't knock it down because it's going to be a big house for cars.
20. Pronoun	My sister is two and a half and she's a baby.
21. Adjective	That's a little bit.
22. Relative Clause	She doesn't like what they're doing.
23. Complement	
(a) Infinitival	They're going to fight.
(b) Participial	Ilike painting pictures.
24. Iteration	I'm trying to catch them to get them back to their cage.
25. Nominalization	He gets a strapping.
26. Nominal Compound	It's like my school band.

10.3 Experiment 3. Specimen Sheets of Structured Materials

Set A

School .... Name .... Birth

Class .... Subject ...... Sch'ng .... mn Age ... yrs ... mths

t.	eg.	Sentence	Score
6	1	John was tired because it was very late	
14	1	He might not have been stopped by them	
3	2	The girls are running to the new teacher	
12	2	The money will not be given by John	
5	2	John was told to clean his shoes himself	
8	2	The drawing of the picture pleased the teacher	
10	2	His breaking the glass made his mother cross	
12	1	The girl will not be hurt by him	
13	1	The cake had not been baked by Mary	
7	2	The policeman came so we went to play	
3	1	The doctor is coming to the school today	
15	1	He twisted his ankle because of the apparatus	
9	2	The boys have come for their new ball	
10	1	His falling down the stairs frightened his mother	
13	2	The party had not been given by Sheila	
4	1	Where are you going for your summer holidays?	
9	1	David has given his sister all his sweets	
11	1	The toy has been made by the boys	
1	2	The girls do not like their new shoes	
2	2	What do you do on Saturday after tea?	
7	1	It rained so the children went home early	
5	1	The girl looked at herself in the mirror	
4	2	How many children like to drink milk today?	
15	2	The ambulance rushed because of the awful accident	
6	2	The baby laughed because she saw the kitten	
1	1	We are not going to the birthday party	
8	1	The barking of the dog made him cry	
14	2	Janet might not have been seen by nurse	
11	2	The chocolate has been eaten by the girls	
2	1	What did the girl hide in the cupboard?	
		Total	

Set B

School .... Name .... Birth ....

Class .... Subject .... Sch'ng ...... mn. Age ... yrs ... mths

t.	eg.	Sentence	Score
11	4	The photograph had been taken by the man	
2	3	What is the name of her little dog?	
3	3	The boys are playing with the new football	
5	3	The boys and girls bought themselves some sweets	
9	3	Mother has given us books for our birthday	
12	3	The books will not be given by her	
2	4	What do you want for your next birthday?	
5	4	The girl washes herself in the new bowl	
4	3	Is that the new teacher in the classroom?	
7	4	The children were good so they went out	
4	4	How many girls are there in the class?	
7	3	The car broke down so we walked home	
13	3	The letter had not been brought by David	
8	4	The crying of the baby woke the mother	
13	4	The dog had not been hit by John	
10	3	Her smacking her sister made the teacher cross	
1	4	They do not like their new school pencils	
6	3	Janet was happy because she found the money	
14	3	Mary might not have been hurt by John	
1	3	You have not asked for your chocolate biscuits	
14	4	She might not have been chased by Alan	
11	3	The desk has been cleaned by the boy	
3	4	The children are running to post their letters	
8	3	The chopping of the tree woke the children	
6	4	The boy ran away because he was naughty	
12	4	The dress will not be made by tomorrow	
10	4	His eating the pie made him feel ill	
15	3	The baker was afraid because of the bull-dog	
9	4	The men have mended the doors and windows	
15	4	The conductor was surprised because the taxi crashed	

Total Set B

t analysis

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.

Set C   Date ....

School .... Name .... Birth ....

Class .... Subject   Sch'ng .... mns. Age ... yrs
... mths

t.	eg.	Sentence	Score
14	5	It might not have been broken by him	
4	6	Does he go home on his own boke?	
8	6	The growing of the flowers made him happy	
3	6	The birds are making their new nests now	
15	6	The captain was afraid because of the storm	
9	5	The fat lady has lost her red slipper	
7	5	The fire burnt well so we kept warm	
14	6	He might not have been brought by car	
1	5	Our teacher has not come to school today	
5	6	Mummy was making herself a new party dress	
2	5	Where do you want to go tomorrow morning?	
5	5	The girl started to cook herself some food	
10	5	Their burning the saucepan made them feel ill	
3	5	The lambs are skipping in the sunny fields	
12	6	The daisies will not be picked by them	
6	5	The boy shouted because the television went off	
7	6	It snowed hard so the roads were covered	
12	5	The chicken will not be hurt by John	
15	5	The servant awoke because the aerodrome was opposite	
11	6	The ball had been lost by the class	
6	6	The lid fell off because the bucket dropped	
10	6	Her knitting the scarf gave her some fun	
13	6	The penknife had not been bought by him	
1	6	The old cat did not drink her milk	
9	6	The lady has given the sisters the parcel	
4	5	When are you going to bring my umbrella?	
11	5	The trees had been cracked by the wind	
8	5	The digging of the garden helped the plants	
2	6	Who are you bringing to the school party?	
13	5	The letter had not been sent by post	

Total Set C

t analysis

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.

10.4 Short Version of Unstructured Material for STM Tasks

Name .... Date .... Age ..... yrs .... mths

String							
1.1	banana	cake					
1.2	bread	pie					
1.3	tea	jelly					
1.4	milk	milk					
1.5	jam	banana					
2.1	egg	egg	fish				
2.2	apple	egg	apple				
2.3	egg	jam	porridge				
2.4	pear	milk	porridge				
2.5	tea	pear	bread				
3.1	tart	jam	salt	tea			
3.2	cabbage	choc'te	salt	milk			
3.3	bread	cabbage	choc'te	tart			
3.4	potato	pie	potato	cabbage			
3.5	cake	fish	apple	jam			

Score page 1 ____

____

Strings

4.1	fish	cake	cake	apple	fish		
4.2	cake	egg	egg	apple	fish		
4.3	apple	cake	fish	egg	apple		
4.4	egg	egg	cake	fish	apple		
4.5	cake	cake	fish	jam	apple		
5.1	fish	cake	egg	fish	cake	apple	
5.2	fish	jam	egg	apple	egg	apple	
5.3	fish	egg	egg	banana	cabbage	potato	
5.4	pie	potato	tart	choc'te	cabbage	bread	
5.5	milk	salt	choc'te	cabbage	tea	salt	
6.1	jam	tart	bread	pear	jelly	tea	por'ge
6.2	milk	pear	por'ge	banana	jam	milk	milk
6.3	jelly	tea	pie	bread	cake	jam	milk
6.4	por'ge	tea	pie	pear	bread	tart	jam
6.5	salt	tea	banana	cake	bread	pie	tea

Total page 2 ____

" " 1 ____

Memory Span: ____

10.5 Experiment 3. Specimen Sheets of Structured Materials

Set A

Date ....

School .... Name .... Birth ....

Class .... Sch'g ....

St	eg.	Transformations	Score
2	7	The teacher came because the window was broken	
1	2	How many children like to drink milk today?	
3	5	The girl started to cook herself some food	
5	3	Mary might not have been hurt by John	
4	7	There was no party so the children cried	
3	1	The girl looked at herself in the mirror	
1	1	Where are you going for your summer holidays?	
2	2	The baby laughed because she saw the kitten	
4	1	It rained so the children went home early	
3	7	Help yourself to another plate of ice-cream	
3	3	The boys and girls bought themselves some sweets	
5	1	He might not have been stopped by them	
3	2	John was told to clean his shoes himself	
1	6	Does he go home on his own bike?	
1	4	How many girls are there in the class?	
2	3	Janet was happy because she found the money	
1	5	When are you going to bring my umbrella?	
5	6	He might not have been brought by car	
4	2	The policeman came so we went to play	
2	6	The lid fell off because the bucket dropped	
2	1	John was tired because it was very late	
4	5	The fire burnt well so we kept warm	
2	5	The boy shouted because the television went off	
1	3	Is that the new teacher in the classroom?	
3	4	The girl washes herself in the new bowl	
5	5	It might not have been broken by him	
4	6	It snowed hard so the roads were covered	
5	4	She might not have been chased by Alan	
4	4	The children were good so they went out	
5	7	They might not have been followed by boys	
5	2	Janet might not have been seen by nurse	
2	4	The boy ran away because he was naughty	
1	7	How far do you go to your school?	
4	3	The car broke down so we walked home	
3	6	Mummy was making herself a new party dress	
		Total Set 1	______

Experiment 3. Set B Date ....

School .... Name .... Birth ....

Class .... Sch'g ....

St	eg.	Transformations	Score
2	8	He twisted his ankle because the apparatus slipped	
3	8	The blue-tit saw itself in the clear water	
5	11	Treasure might not have been stolen by bandits	
4	8	The canteen caught fire so the firemen came	
4	11	He sold his shirt so he had to borrow	
3	9	The boys shared the prize money among themselves	
4	10	The leopard was dangerous so they took care	
4	13	The grease was spilt so the visitor slipped	
3	11	You ought to buy yourself some thick stockings	
3	10	The bridesmaid dressed herself in her velvet suit	
5	14	Kangaroos might not have been caught by anyone	
4	14	The pony came free so John sold rides	
1	12	Do you believe either tale to be true?	
5	12	Pixies might not have been scared by bumble-bees	
1	10	Where ought the new concrete arch be built?	
1	11	Are there always such storms over lonely mountains?	
2	11	The conductor was surprised because the taxi crashed	
5	8	Petticoats might not have been stitched by anybody	
2	13	The captain was afraid because of the storm	
5	13	Uniforms might not have been worn by milkmen	
1	14	When was the diamond sold by the gipsy?	
3	14	I like to exercise my special pets myself	
2	14	Few programmes were sold because of the cost	
1	9	Did the wicked pirate rob the new yacht?	
4	9	The festival was beginning so they called a taxi	
2	10	The baker was afraid because of the bull-dog	
3	12	The boys printed the school concert programmes themselves	
5	10	Accidents might not have been caused by gangs	
1	8	How many books lie on the classroom bookshelf?	
1	13	Why did the fire-engine smash into the hotel?	
2	9	The ambulance rushed because of the awful accident	
3	13	I enjoyed myself at the concert yesterday evening	
4	12	Grandma came so the wife scrubbed the landing	
2	12	The servant awoke because the aeroplane was opposite	
5	9	Concrete might not have been mixed by anyone	
		Total Set 2	___

10.6 Examples of Transformational Structures

Figure 21.

REFLEXIVE TRANSFORMATION (T 3·4)

The girl washes herself in the new bowl.

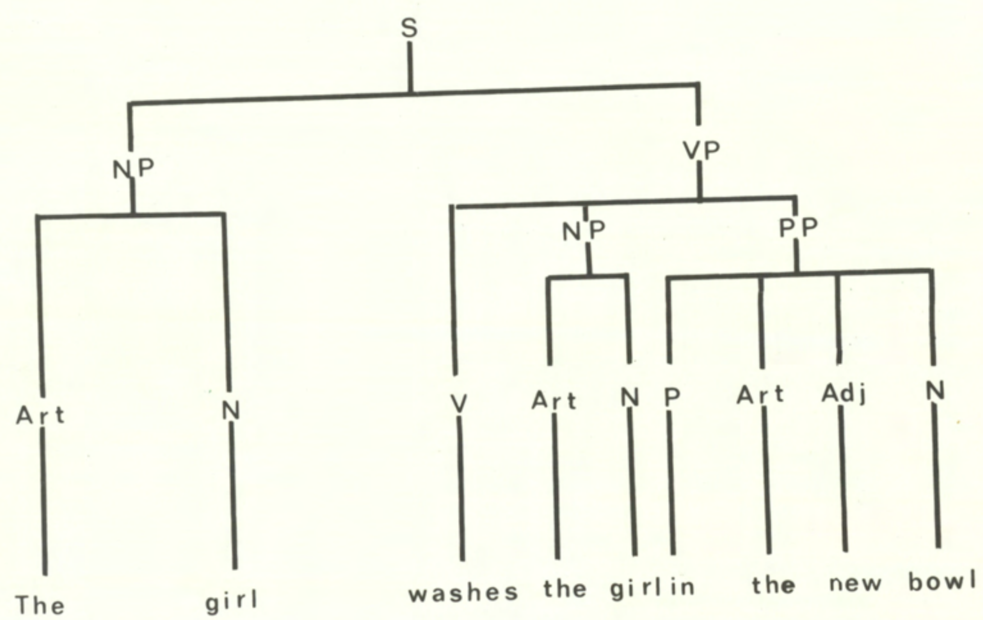


Figure 22.

BECAUSE TRANSFORMATION (T 2·5)

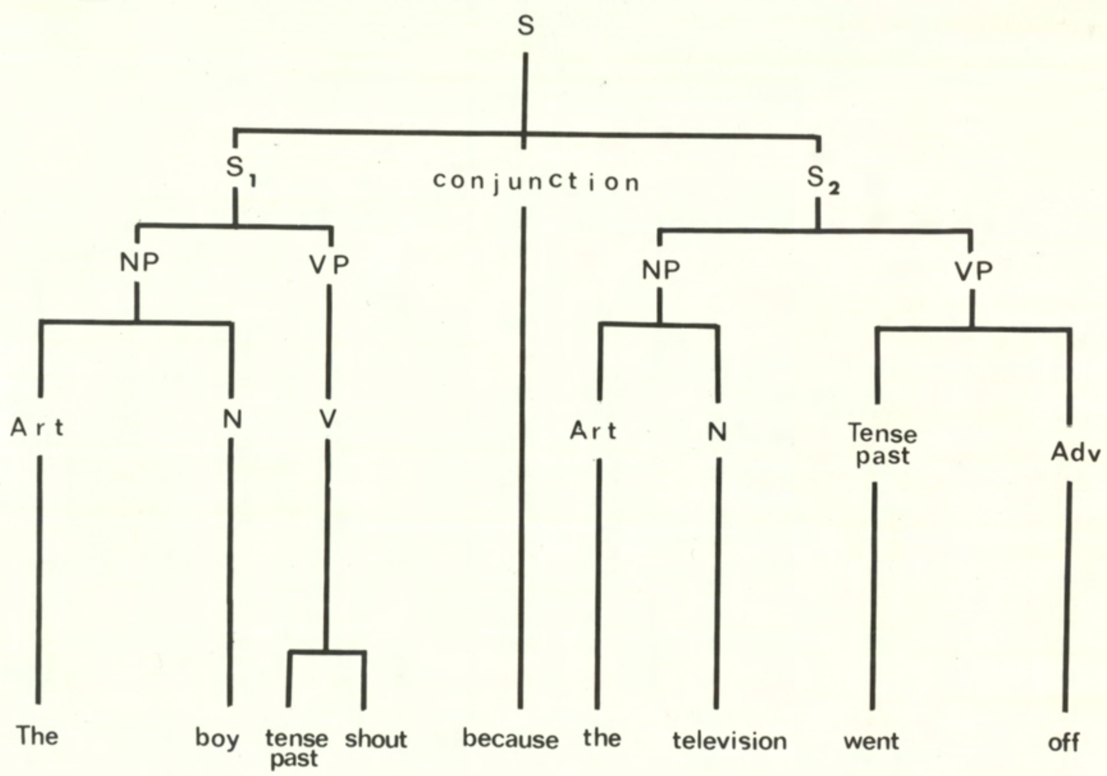
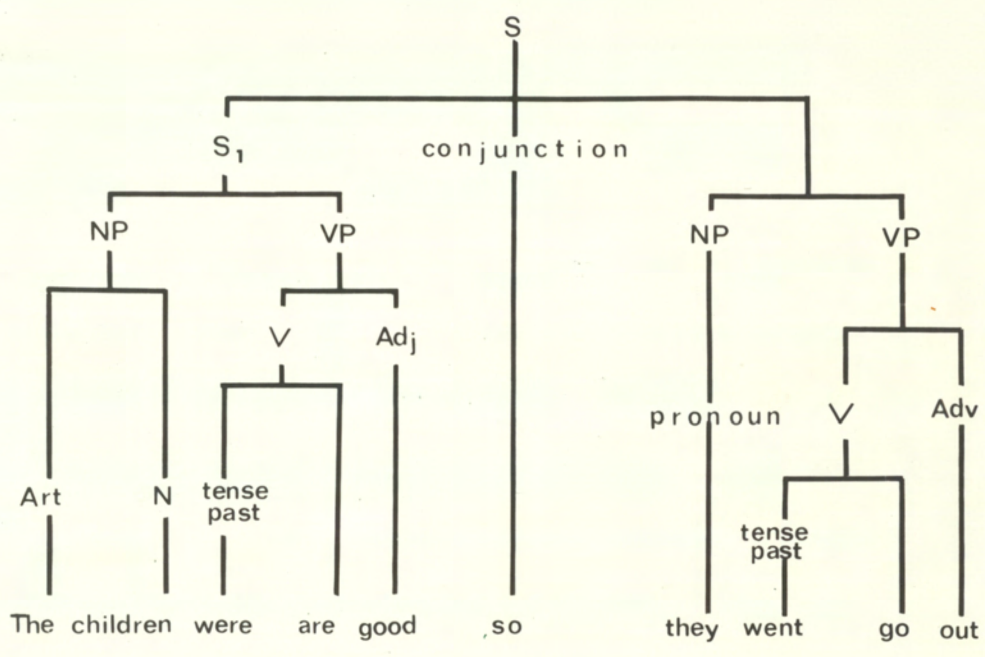


Figure 23.

SO TRANSFORMATION (T4·4)

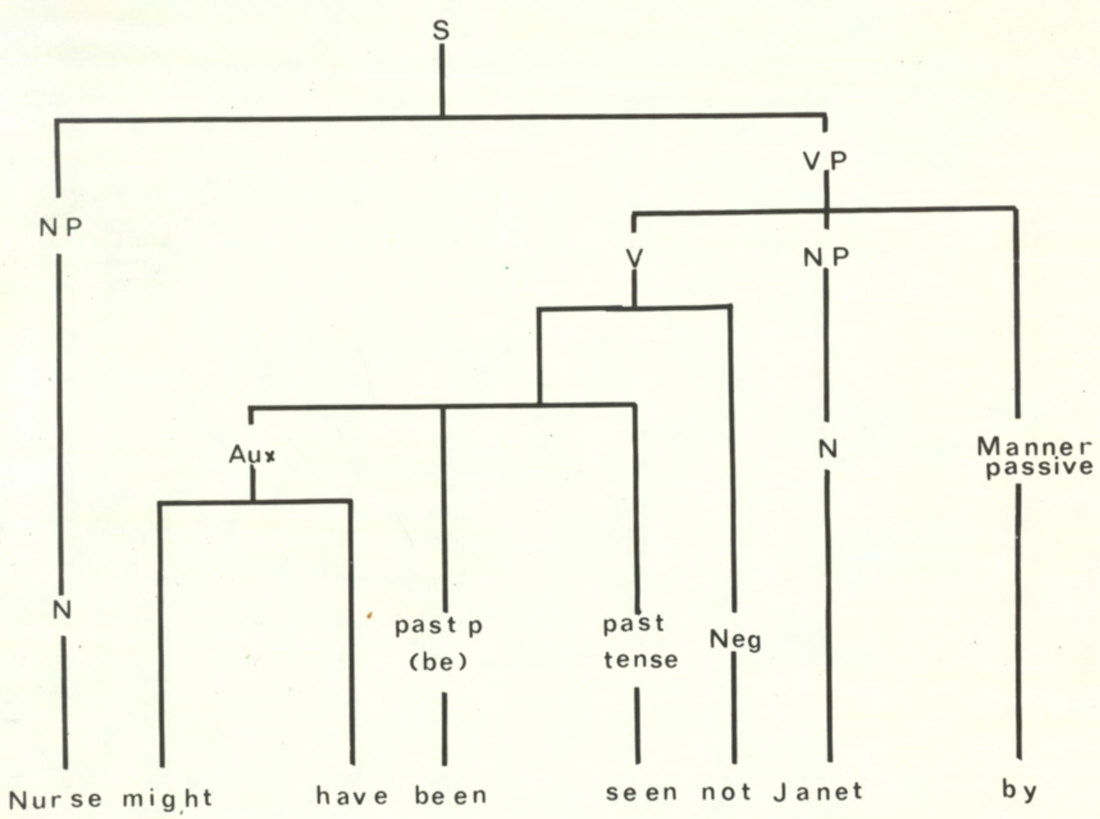


'so' may be

1. adverb meaning thus
2. as conjunction
3. as an interjection
4. as an adjective

Figure **24**

NEGATIVE PASSIVE 'M' TRANSFORMATION
(T 5.2)



10.7 Technical description of apparatus used to record and play back the experimental material in Experiments 2 and 3.

Apparatus

A Ferrograph Series 7 tape recorder was used for recording the transformations and for playback in the experimental situation. Channel 1 of the tape recorder was used for the recording of speech and Channel 2 for recording white noise. To mix the speech and white noise a Leak stereo amplifier was used and to provide enough power to drive six pairs of headphones. Sharpe high quality low impedance headphones were used throughout.
The combined frequency response of the tape recorder and the amplifier was ±2 db. over 50 cps to 20 kcps. The headphones were selected by calibrating them with a Band K artificial ear. The headphones used all had a frequency response of ±2 db. over 100 cps to 2 kcps.

Method of Recording

The pre-recorded speech tape (Channel 1) was played back and monitored. At the beginning of each transformation the tape recorder was stopped so that the white noise could be recorded just before the start of the structure but on the adjacent Channel (2). With the 'Record' switch to Channel 2 a signal from a White Noise Generator was fed to Channel 2 via a press button switch. This press button switch was depressed and the recorder started, the speech on Channel 1 being monitored at the same time. At the end of the transformation the press button switch was released and the recorder stopped.
By repeating this procedure for each transformation, complete

masking is achieved with the minimum of white noise.

Playback

The equipment was set up as in Figure (25). The tape recorder was switched to playback and the internal loudspeakers turned off. The output from each channel was fed to the tape inputs of a Leak stereo amplifier. The record levels of both speech and white noise were selected so that the output controls of the amplifier and the tape recorder were turned half way for a 75 db. level at the headphones. The sound levels of both speech and white noise could be adjusted independently from the tape recorder controls.

Figure 25.

ARRANGEMENT OF APPARATUS FOR RECORDING AND PLAYBACK