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INVESTIGATING THE ROLE OF ESTABLISHED LINGUISTIC KNOWLEDGE IN SUPPORTING SHORT-TERM MEMORY AS MEASURED BY SENTENCE REPETITION

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Tables and Graphs

ABSTRACT

Research provides evidence of correlations between measures of short-term memory (STM) and language abilities and, likewise, between deficits in STM and language. Yet the nature of the relationship between memory and language remains unclear. The phonological component of STM plays a role in the development of language, but linguistic knowledge in turn affects STM performance, with factors such as 'wordlikeness' and phonotactic probability influencing performance on single-word STM tasks.

This study sought to investigate how established linguistic knowledge provides support for STM as measured by sentence recall. Using a design similar to that of Millar and Isard (1963), which compared the ability of adults to repeat grammatical sentences with those where semantic or syntactic rules had been violated, 4-6 year old children were asked to repeat grammatical, anomalous or ungrammatical sentences. The contribution of prosody was examined by presenting sentences with either regular or flat prosody.

The results showed significantly fewer content words were repeated in anomalous compared to grammatical sentences, with a significant and even greater drop in ungrammatical sentences. Presenting sentences with flat as opposed to regular prosody also resulted in a significant reduction of correctly repeated content words across all three sentence types. These findings suggest that prosodic, semantic and, most dramatically, syntactic knowledge provide support for STM as measured in recall tasks.

A qualitative analysis of error types and further exploratory investigations of sentence type and prosody at different sentence lengths were also carried out.

INTRODUCTION

Background

The relationship between short-term memory (STM) and established language knowledge is complex and the exact nature of the relationship remains unclear. Much of the research has sought to separate out these two factors by employing recall tasks which use single words in nonword repetition or word span tasks, in order to focus on STM and minimise the impact of established knowledge. This thesis takes a different approach by looking at the relationship between STM and linguistic knowledge through comparisons of recall for word combinations which vary in linguistic familiarity and therefore in the opportunity to draw on established language knowledge.

Investigating the role of STM in the development of linguistic knowledge

A substantial body of research has investigated the role of STM in establishing linguistic knowledge, in particular in the acquisition of vocabulary. The role of temporary information storage was crucially conceptualised by Baddeley and Hitch in their 1974 'working memory' model (e.g. in Gathercole & Adams, 1994). Research into the role of the working memory in language tasks has focused in particular on its verbal storage system, the 'phonological loop', the component which holds phonological information (see Baddeley's review, 2000). Several studies have used nonword repetition (NWR) to assess the working of the phonological loop, as nonwords compel the listener to rely on the phonological loop when encoding, maintaining and articulating unknown phonological sequences. It has been suggested that repeating such made-up as opposed to real words avoids intrusion of existing lexical and semantic knowledge in tasks which seek to measure phonological short-term memory alone (e.g. Baddeley, Gathercole & Papagno, 1998 in Jefferies, Jones, Bateman & Lambon-Ralph, 2005). It has also been assumed that, as

NWR taps relatively pure phonological memory, it can be used to shed light on the role of phonological memory in vocabulary development.

Indeed, due to their unfamiliarity, the acquisition of new words has much in common with the learning of nonwords. It stands to reason that the greater the capacity to store temporarily unfamiliar phonological sequences, the greater the ease with which newly encountered words can be repeated and established as long-term memory representations (e.g. Gathercole & Baddeley, 1989, 1993b in Gathercole, 1995). Not surprisingly, the ability to repeat nonwords has been associated with vocabulary knowledge (e.g. Gathercole, Willis, Emslie & Baddeley, 1991) and future foreign language competence (Service, 1992 in Gathercole, 1995). Adams and Gathercole (2000) compared typically developing children with high and low NWR scores and noted that language measures differed significantly between the two groups. Gathercole and Baddeley (1989) found that NWR scores were not only significantly associated with current vocabulary knowledge at the ages of four and five, but also highly specific predictors of vocabulary knowledge one year later.

Conversely, children with specific language impairment (SLI) are poorer at NWR than both age-matched controls and younger language-matched controls (see studies reviewed in Gathercole et al, 1991). Botting and Conti-Ramsden (2001) extended Adams and Gathercole's (1989) analysis to 11-year-old children with SLI. They assessed 200 children with SLI and identified a subgroup of 28 subjects with the most extreme scores on the CNRep, the Children's Nonword Repetition task (Gathercole and Baddeley, 1990), with half the subgroup scoring at least 1SD above and half at least 1SD below the original group mean. They then compared the language and literacy abilities of the two halves of the subgroup and found that within this population, linguistic measures also correlated significantly with NWR scores.

Poor NWR scores have even been identified in children who were previously identified as having SLI, though superficially their difficulties are no longer evident (e.g. Bishop, Bishop, Bright, James, Delaney & Tallal, 1999).

The question of bi-directionality

The question arises, however, as to whether the association between phonological memory, as measured using NWR, and linguistic abilities can be reduced to a simple, one-directional causal relationship in which the phonological component of STM supports long-term linguistic knowledge.

Cheung (1996) investigated second-language learning (English) in a group of Hong-Kong 7th graders. He found that phonological memory as measured with NWR was generally predictive of the number of trials required for pupils to acquire new English words, thus confirming the close link between the phonological memory capacity and the acquisition of novel phonological forms. Yet this relationship was only observed in students whose English vocabulary size was below the group median and not in those who had achieved greater proficiency. It appears that at a certain stage, long-term language knowledge interacts with and maybe even reduces the impact of phonological memory.

Gathercole (1995) also advocated a "dynamic and reciprocal" developmental relationship between NWR and vocabulary acquisition, citing in support Gathercole et al. (1991 & 1992), who found that NWR provided a highly specific predictor of later vocabulary development between the aged of four and five. However, by the age of five, the relationship between NWR at five and vocabulary knowledge at six was much weaker than the relationship between children's vocabulary knowledge at five and NWR the following year. It therefore appears that in younger children phonological STM drives vocabulary acquisition, whilst older children are more likely to use their larger long-term memory store of lexical items to support accurate NWR.

These studies underline the role of established linguistic knowledge in recall tasks and support the argument for a bi-directional relationship between phonological short-term memory and established linguistic knowledge.

The problem with nonwords

The contribution of long-term language skills can explain why memory span is greater for words than for nonwords and why it is easier to recall high frequency and high imageability as opposed to low frequency and low imageability words (see studies reviewed in Martin, Lesch & Bartha, 1999).

The use of nonwords in recall tasks seeks to minimise such intrusion of long-term linguistic knowledge in order to measure 'pure' phonological memory, yet it cannot avoid it altogether. This is most apparent in the 'wordlikeness' effect, which refers to the finding that the more wordlike the nonword, the greater the probability of accurate repetition (e.g. Gathercole & Martin, 1996). Numerous studies have investigated this effect. Dollaghan, Biber and Campbell (1995) discovered children repeated multisyllabic nonwords better if the stressed syllable was itself a word, and repetition errors consisted largely of word substitutions in place of nonlexical syllables. Connine, Blasko & Titone (1993) found nonwords differing in one or two linguistic features from a base word still triggered significant priming effects for semantic association.

Gathercole (1995) noted that wordlikeness had a significant effect on repetition accuracy in normally developing four-to-five year olds. As memory span measures were more closely related to accurate repetition of nonwords of lower wordlikeness, she concluded that the less wordlike stimuli depend to a larger extent on phonological memory, whilst the more wordlike items are mediated by long-term knowledge.

Gathercole and Thorn (1995 in Gathercole & Martin, 1996) compared bilingual children who had learnt English and French simultaneously with those who learnt French after English. Whilst the former group showed a wordlikeness effect on NWR in both languages, the latter only displayed this in their native English, again attesting to the influence of established early sound structures on NWR.

The influence of long-term language knowledge can be minimised with the careful construction of nonwords, yet it is impossible to eliminate its influence altogether. NWR undoubtedly sheds light on the phonological working memory, but it cannot provide a straightforward window on its workings as even the frequency of particular phoneme sequences, particular syllable positions and the phonotactic rules of English make it impossible to eliminate long-term memory (LTM) input completely (Dollaghan et al, 1995).

A further problem with nonwords arises from their being confined to the one-word level. By limiting investigations of STM to repetition of disconnected nonwords, little insight can be gained into linguistic influences of semantics and syntax on recall, which extend beyond the single word level and operate within a sentence framework.

Word list and sentence repetition as measures of memory

Measures of STM span, such as word list and sentence repetition (SR), are evidently subject to LTM influences as they depend on vocabulary stored in the lexical memory. However, LTM contribution varies between repetition of word lists and sentences. McCarthy and Warrington (1987) found a double dissociation of STM for three-word lists and sentences in three aphasic patients. Two patients presented with severe impairments of recall of unrelated stimuli in lists but good verbatim recall of meaningful sentences, whilst one patient was more accurate at recalling word lists than sentences. Increasing the extent of meaningfulness of lists benefited the list-impaired patients and presenting incomplete sentences had a negative impact on them but not on the span-preserved patient. McCarthy and Warrington argued that the phonological store is relied upon for list repetition, whilst a "dynamic, anticipatory and integrative memory system" underpins sentence repetition, though phonological STM may still support syntactically complex sentences.

Other researchers also minimise the importance of phonological short-term memory (PSTM) in sentence repetition. Marshall and Nation (2003) found children with good reading accuracy but impaired reading comprehension accurately repeated word lists but were worse at SR compared with normal controls and their errors were more likely to alter sentence meaning. Marshall and Nation concluded that in contrast to repetition of word lists, SR involves word and syntax processing ('surface level'), understanding sentence meaning ('propositional level') and integration of these two levels with long-term knowledge ('situational level').

Others, however, acknowledge the phonological contribution to SR. Willis and Gathercole's (2001) experiments with four-to-five year old children found firstly, that word length significantly influenced SR but not comprehension tasks. Secondly, when children were grouped on the basis of PSTM scores (using NWR and digit span tests), those with higher PSTM scores were better at sentence repetition than those with lower scores, which again supports PSTM contribution to sentence regeneration.

Hanten and Martin (2000) followed Martin and Romani's (1994) investigations of adults with head injuries, with a study of two children with head injuries, one of whom presented with a phonological STM and the other with a semantic STM deficit. They found the children performed in a similar way to the adults, in that the child with a PSTM deficit showed greater impairment when repeating sentences than the child with a semantic STM deficit. However, the former performed in a similar manner to the control subjects in sentence comprehension tasks, whilst the latter was very impaired relative to the controls. The authors proposed that whilst sentence comprehension is constrained by processing at the syntactic and conceptual level, SR taxes primarily PSTM as well as conceptual representations.

Researchers have looked at psycholinguistic markers which aim to differentiate accurately between individuals with and without language disorders in language assessments (Slobin & Welsh, 1971) and screening programmes (e.g. Sturner, Kunze, Funk & Green, 1993). Conti-Ramsden, Botting and Faragher (2001)'s study emphasises the importance of SR as a psycholinguistic marker for SLI. They compared the potential psycholinguistic markers of third person singular, past tense, NWR and SR with regard to sensitivity, specificity and accuracy when assessing 11-year-olds with a history of SLI. There was a significant correlation between NWR (the second best marker) and SR, but the latter provided the most significant results, with high levels of sensitivity (90%), specificity (85%) and overall accuracy (88%). It was also able to identify children with a history of SLI even where skills had improved.

Despite such endorsement, the fact that SR involves contributions from such a variety of linguistic sources raises questions about what SR assesses beyond PSTM and what can be inferred from the results of sentence recall tests. Yet instead of trying to eliminate all factors apart from PSTM as NWR attempts to do, SR can offer a useful alternative approach, by acknowledging instead various influences on SR and then attempting to quantify their relative importance, as seen in the following study.

Miller and Isard's (1962) investigations into the role of syntactic and semantic rules in auditory perception in adults

Miller and Isard set out to investigate the role of syntactic and semantic rules in sentence recall tasks and to assess the relative contribution of these linguistic rules to auditory perception. For this purpose they formulated fifty grammatical sentences using ten different phrase structures, each structure represented by five different sentences. Two structurally identical sentences included for instance *The book explained the complicated mathematical formula* and *The club elected the worst possible officers*, which, ignoring the article *the*, consist of five meaningful words. They then proceeded systematically to violate the linguistic rules of semantics and syntax. These generally facilitate recall by limiting the number of alternative words that can fill particular positions in a sentence. To construct 'anomalous' sentences the authors exchanged words using the five grammatical sentences with identical sentence structure by taking the first word from the first well-formed sentence, the second word from the next sentence and so on (e.g. *The book elected the heavy health waltz*). They repeated this with all ten phrase structure types, thereby creating 50 new sentences, which were syntactically admissible but semantically anomalous. Finally, the authors constructed 50 'ungrammatical' strings by permuting word positions (e.g. *Explained the officers bold health gay the*), which violates both semantic and syntactic rules. The resulting 150 sentences were taped and presented to adult subjects in random order.

Responses were scored for both the number of correct 'principal' (content) words (five per sentence) and the number of correct complete sentence repetitions. Scores of 88.6% for grammatical, 79.3% for anomalous and 56.1% for ungrammatical sentences showed a statistically significant difference between sentence types as did the corresponding scores for correct principal words of 97.5%, 95.8% and 88.3% respectively. The authors concluded that both syntactic and semantic rules are involved in the perception of sentences, but semantically anomalous sentences are intermediate in difficulty; harder to repeat than normal sentences but not as difficult as ungrammatical strings.

The present study

This study seeks to investigate whether Miller and Isard's findings can be replicated with typically developing children. As noted above (Gathercole, 1995), the dramatic development of memory skills in children between the ages of four and eight brings changes in the pattern of association between vocabulary knowledge and NWR. Phonological memory appears to be the driving force in the relationship at the earlier stage, but vocabulary the principle pacemaker by the age of eight.

Hanten and Martin's study (2000) failed to find greater involvement of phonological components in sentence *comprehension* in ten-year old children with head injury than in adults with similar impairments, yet it was suggested that younger children may nevertheless rely to a greater extent on PSTM for sentence processing. If this were the case, then sentence *repetition* accuracy, with its even greater PSTM component, could be expected to reflect a different balance between PSTM and long-term language skills in children compared to adults. If children are not yet adept at using semantic and syntactic information to chunk and retain information, long-term language knowledge may not exert the same degree of influence as in adults. Conversely, an immature PSTM may lead to greater reliance on language skills when retaining and repeating sentences.

The purpose of repeating Miller and Isard's study with children is to explore these questions further. However, in addition to investigating the role of syntax and semantics, this study examines the role of prosody on sentence repetition. Prosody plays an important role in sentence processing, too, as parents speaking with exaggerated intonation instinctively sense. Pauses in speech and intonation patterns assist chunking of words for ease of processing. Slobin and Welsh's (1971) longitudinal study of two-year-old 'Echo' noted that if sentences exceeded her productive capacities, emphasis could lead her to repeat words otherwise omitted. Scholes (1970 in Bonvillian et al, 1978) found no effect of intonation on children's sentence repetition. However, Scholes' sentences were only three to five words long. Bonvillian et al.'s own study found that imitation of long sentences (up to 12 words) by nursery age children was significantly better if sentences were presented with regular as opposed to flat intonation. Children may fall back on intonation to aid sentence processing when their abilities are stretched in longer sequences, especially if the rules of semantics and syntax have been violated. The impact of prosody on sentence repetition is investigated here by presenting the grammatical, anomalous and ungrammatical sentences with both regular and flat intonation.

METHOD

Research questions and hypotheses

The following questions arise:
To what extent does semantic and syntactic knowledge affect the span of words recalled and does the prosodic pattern play a role in sentence recall?
The following hypotheses are proposed:

1. Repetition scores (of both content and function words) will be significantly lower for semantically anomalous sentences than for sentences that are semantically and syntactically well-formed.

2. Repetition scores will be significantly lower for ungrammatical sentences than for sentences that are semantically and syntactically well-formed.

3. Repetition scores will be significantly lower for ungrammatical sentences than for anomalous sentences.

4. Repetition scores will be significantly lower for sentences delivered with flat prosody than for sentences delivered with regular prosody.

Design

All 22 participants aged 4.09– 6.11 were tested on the following three standardised assessments to ascertain that their STM and receptive language skills fell within the average range:
1. Receptive vocabulary: British Picture Vocabulary Scales (BPVS); (Dunn & Dunn, 1982)
2. Syntactic comprehension: Test for Reception of Grammar (TROG); (Bishop, 1983)

3. Short-term memory: Digit Span Test from the Aston Index LDA (Newton & Thomson, 1982).

For the experimental task participants were asked to repeat 20 grammatical, 20 anomalous and 20 ungrammatical sentences matched for vocabulary and sentence length, which were read out to them by the researcher. All 60 sentences were presented twice, once with regular and once with flat prosody. Presentation order was varied systematically across children. The standardised assessments were interspersed between four blocks of test sentences to break the lengthy list of sentences into manageable parts. The number of correctly repeated content and function words within each condition was counted and error types noted.

A two-way within subjects Analysis of Variance (ANOVA) design was carried out with two independent variables: 'Sentence type' with three levels (well-formed, anomalous and ungrammatical), and 'Prosody' with two levels (regular or flat intonation). The two dependent variables were number of correctly repeated content words and number of correctly repeated function words. The study went on to carry out a qualitative analysis of error types.

Participants and selection criteria

The study aimed to recruit between 20 and 30 children of between five and six years from reception and year one classes. Having obtained ethical approval and permission from a local suburban state school in North West London, class teachers distributed consent forms to parents of 54 children in these classes. The parents of 22 children gave their consent for their children to participate in the study and to be audio-recorded (see Appendix I and II for letter to parents and consent form).

Staff were informed of the study's purpose and given selection criteria for possible participants, as the study aimed to investigate STM and language abilities of a range of typically developing children. Children were to be excluded from the study in the case of a known history of hearing loss, a major physical disability, diagnosis of moderate learning difficulties or where English was not the first language. On the basis of staff reports these criteria were assumed to be satisfied.

Two of the children were included despite being under the age of five, as their teacher's reports and standardised test results showed no obvious differences between them and their peers. Although one child was subsequently identified as seeing a SLT for a slight language disorder/delay it was decided to include his data in the study as he met the study's selection criteria: testing of receptive vocabulary and syntactic comprehension showed him to be within the average range (i.e. within 1 SD of the mean). Of the 22 children one was unwilling to complete the test battery and testing was discontinued.

Materials

BPVS

This assessment aims to measure a child's receptive vocabulary. A test item is read out to the child who is asked to select the picture best representing the test item from a choice of four pictures presented. Test items are a selection of nouns, verbs and adjectives, which gradually increase in complexity. The test procedure was followed.

TROG

This assessment purports to measure syntactic comprehension. As the BPVS had been administered it was not considered necessary to carry out the TROG's preliminary test of receptive vocabulary. For the test proper the child is presented with four pictures on a page. A sentence is read aloud and the child is asked to point to the picture best representing the sentence heard. The test is divided into blocks of four sentences. The correct pictures for all four sentences of a block must be correctly selected to pass a block. Test items increase in syntactic complexity, progressing for instance from negatives to post-modified subjects and relative clauses. The test procedure was followed.

DIGIT SPAN TEST

This test of STM measures auditory sequential memory by asking a child to repeat a series of digits starting with two two-digit sequences. The length of sequences is increased gradually by a digit until the child fails to repeat correctly both examples of a given sequence. The child is asked to recall sequences both in a forward and reverse order (e.g. 1-3 becoming 3-1). The resulting number of all the correct forward and backward sequences is counted and divided by two to obtain a score which can be compared against age norms.

TEST SENTENCES

Construction of test sentences followed the method employed by Miller and Isard (1963) with some modifications. Four sets of five grammatical sentences were constructed, each set representative of a grammatical structure. The researcher aimed to include only grammatical structures and vocabulary considered age-appropriate for the average four- to six-year-old. All sentences within a set contained the same ratio of content and function words, with members of the same syntactic class (e.g. nouns, adjectives etc.) set in equivalent sentence positions. Additionally, words were matched for syllable length. Examples of different sentences within a grammatical set would be: *The baby likes to hold the furry teddy* and *The teacher starts to tell the funny story* (see Appendix III).

Anomalous sentences were constructed by combining words from different sentences within a set. This ensured that sentences were syntactically acceptable but semantically anomalous and that vocabulary was matched across conditions (e.g. *The baby starts to land the scary lettuce* or *The teacher hopes to hurt the tasty teddy*).

Ungrammatical sentences were constructed by jumbling up the words of grammatical sentences, with the same randomisation of word order applied across all sentences in a set (e.g. *The furry hold to likes the teddy baby* or *The funny tell to starts the story teacher*). This created sentences that violated both semantic and syntactic rules. It was decided to jumble up grammatical as opposed to anomalous sentences to minimise somewhat the effect of ungrammaticality on semantics. This allowed the violation of syntactic rules to exert the primary influence, whilst preserving possible conceptual interpretation of relations between words.

This created 20 grammatical, 20 anomalous and 20 ungrammatical sentences. All sixty sentences were numbered and randomised, as it was thought that presenting sentences in groups of grammatical, anomalous and ungrammatical sentences may lead to a practice effect with children adjusting to a sentence type, which might help recall. Two separate sentence lists were randomly compiled (Appendix IV) to minimise the possibility of a particular albeit random sentence order unintentionally facilitating recall. The children's responses were audio-recorded on a Sony TCM-450DV 'CLEAR VOICE' cassette recorder to ensure accurate scoring.

Procedure

Testing was conducted over two three-day periods. Each testing session lasted approximately one hour. It was carried out where possible in a quiet area and without breaks, as none of the children requested one. As outlined above, all 60 test sentences were randomised twice to create two different randomised lists, lists A and B. Half the children were presented with prosodic sentences from list A (AP+) and with sentences delivered with flat intonation from list B (BP-), with the opposite arrangement for the other half of children: AP- and BP+. In order to avoid overburdening the children's attention span, both lists were further divided in half, creating four blocks of 30 sentences, two of which were presented with regular and two with flat intonation. The researcher alternated prosody type between each new section and presentation of the blocks was counterbalanced. Where A and B stand for the two word lists, 1 and 2 for the first and second half of a list and P+ and P- denotes regular or flat prosody, test materials were presented using the following permutations:

A1P+; B1P-; A2P+; B2P-
B1P+; A1P-; B2P+; A2P-
A1P-; B1P+; A2P-; B2P+
B1P-; A1P+; B2P-; A2P+

The four blocks were interspersed with the three standardised tests to minimise fatigue and boredom. Standardised assessments were always presented in the same order to create identical test conditions. Children sat at a table at a right angle to the researcher. Standardised tests were presented at the child's own pace. Test sentences were presented at approximately two words per second. The children were asked to repeat the sentences but told that "some sentences will sound normal but others will sound a bit funny" and in some "I will sound like a robot". Their responses were then audio-recorded. Each child received a personalised certificate, on which four circles, a star and the words 'I AM A STAR' were printed. On completion of each of the four groups of sentences, children chose a sticker to stick in one of the circles, as a reward and to encourage continued participation.

As mentioned above, all but one child completed all tasks and data from the discontinued session was not included in the study. Data from two other children also could not be included. In one case the researcher accidentally omitted one block and presented another one twice instead. In a further case a very shy child whispered 'don't know' for most of the first block and only warmed to the task later, which rendered it difficult to make valid comparisons between different sets of the data.

Scoring

The data of 19 children were scored for analysis. Scoring of standardised assessments took place in the prescribed manner at the end of morning and afternoon sessions. Scoring of test material was carried out after transcribing the children's responses. The correct number of content and function words was calculated separately for each of the six conditions: grammatical/prosody (GP); anomalous/prosody (AP); ungrammatical/prosody (UP); grammatical/no prosody (GNP); anomalous/no prosody (ANP); ungrammatical/no prosody (UNP) and recorded along with error types on score sheets (Appendix V). This allowed not only a quantitative statistical analysis of errors, but also a qualitative analysis of error types to be carried out. Scores were analysed using the SPSS software package.

The following error categories were identified: omissions, refusals (indicated by 'don't know'), replacement by real words, unidentified words or weak fillers, tense or singular/plural changes and the rearrangement or correction of syntax (generally only in ungrammatical sentences). During scoring it became difficult to distinguish between the categories of unidentified words and weak fillers, and they were amalgamated. Whilst omissions, refusals and replacements influenced word scores, minor tense or singular/plural changes (addition or omission of *–s)* and syntax rearrangement did not invalidate a correct word score, but were noted and counted for the qualitative analysis only. Interchanges of 'a' or 'the' were also noted but scored as correct. Multiple errors within the same category were scored only once per sentence.

RESULTS

1. Standardised tests

All children in the study met the criteria for participation, obtaining a standardised score of at least 85 on the BPVS and TROG. Scores for the digit span test were generally average or above. Four children scored just 0.5 below and one child scored 1.5 below the age norm for digit span, but as this still fell within two digits of the average, it was decided that all the children's experimental data was admissible for analysis (see Appendix VI for test results).

2. Experimental task

Content and function words were scored separately as they differ strongly with regard to their phonological properties and the semantic and syntactic information they carry.

2.1.CONTENT WORD DATA

2.1.a. Descriptive statistics

Descriptive statistics for content word repetition in the six sentence conditions are listed in Table 1.

It should be noted that the data of one of the 19 children were filtered as she failed to repeat most ungrammatical sentences (in both prosodic conditions) and it was felt that including her ungrammatical sentence scores would lower the average so drastically as to skew the data and render any results unrepresentative.

Table 1. *Descriptive Statistics for Content Word Repetition in the Six Sentence Conditions*

Content Word Repetition Scores N=18	**Grammatical Sentences**		**Anomalous Sentences**		**Ungrammatical Sentences**	
	Regular Prosody	**Flat Prosody**	**Regular Prosody**	**Flat Prosody**	**Regular Prosody**	**Flat Prosody**
Mean	84.06	78.50	81.61	71.83	56.28	48.61
Minimum	74	68	69	59	43	35
Maximum	90	85	89	85	78	68
Standard Deviation	4.976	4.618	5.521	6.456	8.989	10.689
Variance	24.761	21.324	30.487	41.676	80.801	114.252

Table 1 shows:

1) Semantics and Syntax: More content words were repeated in grammatical as opposed to anomalous sentences and a greater number of content words were repeated correctly in both grammatical and anomalous sentences than in ungrammatical sentences.
2) Variance was greater for anomalous sentences than for grammatical sentences and variance for ungrammatical sentences was considerably greater than for both other sentence types.
3) Prosody: Fewer content words were repeated correctly where sentences were presented with flat as opposed to regular prosody.
4) With the exception of grammatical sentences, score variance increased when sentences were read with flat as opposed to regular prosody. This was particularly noticeable for ungrammatical sentences.

2.1.b. Statistical analysis of content word data

After establishing that the data met the necessary criteria for parametric tests, a two-way within subjects ANOVA was carried out to investigate whether differences between scores were statistically significant, in line with hypotheses outlined above.

Table 2. *Summary of the ANOVA Table for Tests of Within Subjects Contrasts*

Sentence type and prosody effects N=18	**SENTENCE**	**PROSODY**	Type III Sum of Squares	df	Mean Square	F	Sig. 2-tailed	Sig. 1-tailed
SENTENCE	Linear		14964.500	1	14964.500	331.030	.000	.000
Error (Sentence)	Linear		768.500	17	45.206			
PROSODY		Linear	1587.000	1	1587.000	40.428	.000	.000
Error (Prosody)		Linear	667.333	17	39.255			
SENTENCE * PROSODY	Linear	Linear	20.056	1	20.056	1.327	.265	.133
Error (SENTENCE *PROSODY	Linear	Linear	256.944	17	15.114	1.327	NS	NS

The results of the ANOVA as summarised in Table 2 show:

The main effect of sentence type is highly significant: $F(1,17) = 331.030$, $p<0.001$.

Hypothesis 1

Repetition scores will be significantly lower for semantically anomalous sentences than for sentences that are semantically and syntactically well-formed

Post-hoc paired T-tests were used to compare separately different sentence conditions in the ANOVA (for the sake of brevity, semantically and syntactically well-formed sentences are referred to as 'grammatical'):
Post-hoc T-tests confirm that the effect of sentence type on content words scores is significant when comparing anomalous with grammatical sentences delivered with regular or flat prosody:
regular prosody: $t(17) = 2.61$, $p<0.01$; flat prosody: $t(17) = 5.066$, $p<0.001$.
Examination of the means in Table 1 reveals that in both prosodic conditions significantly fewer content words were repeated correctly in anomalous sentences than in grammatical sentences. The hypothesis is therefore accepted (for content word repetition scores).

Hypothesis 2

Repetition scores will be significantly lower for ungrammatical sentences than for sentences that are semantically and syntactically well-formed

Post-hoc T-tests confirm that the effect of sentence type on content word scores is highly significant when comparing ungrammatical with grammatical sentences delivered with regular or flat prosody:
regular prosody: $t(17) = 16.794$, $p<0.001$; flat prosody: $t(17) = 15.007$, $p<0.001$.
Examination of the means in Table 1 reveals that in both prosodic conditions significantly fewer content words were repeated correctly in ungrammatical sentences than in grammatical sentences. The hypothesis is therefore accepted (for content word repetition scores).

Hypothesis 3

Repetition scores will be significantly lower for ungrammatical than for anomalous sentences.

Post-hoc T-tests confirm that the effect of sentence type on content word scores is highly significant when comparing ungrammatical with anomalous sentences delivered with regular or flat prosody:

regular prosody: $t(17) = 17.463$, $p<0.001$; flat prosody: $t(17) = 11.394$, $p<0.001$.

Examination of the means in Table 1 reveals that in both prosodic conditions significantly fewer content words were repeated correctly in ungrammatical sentences than in anomalous sentences. The hypothesis is therefore accepted (for content word repetition scores).

Hypothesis 4

Repetition scores will be significantly lower for sentences delivered with flat prosody than for sentences delivered with regular prosody

The results of the ANOVA as summarised in Table 2 show:

The main effect of prosody is highly significant: $F(1,17) = 40.428$, $p<0.001$.

Post-hoc paired T-tests were used to compare separately different prosodic conditions in the ANOVA.

Post-hoc T-tests confirm that the effect of prosody on content word scores is highly significant in comparisons of all three sentence types:

grammatical sentences: $t(17) = 4.969$, $p<0.001$

anomalous sentences: $t(17) = 7.464$, $p<0.001$

ungrammatical sentences: $t(17) = 3.680$, $p<0.005$

Examination of the means in Table 1 reveals that for all three sentence types significantly fewer content words were repeated correctly when sentences were delivered with flat prosody rather than regular prosody.

The hypothesis is therefore accepted (for content word scores).

The results of the ANOVA as summarised in Table 2 show no significant interaction of sentence type and prosody, $F(1,17) = 1.327$, Not Significant. These findings are illustrated in Figure 1 with the plotting of cell means.

Figure 1. *Profile Plots for Sentence Type and Prosody Effects*

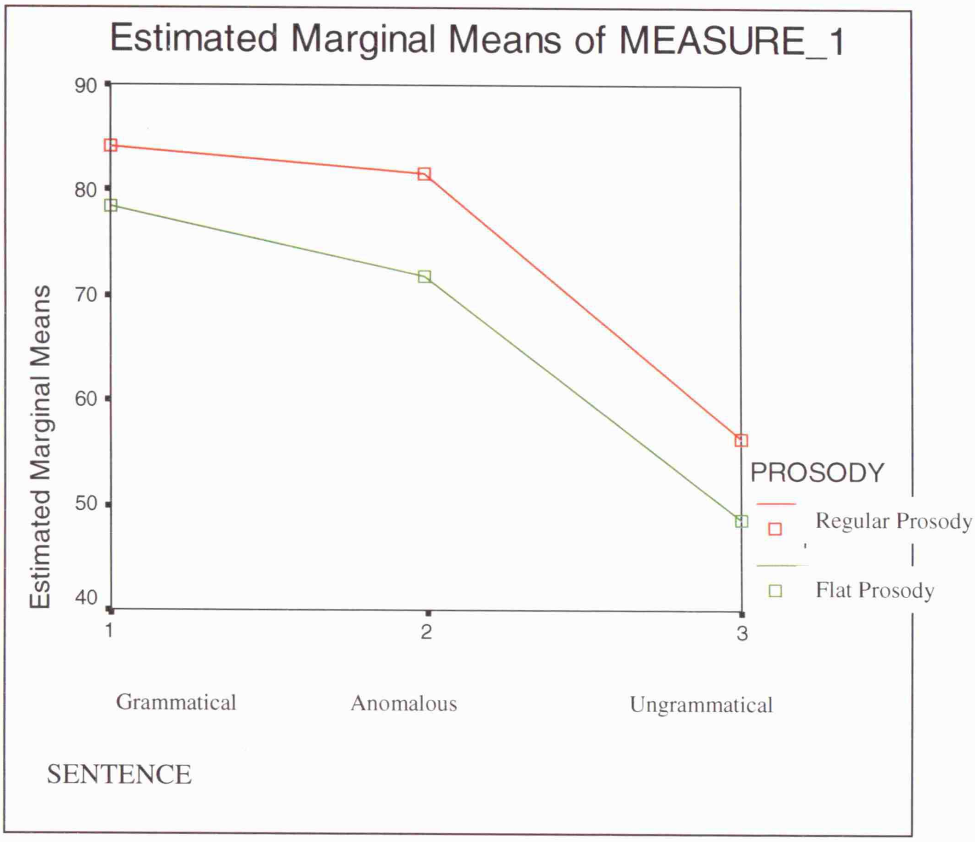


Figure 1 shows that means for grammatical sentences are higher than for anomalous sentences, with both means considerably higher than for ungrammatical sentences. The plots for both prosodic conditions show a similar parallel trend with averages for flat prosody consistently lower than for regular prosody. The graphs do not cross, which indicates the lack of interaction between variables.

2.2. FUNCTION WORD DATA

The original intention was to carry out a corresponding ANOVA using function word data. However, it became clear during testing that function word repetition was not sufficiently discriminating. Over four fifths of function words in test sentences consisted of either definite or indefinite articles; auxiliaries *has*, *was* and *is*; the infinitival *to* or the preposition *by* in passive constructions. Sentences contained between one and four function words and children would opt automatically for the common function words listed above as they aimed to fill gaps and impose structure when repeating sentences. For instance, articles were often added in several novel sentence positions as fillers and the child would then automatically score two function words if the target sentence happened to contain two articles.

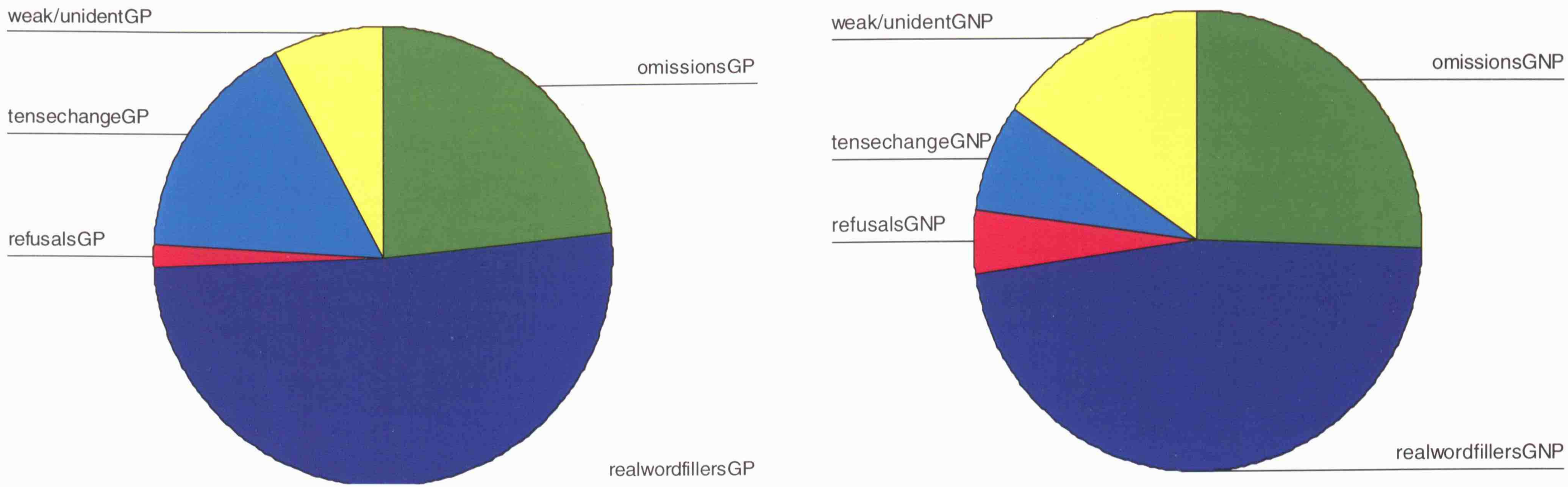
However, the impact of function words appeared more noticeable where their increased numbers lengthened sentences. Whilst all sentences contained only four or five content words, the number of function words varied more widely and largely determined sentence length variation, thereby influencing whether children were recalling words below or close to their maximum word span.

It was therefore decided to carry out some further analysis of the data to investigate whether the effects of sentence type and prosody varied with sentence length. This is discussed in section four.

3. Qualitative analysis of error types

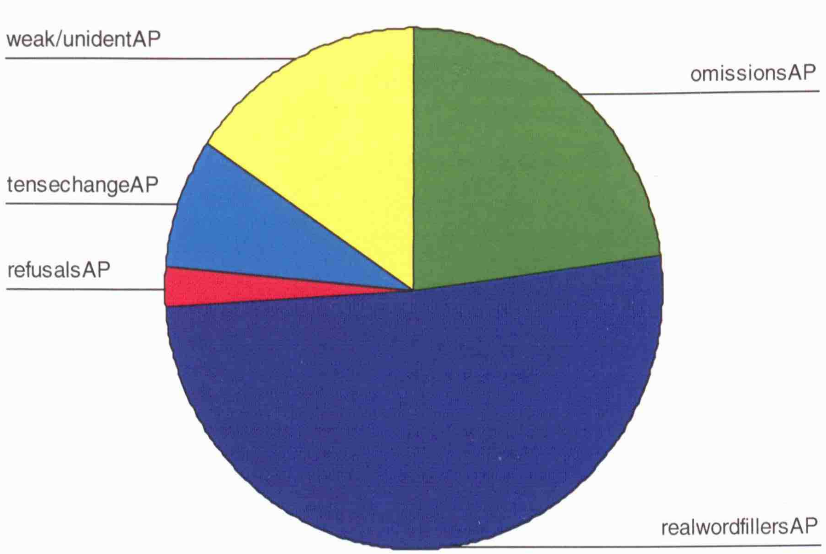
The frequency of the following error types was analysed and illustrated with pie charts in Figures 2-5 (brackets refer to relevant labelling in the pie charts): omissions, refusals, real word fillers (realwordfillers), weak or unidentified word fillers (weak/unident), tense or singular/plural changes (tensechange) and partial or complete rearrangement of word order (correctsyntax).

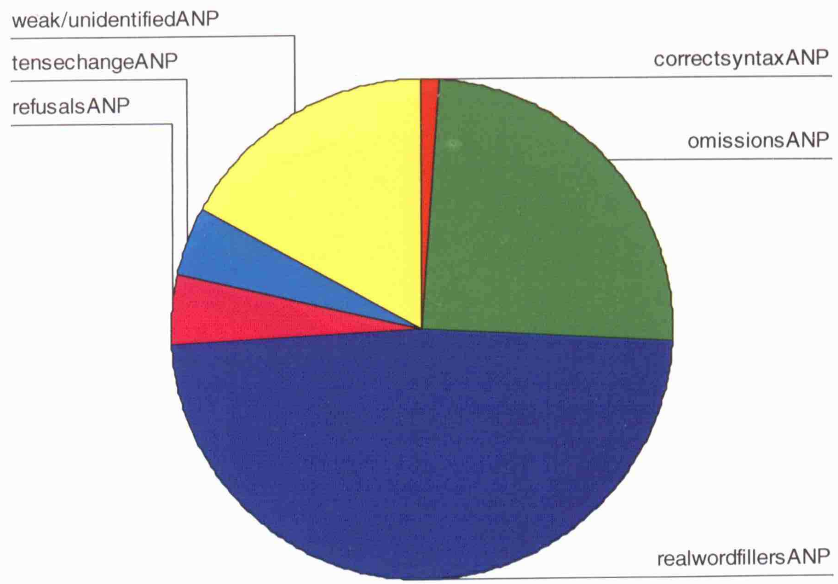
Figure 2. *Frequency of Error Types for Grammatical Sentences*



In the case of grammatical sentences, real word fillers accounted for approximately half and omissions for approximately a quarter of all errors in both prosodic conditions. The last quarter of all errors consisted of refusals, tense or singular/plural (TSP) changes and weak or unidentified (WUW) word fillers. Refusals comprised the smallest error category in both prosodic conditions although their number increased where sentences were read with flat prosody. TSP changes outnumbered WUW fillers in sentences read with regular prosody, but the reverse pattern occurred in the flat prosody condition with WUW fillers outnumbering TSP changes.

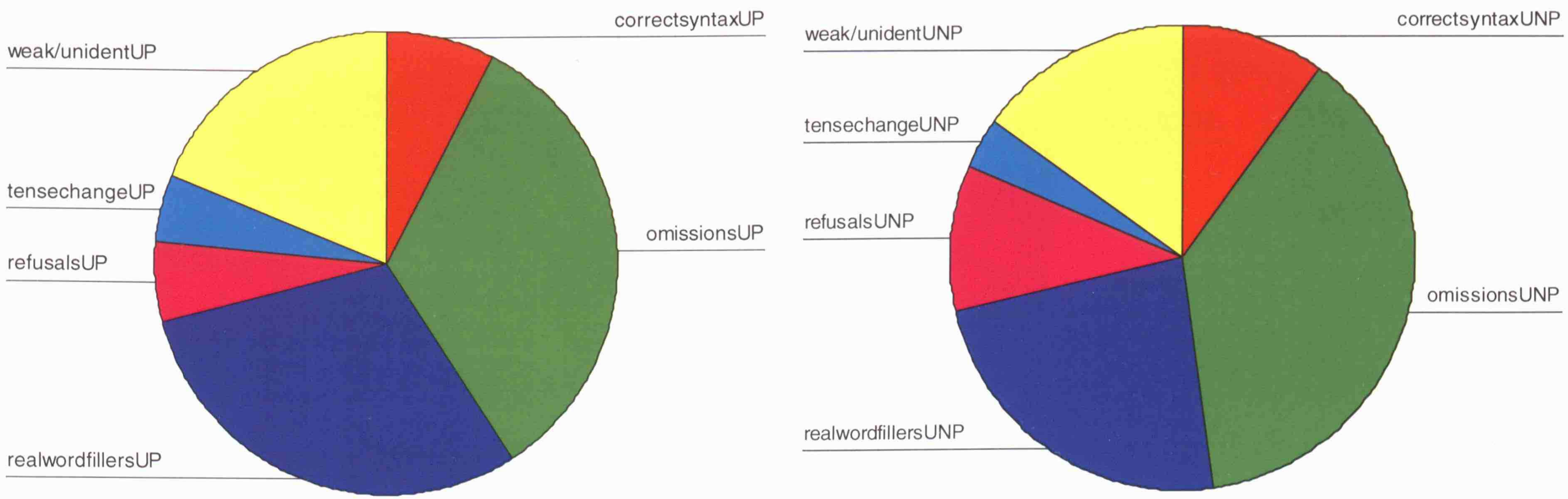
Figure 3. *Frequency of Error Types for Anomalous Sentences*





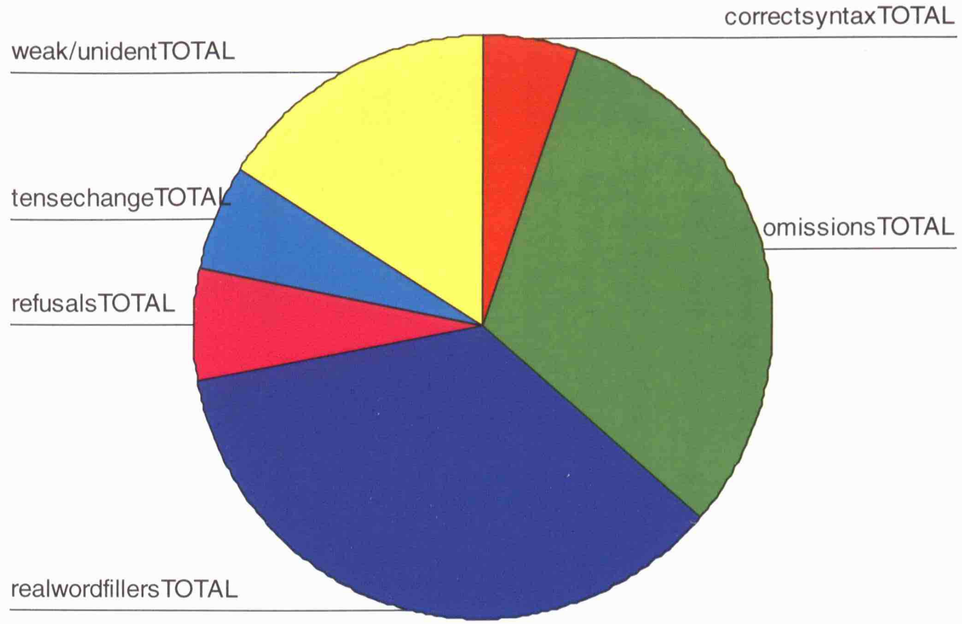
In the case of anomalous sentences real word fillers again accounted for approximately half and omissions for approximately a quarter of errors in both prosodic conditions. WUW fillers comprised the biggest error category within the remaining quarter of errors, their number increasing marginally where sentences were read with flat prosody. Refusals comprised the smallest error category in the regular prosody condition but their number increased and was about equal to TSP changes in the flat prosody condition. Overall error patterns for grammatical and anomalous sentences were similar with the small exception of a very few cases of syntax rearrangement which probably served to impose clearer meaning in the flat prosody condition.

Figure 4. *Frequency of Error Types for Ungrammatical Sentences*



A different picture presents itself for ungrammatical sentences. In both prosodic conditions the most frequent error type (about a third of errors) consisted of omissions, as the STM struggled to cope with syntactically unstructured information. The next largest category was real word fillers, just under a quarter of errors in the flat prosody condition, but approaching the level of omissions where sentences were read with regular prosody. WUW fillers remained the next largest error type. Neither their number nor the number of TSP changes varied greatly over sentence type. However, refusals increased, especially in the flat prosody condition, and syntax was rearranged, again most noticeably in the flat prosody condition, in an attempt to restructure the jumble of words.

Figure 5. *Total Frequency of Error Types across Sentences*



Across sentences real word fillers and omissions each comprised about a third of all errors and WUW fillers accounted for approximately a sixth of errors. The remaining errors were divided fairly evenly between refusals, TSP changes and syntax rearrangement.

4. Further statistical analysis

As discussed in section 2.2., further statistical analysis was carried out to determine whether the effects of sentence type and prosody varied with sentence length.

4. 1. PROCEDURE

The original test sentences consisted of five, eight or nine words. The collated data were used to calculate word span averages for each child and for the group at all three sentence lengths in each of the six sentence conditions (i.e. grammatical, anomalous and ungrammatical sentences both with and without prosody). When calculating averages, sentences were not included if a child had failed to answer or had only recalled one word (generally in the ungrammatical sentences), as it was felt that a score of zero or one would render the data unrepresentative.

4.2. RESULTS

4.2.a. Descriptive statistics

Table 3. *Group Word Span Averages in all Six Sentence Conditions*

N=18	**Prosody**	**5-word sentences**	**8-word sentences**	**9-word sentences**
Grammatical	Regular	4.82	7.67	**8.14**
	Flat	4.78	7.61	7.51
Anomalous	Regular	4.67	7.59	**7.96**
	Flat	4.56	7.2	7.27
Ungrammatical	Regular	4.17	5.68	**5.2**
	Flat	4.08	4.88	4.94

The data in Table 3, which shows group word span averages in all six sentence conditions, mirrors the earlier findings. Fewer words were recalled correctly in sentences delivered with flat as opposed to regular prosody and fewer words are recalled correctly in anomalous sentences as opposed to grammatical sentences with even fewer correct repetitions in ungrammatical sentences. The impact of sentence type and prosody appears most marked for ungrammatical eight- or nine-word sentences and is relatively small in the case of 5-word sentences, where subjects performed throughout closer to ceiling.

The longer 9-word sentences with prosody (in bold) were singled out for investigation to minimise the possibility of a ceiling effect. The slight reduction of words recalled in the anomalous compared to the grammatical sentence condition points to some reliance on semantics in recall. However, a far greater drop occurred in the ungrammatical condition. It is in line with the average word span of 5+/-2 (Miller, 1956) and mirrors the children's performance in the digit span test, where the average recall for the group was 5.36. This more dramatic drop in recall where semantic and syntactic rules are violated compared to the anomalous condition where only semantics is affected, supports the notion that it is primarily the syntactic aspect of existing language knowledge which assists recall.

4.2.b. Statistical analysis

An attempt to analyse the relationships between sentence length, sentence type and prosody using ANOVAs was abandoned, as the data did not meet parametric conditions. However, the data did meet conditions for paired samples T-tests. The results are summarised in Tables 4 and 5.

Table 4. *Sentence Type Effect at Different Sentence Lengths*

Sentence types * N=18	**Prosody type**	**Sentence length**	**df**	**t**	**Sig. 2-tail**	**Sig. 1-tail**	**p**
G-A	Regular	5-word	17	2.176	.044	.022	p<.05
		8-word	17	.631	.536	.268	NS
		9-word	17	.625	.540	.270	NS
	Flat	5-word	17	2.591	.019	.010	p<.05
		8-word	17	2.900	.010	.005	p<.01
		9-word	17	.952	.354	.177	NS
A-U	Regular	5-word	17	3.307	.004	.002	p<.005
		8-word	17	9.483	.000	.000	p<.001
		9-word	17	10.244	.000	.000	p<.001
	Flat	5-word	17	5.101	.000	.000	p<.001
		8-word	17	8.994	.000	.000	p<.001
		9-word	17	5.576	.000	.000	p<.001
G-U	Regular	5-word	17	4.325	.000	.000	p<.001
		8-word	17	10.805	.000	.000	p<.001
		9-word	17	10.071	.000	.000	p<.001
	Flat	5-word	17	6.033	.000	.000	p<.001
		8-word	17	10.131	.000	.000	p<.001
		9-word	17	7.713	.000	.000	p<.001

*G=grammatical; A=Anomalous; U=Ungrammatical

Inspection of the table, supported by inspection of the boxplots (Appendix VII), shows a consistent, highly significant sentence type effect at all three sentence lengths when comparing repetition scores for ungrammatical sentences with scores for both other sentence types. This confirms the considerable impact the syntactic framework has on recall.

When analysing differences between grammatical and anomalous sentences, which illustrates the impact of semantics alone, the picture is more varied and less conclusive. For 9-word sentences the sentence type effect is not significant in either prosodic condition, whilst for 5-word sentences the effect is significant in both prosodic conditions and in 8-word sentences the effect is only significant where sentences are delivered with flat prosody (p<.01).

Table 5. *Prosody Effect at Different Sentence Lengths*

N=18	Sentence length	df	t	Sig. 2-tail	Sig. 1-tail	p
Grammatical Sentences Regular/Flat Prosody	5-word	17	.352	.729	.365	NS
	8-word	17	1.087	.292	.146	NS
	9-word	17	3.004	.008	.004	p<.005
Anomalous Sentences Regular/Flat Prosody	5-word	17	.706	.490	.245	NS
	8-word	17	3.603	.002	.001	p<.005
	9-word	17	4.053	.001	.001	p<.005
Ungrammatical Sentences Regular/Flat Prosody	5-word	17	1.321	.204	.102	NS
	8-word	17	3.678	.002	.001	p<.005
	9-word	17	.948	.356	.178	NS

Inspection of Table 5 shows that the prosody effect is not significant at the 5-word level for any sentence type. Prosody may have less of an impact on 5-word sentences, as recall of five words is within the average list span, so chunking is unnecessary. At the 8-word level the prosody effect is not significant for grammatical sentences but highly significant for the more difficult anomalous and ungrammatical sentences, possibly because violation of semantic and syntactic rules has increased the need for support from prosody. This could also explain the significant effect of prosody on anomalous sentences at the 9-word level. Yet the fact that at the 9-word level prosody is significant for grammatical but not for the most difficult ungrammatical sentences is more perplexing, though the latter may possibly be explained by the combined impact of ungrammatical and long sentences resulting in total overload, thereby rendering the prosody effect relatively insignificant.

It is important to note that test materials were constructed to control for potential confounding variables in comparisons of the conditions of sentence type and prosody. Such controls were not exercised across different sentence lengths since length was not one of the experimental variables. Consequently, this section, which looks at the impact of sentence length, can indicate trends but not yield any firm conclusions. For instance, the results in Table 4 imply that the withdrawal of semantic cues alone in the anomalous sentence condition has a significant impact at the 5-word level. However, this may be the result of the high concentration of content words (four out of five words) in 5-word sentences (e.g. *Happy children should sing loudly*). This contrasts with longer sentences where content words only make up about half the words (e.g. *The gold crown was hidden by the bad princess*). Yet Table 4 also lends further strong support to the overwhelming impact of syntax on sentence recall. Likewise, the trend noted in Table 5 of prosody exerting an influence only in the case of longer sentences also requires further investigation, as it may reflect greater prosodic variation due to presence of function words, rather than an impact of sentence length. Therefore, the role of prosody needs to be investigated for sentences better matched in semantic and prosodic structure before any firm conclusions can be drawn.

DISCUSSION

Discussion of quantitative results

This study was designed to explore the effects of sentence type and prosody on STM as measured in sentence recall tasks, with separate investigations for content and function word recall, as they differ strongly with regard to their phonological properties and the semantic and syntactic information they carry. Whilst an analysis of content words was carried out, it was decided to abandon further investigations of function words, as the data proved to be insufficiently discriminating. Instead function word data was used with content word data to investigate the main effects at different sentence lengths (see below). Consequently all hypotheses are discussed only with regard to content words.

An ANOVA was carried out to study the effects of sentence type and prosody. The results of the ANOVA revealed highly significant main effects of sentence type and prosody with no interaction. Post-hoc paired T-tests were used to compare sentence conditions. The results are discussed in relation to each of the hypotheses.

Hypothesis 1

Repetition scores will be significantly lower for semantically anomalous sentences than for sentences that are semantically and syntactically well-formed.

Post-hoc paired T-tests revealed that, regardless of prosodic condition, significantly fewer content words were repeated correctly in anomalous compared to grammatical sentences. The hypothesis was therefore accepted. The results support the notion that semantics supports STM in sentence recall.

Hypothesis 2

Repetition scores will be significantly lower for ungrammatical sentences than for sentences that are semantically and syntactically well-formed.

Post-hoc paired T-tests showed that, regardless of prosodic condition, significantly fewer content words were repeated correctly in ungrammatical compared to grammatical sentences. The hypothesis was therefore accepted. The results support the notion that syntax supports STM in sentence recall. However, as ungrammatical sentences violate both semantic and syntactic rules, it is not possible to determine precisely the respective impact of semantic and syntactic knowledge on SR (see discussion below).

Hypothesis 3

Repetition scores will be significantly lower for ungrammatical sentences than for anomalous sentences.

Post-hoc paired T-tests confirmed that, regardless of prosodic condition, significantly fewer content words were repeated correctly in ungrammatical compared to anomalous sentences. The hypothesis was therefore accepted.

As mentioned above, it is impossible to determine precisely the relative impact that violation of semantic and syntactic rules in ungrammatical sentences has on SR. Figure 1 shows that the effect of ungrammaticality on SR is considerably greater than the effect of violating semantic rules alone in anomalous sentences. Yet it is too simplistic to calculate the impact of syntax by subtracting the effect seen in anomalous sentences from that in ungrammatical ones, as the effect in ungrammatical sentences may be due to an interaction of semantics and syntax rather than the sum of their effects. Furthermore, the disruptive effect that the introduction of anomalous words has on semantics is not necessarily comparable to the violation of semantic rules in ungrammatical sentences, where the relational meaning carried by syntax is lost. Nevertheless, the far greater disruptive effect that rendering sentences ungrammatical has on SR compared to that of anomalous sentences points to the overriding contribution of syntax compared to semantics on SR. A strong reliance on syntax to support recall is also evident in the children's attempts to restructure ungrammatical sentences in a syntactically acceptable way (see below).

Hypothesis 4

Repetition scores will be significantly lower for sentences delivered with flat prosody than for sentences delivered with regular prosody.

The results of the ANOVA showed a highly significant main effect of prosody. Post-hoc paired T-tests confirmed that the effect of prosody on content word scores is highly significant when comparing sentences for all three sentence types. The hypothesis was therefore accepted.

Discussion of error types

The frequency of error types was calculated and illustrated by pie charts (see Figures 2-5). The pattern of errors was found to be similar for grammatical and anomalous sentences. Real word fillers comprised about half of all errors, which may indicate a wish to preserve some meaning and syntax, even if the original words of a sentence cannot be recalled. Where this failed, words were omitted (the second largest error category with a quarter of all errors) or replaced with weak or unidentified word fillers. This latter error type comprised the third largest error category with the exception of grammatical sentences with prosody. Instead, grammatical prosodic sentences saw a larger number of tense or number changes which, however, only marginally affected sentence meaning and were usually syntactically admissible. Tense and number changes and refusals constituted the least frequent of error types, refusals being especially rare in easily recalled grammatical and anomalous sentences. A few cases of syntax rearrangement occurred in the anomalous/flat prosody condition, possibly to help reconstruct some meaning.

In the case of the more challenging ungrammatical sentences two main changes occurred. Firstly, the number of omissions increased, overtaking real word fillers to become the largest error category. Secondly, syntax correction, which was obviously not called for in the above conditions (though noted in some anomalous/flat prosody sentences) emerged in an attempt to organise the unstructured jumble of words. Some sentences were correctly restructured, yet most were only reorganised in parts (e.g. *The gold hidden the was princess crown by bad* became *the gold princess was hidden by bad)*, usually in conjunction with vocabulary changes (e.g. *The sad rescued a was fireman dog by brave* became *The scary fireman was dogged by brave* or *A new planted a was teacher bush by nice* became *There was a new teacher that got planted by nice*). As noted above, these examples demonstrate a strong reliance on the syntactic framework to aid recall.

The frequency of other error types did not change dramatically compared to grammatical and anomalous sentences, but there was a noticeable rise in refusals especially in the flat prosody condition.

Implications

The results in this study correspond to Miller and Isard's (1962), who found a significant effect of sentence type when comparing grammatical, anomalous and ungrammatical sentences. It appears therefore that 5- to 6-year-old children rely on established semantic and syntactic knowledge to support STM in recall tasks in much the same way as adults. This also tallies with Marshall and Nation's (2003) findings, which point to 'propositional level' processing, (understanding the general meaning of a sentence) and 'surface level' involvement (processing of syntax and words) as playing an essential role in children's SR. Moreover, Miller and Isard found semantically anomalous sentences to be "intermediate in difficulty, falling below the normal sentences but above the ungrammatical strings in terms of the measures of perceptual accuracy that we have employed", with ungrammatical posing the greatest difficulties for accurate recall. This study noted that for 5- to 6-year-old children the same gradation of difficulty applied when repeating different sentence types, with ungrammaticality exerting a much greater negative effect on recall than disruption of semantics alone.

Unlike Scholes (1970, in Bonvillian et al, 1978) who found no significant effect of intonation patterns on children's repetition, this study's findings agree with those of Bonvillian and colleagues who found a significant effect of prosody where nursery age children were asked to imitate longer sentences of up to 12 words. Yet this study failed to find any interaction between the effects analysed. The parallel graphs in Figure 3 show an effect for prosody, which though not as dramatic as the effect of ungrammaticality, remains significant across sentence type. It appears therefore that prosody exerts a constant but independent effect on recall. Future studies of linguistic knowledge on STM may wish to consider this effect as predictable yet separate, thereby minimising the need to include this factor in other studies of interactive effects.

As Gathercole (1999) has pointed out, children's capacity to retain information for brief periods of time increases dramatically from pre-school age. Whilst the results in this study allow Miller and Isard's conclusions to be extended to children as young as 5-6 years, they cannot necessarily be extended to younger age groups, where linguistic knowledge may still be too immature to provide reliable support for STM. Further investigations are required to establish the age at which established knowledge enhances recall.

The results in this study refer to typically developing children and the pattern of effects can serve as a template against which to compare the effects of semantics, syntax and prosody in children with SLI. Whilst many areas of language prove challenging to children with SLI (see Bishop's 1992 review as mentioned in Gathercole and Martin, 1996), syntax emerges as a particular area of difficulty characterised by diverse problems such as failure to acquire grammatical morphemes and problems in hierarchical structuring (Gopnik & Crago, 1991; Cromer, 1978, both in Gathercole and Martin, 1996). Future studies may show a similar pattern but reduced overall recall in children with

SLI compared to typically developing children, which would imply similar reliance on established linguistic knowledge but greater constraints with regard to both STM and language processing abilities in this population. Alternatively, children with SLI may be disproportionally affected by the withdrawal of semantic, syntactic or prosodic information. This would indicate a greater problem with STM itself, which becomes apparent with the removal of supporting linguistic knowledge. Conversely, if their limited language abilities are the greater problem, they may rely to a lesser extent on syntax and memorise in a more rote like fashion, and therefore be less affected by the withdrawal of such linguistic input.

Preliminary exploration of word span and of effects of sentence length

As outlined above, it was felt that any analysis of function words would not yield informative or reliable results. Instead, as number of function words rather than content words determined sentence length, it was felt that investigating their impact through this measure would be of greater use. It was therefore decided to investigate whether the effects of sentence type and prosody varied with sentence length. An attempt to analyse this using ANOVAs was abandoned as the data did not meet parametric conditions.

It was not possible to investigate properly word span itself, as sentence lengths were restricted to lengths of five, eight or nine words. Instead, the collated data were used to calculate word span averages for each child and for the group in all six conditions (three sentence types in both prosodic conditions) in order to pursue two lines of inquiry: to compare mean word spans for each sentence condition and to investigate the two main effects at different sentence lengths in a series of paired T-tests.

Mean word spans for the longer 9-word sentences delivered with regular prosody were of particular interest for investigating the former, as recall at this length was less likely to be at ceiling level, particularly for ungrammatical sentences which due to their jumbled word order most resemble random word strings. The high average group span for grammatical sentences of 8.14 was near to ceiling and dropped only slightly to 7.96 in the anomalous sentence condition. Yet it fell dramatically to 5.36 for ungrammatical sentences, again emphasising the strong impact of syntax on sentence recall. This score, which conforms to the average span for word strings of 5+/-2 (Miller, 1956), is also in line with the group's average digit span of 5.36.

The two main effects were examined at different sentence lengths. Further analysis of sentence type supported the highly significant effect of syntax at all sentence lengths. Yet the picture was more varied when comparing anomalous and grammatical sentences, with inconsistent results across sentence length and prosodic condition.

Analysis of the prosody effect produced a non-significant result at the 5-word level, possibly because in short sentences chunking, which prosody facilitates, is less crucial. This supports Bonvillian et al. (1978) who suggested that Scholes' (1970) failure to find a significant effect of prosody on children's SR could be due to test sentences being only three to five words long. However, no consistent pattern was discernible regarding the prosody effect where sentence length increased to eight and nine words.

Even though test materials were not matched on all properties, the above results point to a significant syntax effect which supports the original robust findings. Results also suggest possible variation of prosody effect at different sentence lengths, but no firm conclusions can be derived from this analysis, as the original experiment was not designed to control for confounding variables in these additional investigations and to allow for an interpretation of multiple findings. Any reliable findings and interpretations require further investigations.

Improving the experimental design

There are several ways in which the experimental design could have been improved. Firstly, the vocabulary for the test sentences could have been chosen in a more methodical manner, possibly consulting word lists for frequency and age of acquisition. For instance, several children were not familiar with the word *performed.* However, the great majority of words provided no difficulties and as the use of any unfamiliar words was consistent across conditions this did not affect results.

Secondly, a greater variety of function words might have been chosen. Failure to do so led to a situation in which highly significant results pertaining to the impact of sentence type and prosody on content word recall were obtained, whilst very little was gleaned about the impact such established linguistic knowledge has on function words. It is worth pointing out, though, that Miller and Isard chose to ignore function words, focusing instead on the correct repetition of whole sentences and content words. Nevertheless, any future research studying the effects of sentence type and prosody at different sentence lengths will need to ensure a relatively similar distribution of varied content and function words across different sentence lengths.

Thirdly, presenting words with regular as opposed to flat prosody takes less time, as normal prosodic delivery minimises gaps between words and reduces unstressed words. As increasing presentation duration has been shown to place a greater load on STM (Bond, 2004), further thought must be given to controlling for the confounding variable of stimulus duration in prosodic conditions.

Finally, the children were asked to repeat a large number of sentences. Unsurprisingly, their interest waned as the session wore on and it was only the promise of stickers that spurred them on. Whilst this boredom effect was controlled for by randomising sentence types and counterbalancing prosody, the session could have been rendered more enjoyable if the children had been asked to repeat fewer sentences. Future studies might consider how many sentences are needed to obtain robust results.

Summary and future research

This study set out to investigate the extent to which semantic and syntactic knowledge and prosodic pattern affect STM in sentence recall tasks. The results of content word data analysis support the notion that STM is increased by both semantic and syntactic knowledge and prosody in recall tasks, with syntactic knowledge playing the most supportive role.

Taking these findings as a starting point, future investigations may look firstly at the role of function words in sentence recall tasks and secondly, explore further the interaction of sentence type and prosody with sentence length.

Thirdly, semantics and syntax are only two aspects of linguistic knowledge that have been investigated here. Further research might consider the effect that familiarity of vocabulary has on sentence recall. This could involve replacing some familiar words with nonwords in key positions and analysing the resulting effect on recall.

Finally, this study might be a useful starting point for data comparisons with other populations, such as younger children and children with SLI. Such comparisons can help explore STM constraints and constraints on language processing and knowledge, and lead to a better understanding of any underlying difficulties. In summary, further consideration might be given to the benefits the relatively underutilised tool of SR can bring to the investigation of STM and language processing in different populations.

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Jane Maxim
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Appendix I:

CONFIDENTIAL

Project Title: An investigation into the contribution of language knowledge to short-term memory performance

Investigators: Dr. Shula Chiat, Mrs. Barbara Cohen
Department of Human Communication Science, University College London
Chandler House, 2 Wakefield Street, London WC1N 1PF

I am a registered speech and language therapist and final year MSc student in Human Communication at University College London. As part of my studies, I am carrying out a research project in which I am investigating the role of language knowledge in short-term memory tasks.

In order to carry out my study, I hope to see approximately 30 children in school for up to an hour each. During these sessions, I will first present the children with two widely used tests of grammar and vocabulary which require the child to point to the relevant picture on hearing a sentence or word. I will then present a novel sentence repetition task, which serves as an indicator of short-term memory. This will include sentences which are grammatical, ungrammatical or which do not make sense despite obeying grammatical rules. These sentences will be read in either a monotonous manner, with even stress on every syllable, or with a normal rhythmic pattern. I will carry out these tasks at the child's pace, taking breaks as appropriate, and spreading the tasks over two sessions if necessary. The sessions will be audio recorded so that I can write down the child's responses after the session. The audio recording will be destroyed at the end of the study (September 2005).

The results of each child's assessments will be anonymous, identified by number only. However, I will be happy to give you your child's results should you wish. You will also be welcome to read the final report of the study. Apart from this, there is no direct benefit to your child. However, we hope that the findings from this study will contribute to our understanding of the interaction between language skills and short-term memory, and will be of use with children who have language difficulties.

I will only include children who are happy to join the sessions. If they show distress at any point in the session, I will terminate the session.

Your child does not have to take part in this study if you do not want them to, and even if you agree to your child taking part, you may withdraw them at any time without having to give a reason. If you are willing for your child to participate in this study, I would be grateful if you would fill in the attached consent form and return it to your child's teacher.

If you have any further concerns or questions, please do not hesitate to contact my supervisor, Shula Chiat (see contact details above).

Many thanks for giving this your consideration.
Yours sincerely

Barbara Cohen
MSc Human Communication student, University College London

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the UCL/UCLH Committees on the Ethics of Human Research.

Appendix II:

CONFIDENTIAL

Parental consent form

Project title: An investigation of the role of syntax and semantics in providing 'top-down' support for short-term memory as measured in sentence repetition tasks

Investigators: Dr. Shula Chiat and Mrs. Barbara Cohen
Department of Human Communication Science, University College London
Chandler House, 2 Wakefield Street, London WC1N 1PF
Telephone: 020-7679-4242

To be completed by parent(s) or guardian(s):

1. Have you read the information sheet about this study? Yes/No*

2. Have you had an opportunity to ask questions and discuss this study? Yes/No*

3. Have you received satisfactory answers to all your questions? Yes/No*

4. Have you received enough information about this study? Yes/No*

5. Do you understand that you are free to withdraw your child from the study at any time without giving a reason? Yes/No*

6. Do you agree to allow your child to take part in this study? Yes/No*

7. If your answer to (6) is 'Yes':
   - Do you give permission for any assessments of your child to be available to the school's teaching staff? Yes/No*

   - Do you give permission for any assessments of your child to be used anonymously for further research or teaching purposes? Yes/No*

Signed..Date.....................

Name (in block letters)...

Relationship to child..

Signature of investigator...

*Delete as appropriate

Appendix III: **Test Sentences**

Structure A (SVO using emotional/mental state verbs)

GRAMMATICAL:
The baby likes to hold the furry teddy. The teacher starts to tell the funny story. A pilot hopes to land the noisy airplane. A spider tries to hurt the scary monster. A rabbit wants to bite the tasty lettuce.

ANOMALOUS:
The baby starts to land the scary lettuce. The teacher hopes to hurt the tasty teddy. A pilot tries to bite the furry story. A spider wants to hold the funny airplane. A rabbit likes to tell the noisy monster.

UNGRAMMATICAL
The furry hold to likes the teddy baby. The funny tell to starts the story teacher. A noisy land to hopes the airplane pilot. A scary hurt to tries the monster spider. A tasty bite to wants the lettuce rabbit. ('start' is not mental state verb, but could not think of replacement)

Structure B (modal verbs)

GRAMMATICAL:
Happy children should sing loudly. Messy bedrooms may smell strongly. Tasty ice-creams can melt quickly. Tiny kittens will play sweetly. Prickly roses might scratch badly.

ANOMALOUS:
Happy ice-creams may play badly. Messy kittens can scratch loudly. Tasty roses will sing strongly. Tiny children might smell quickly. Prickly bedrooms should melt sweetly.

UNGRAMMATICAL:
Sing children loudly happy should. Smell bedrooms strongly messy may. Melt ice-creams quickly tasty can. Play kittens sweetly tiny will. Scratch roses badly prickly might.

Structure C (passive)

GRAMMATICAL:
The sad dog was rescued by a brave fireman. The red ball was headed by the tall captain. A new song was performed by the cool singer. The gold crown was hidden by the bad princess. A green bush was planted by a nice teacher.

ANOMALOUS:
The sad ball was performed by the bad teacher. The red song was hidden by a nice fireman. A new crown was planted by a brave captain. The gold bush

was rescued by the tall singer. The green dog was headed by the cool princess.

UNGRAMMATICAL:
The sad rescued a was fireman dog by brave. The red headed the was captain ball by tall. A tall performed the was singer song by cool. The gold hidden the was princess crown by bad. A new planted a was teacher bush by nice.

Structure D (progressive/perfective with adverb and PP)

GRAMMATICAL:
The cold snow has fallen on the chimney. The old dog is barking in the garden. The shy boy is waiting for his present. The sick child has written to her teacher. The blue bike is rolling down the mountain.

ANOMALOUS:
The shy snow is barking to the mountain. The sick dog is waiting down the chimney. The blue boy has written on the garden. The cold child is rolling in his present. The old bike has fallen for her teacher.

UNGRAMMATICAL:
The on fallen has snow cold chimney the. The in barking is dog old garden the. The for waiting is boy shy present his. The to written has child sick teacher her. The down rolling is bike blue mountain

Appendix IV: **Order of Test Material**

ORDER A:

37: The red song was hidden by a nice fireman
1: The baby likes to hold the furry teddy
60: The down rolling is bike blue mountain the
13: A noisy land to hopes the airplane pilot
16: Happy children should sing loudly
25: Prickly bedrooms should melt sweetly
46: The cold snow has fallen on the chimney
24: Tiny children might smell quickly
14: A scary hurt to tries the monster spider
55: The old bike has fallen for her teacher
22: Messy kittens can scratch loudly
27: Smell bedrooms strongly messy may
33: A new song was performed by the cool singer
6: The baby starts to land the scary lettuce
19: Tiny kittens will play sweetly
36: The sad ball was performed by the bad teacher
15: A tasty bite to wants the lettuce rabbit
4: A spider tries to hurt the scary monster
47: The old dog is barking in the garden
42: The red headed the was captain ball by tall
26: Sing children loudly happy should
20: Prickly roses might scratch badly
41: The sad rescued a was fireman dog by brave
7: The teacher hopes to hurt the tasty teddy
35: A green bush was planted by a nice teacher
39: The gold bush was rescued by the tall singer
54: The cold child is rolling in his present
28: Melt ice-creams quickly tasty can
51: The shy snow is barking to the mountain
34: The gold crown was hidden by the bad princess
50: The blue bike is rolling down the mountain
12: The funny tell to starts the story teacher
23: Tasty roses will sing strongly
30: Scratch roses badly prickly might
52: The sick dog is waiting down the chimney
29: Play kittens sweetly tiny will
11: The furry hold to likes the teddy baby
56: The on fallen has snow cold chimney the
58: The for waiting is boy shy present his
32: The red ball was headed by the tall captain
21: Happy ice-creams may play badly
40: The green dog was headed by the cool princess
53: The blue boy had written on the garden
5: A rabbit wants to bite the tasty lettuce
44: The gold hidden the was princess crown by bad

3: A pilot hopes to land the noisy airplane
48: The shy boy is waiting for his present
49: The sick child has written to her teacher
9: A spider wants to hold the funny airplane
10: A rabbit likes to tell the noisy monster
59: The to written has child sick teacher her
8: A pilot tries to bite the furry story
43: A tall performed the was singer song by cool
57: The in barking is dog old garden the
31: The sad dog was rescued by a brave fireman
18: Tasty ice-creams can melt quickly
17: Messy bedrooms may smell strongly
45: A new planted a was teacher bush by nice
2: The teacher starts to tell the funny story
38: A new crown was planted by a brave captain

ORDER B:

10: A rabbit likes to tell the noisy monster
26: Sing children loudly happy should
29: Play kittens sweetly tiny will
56: The on fallen has snow cold chimney the
20: Prickly roses might scratch badly
44: The gold hidden the was princess crown by bad
19: Tiny kittens will play sweetly
21: Happy ice-creams may play badly
57: The in barking is dog old garden the
30: Scratch roses badly prickly might
34: The gold crown was hidden by the bad princess
12: The funny tell to starts the story teacher
3: A pilot hopes to land the noisy airplane
7: The teacher hopes to hurt the tasty teddy
25: Prickly bedrooms should melt sweetly
38: A new crown was planted by a brave captain
50: The blue bike is rolling down the mountain
14: A scary hurt to tries the monster spider
33: A new song was performed by the cool singer
4: A spider tries to hurt the scary monster
45: A new planted a was teacher bush by nice
16: Happy children should sing loudly
42: The red headed the was captain ball by tall
41: The sad rescued a was fireman dog by brave
23: Tasty roses will sing strongly
47: The old dog is barking in the garden
32: The red ball was headed by the tall captain
36: The sad ball was performed by the bad teacher
27: Smell bedrooms strongly messy may
52: The sick dog is waiting down the chimney
40: The green dog was headed by the cool princess
2: The teacher starts to tell the funny story
51: The shy snow is barking to the mountain
5: A rabbit wants to bite the tasty lettuce
28: Melt ice-creams quickly tasty can
48: The shy boy is waiting for his present
59: The to written has child sick teacher her
6: The baby starts to land the scary lettuce
18: Tasty ice-creams can melt quickly
11: The furry hold to likes the teddy baby
53: The blue boy has written on the garden
17: Messy bedrooms may smell strongly
55: The old bike has fallen for her teacher
15: A tasty bite to wants the lettuce rabbit
35: A green bush was planted by a nice teacher
22: Messy kittens can scratch loudly
46: The cold snow has fallen on the chimney

1: The baby likes to hold the furry teddy
39: The gold bush was rescued by the tall singer
54: The cold child is rolling in his present
9: A spider wants to hold the funny airplane
58: The for waiting is boy shy present his
24: Tiny children might smell quickly
37: The red song was hidden by a nice fireman
43: A tall performed the was singer song by cool
8: A pilot tries to bite the furry story
31: The sad dog was rescued by a brave fireman
49: The sick child has written to her teacher
60: The down rolling is bike blue mountain the
13: A noisy land to hopes the airline pilot

Appendix V: Sample Score Sheet

Ungrammatical P+	**Cont wrds corr**	*Funct Wrds corr*	Strategies: Omis sions	Ref usal	Real word fillers	Weak word fillers	Unidentified word fillers	Change tense/ plural	Correct g Syntax
6 The furry hold to likes the teddy baby (**5**,*3*)									
7 The funny tell to starts the story teacher (**5**,*3*)									
8 A noisy land to hopes the airplane pilot (**5**,*3*)									
9 A scary hurt to tries the monster spider(**5**,*3*)									
10 A tasty bite to wants the lettuce rabbit (**5**,*3*)									
21 Sing children loudly happy should (**4**,*1*)									
22 Smell bedrooms strongly messy may (**4**,*1*)									
23 Melt ice-creams quickly tasty can (**4**,*1*)									
24 Play kittens sweetly tiny will (**4**,*1*)									
25 Scratch roses badly prickly might (**4**,*1*)									
36 The sad rescued a was fireman dog by brave (**5**,*4*)									
37 The red headed the was captain ball by tall (**5**,*4*)									
38 A tall performed the was singer song by cool (**5**,*4*)									
39 The gold hidden the was princess crown by bad (**5**,*4*)									
40 A new planted a was teacher bush by nice (**5**,*4*)									
51 The on fallen has snow cold chimney the (**4**,*4*)									
52 The in barking is dog old garden the (**4**,*4*)									
53 The for waiting is boy shy present his (**4**,*4*)									
54 The to written has child sick teacher her (**4**,*4*)									
55 The down rolling is bike blue mountain the (**4**,*4*)									
Total									

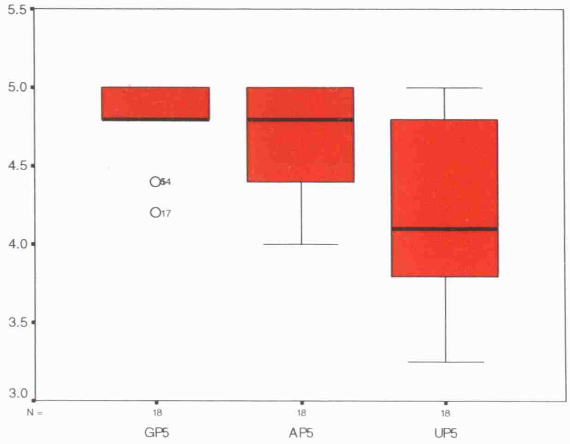
Appendix VI:

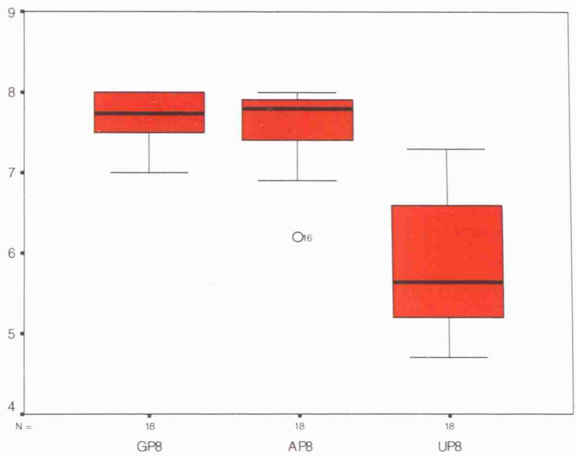
Standardised Test Results:

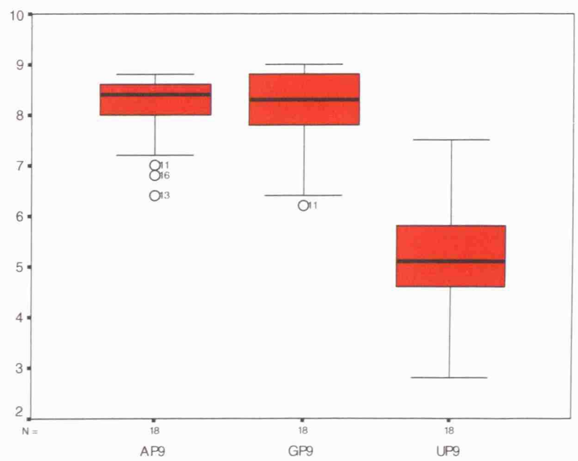
	Subject Nbr.	BPVS	TROG Stand Score (Percentile)	Digit Span Av. for age 5-6: 4.5 Av. for age 6-7: 5	Comments
RE CEP TION	1	102	125 (95)	3 / 4.5	
	2	102	107 (75)	5.5/ 4.5	under 5 (4.09)
	3	110	103 (66)	5 / 4.5	under 5 (4.10)
	4	114	135 (99)	5 / 4.5	
	5	107	123 (95)	6.5/ 4.5	
	6	97	95 (42)	5 / 4.5	
	7	100	125 (95)	4.5/ 4.5	
	8	112	132 (99)	7.5/ 4.5	
	9	92	87 (25)	6.5/ 4.5	
	10	106	105 (75)	5.5/ 4.5	
YEAR 1	11	101	99 (50)	4.5/ 5	
	12	94	117 (90)	6 / 5	
	13	92	91 (34)	6 / 5	
	14	105	---	---	refused to continue
	15	100	139 (99)	7.5/ 5	
	16	99	117 (90)	5.5/ 5	
	17	108	95 (42)	4.5/ 5	
	18	126+	126 (95)	5 / 5	BPVS discontinued
	19	101	117 (90)	4 / 5	
	20	110	95 (42)	4.5/ 5	
	21	95	117 (90)	6 / 5	
	22	95	99 (50)	4.5/ 5	

Appendix VII

Boxplots: sentence types with regular prosody







Boxplots continued: sentence types with flat prosody