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**INVESTIGATING THE RELATIONSHIP BETWEEN SPEECH
DISCRIMINATION SKILLS IN RECEPTION CLASS AND
RECEPTIVE LANGUAGE ABILITY IN YEAR TWO**

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Submitted in partial fulfilment of the MSc in Speech and Language Sciences

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ABSTRACT

Language development is affected by a multitude of factors. Many studies have shown a correlation between auditory discrimination and language ability in children up to three years old (Benasich et al, 2002; Talay, 1996; Tsao et al, 2004). Evidence of a link between auditory discrimination and language abilities in older school-aged children has been less clear. This study investigates the relationship between speech discrimination in 4-5 year olds and receptive language ability at 6-7 years and hypothesises that there will be a relationship between the two.

Previous research has shown that children have more difficulties discriminating speech as the level of background noise increases, and that children with language difficulties have greater difficulties than those without (Ziegler et al, 2005; Bradlow et al, 2003; Cunningham et al, 2001). This study also hypothesises that speech discrimination in noise scores at 4-5 years will be a better predictor of receptive language at 6-7 years than speech discrimination in quiet scores.

Speech discrimination skills and receptive language were assessed in 54 children when they were in reception class (4-5 years) and when they were in year two (6-7 years). The results showed that there was no significant correlation between speech discrimination at 4-5 years and receptive language at 6-7 years. Regression analyses indicated that speech discrimination scores in quiet and noise at 4-5 years did not add to the predictive value of a language measure at 4-5 years in predicting language outcome at 6-7 years.

The study concluded that although there was no significant correlation between speech discrimination at 4-5 years and receptive language at 6-7 years, it is possible that earlier speech discrimination difficulties that have since resolved, contribute to later language difficulties. Measuring speech discrimination skills at 4-5 years could still be a useful clinical tool to identify children that have difficulties that might make understanding language more effortful, even if they do not lead to persisting receptive language difficulties, and who may be at risk for expressive language or literacy difficulties.

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INTRODUCTION

There is a great amount of individual variation in the rate at which children develop language. Most children are able to develop language easily. However, a small subset of children have more difficulty and 5-10% of children have a specific language impairment (Leonard, 2000). Language development is affected by a multitude of factors, including cognitive skills such as attention and memory. Another skill that is thought to be involved in language development is auditory discrimination. It is difficult to investigate the relationship between any one factor and language development without other factors confounding the results.

Auditory discrimination involves the ability to differentiate between different sounds (speech or non-speech) by comparing and contrasting them. Speech discrimination involves differentiating between spoken speech sounds, and enables recognition of words as different from each other, even if they are acoustically similar, for example, 'pin' and 'bin' (Vance et al, 2005). A child with auditory discrimination difficulties might pass a hearing test, but be unable to detect differences between sounds. In the first few weeks after birth, typically developing infants can discriminate phoneme contrasts that exist in their own language, as well as those that exist in other languages. By 10-12 months, infants, like adults, only discriminate the contrasts present in their own language (Kuhl et al, 1992, in Benasich et al, 2002).

To comprehend and produce language, it is important for a child to be able to recognise the sound patterns of their own language. Stackhouse and Wells (1997), propose a psycholinguistic model of speech processing, in which intact auditory discrimination skills allow children to store accurate phonological representations and motor programs. To acquire vocabulary phonological representations of sequences of sounds must be stored in a lexicon and mapped to their meaning. Werker et al (2002), investigated word learning in infants and found that 14 month olds failed to associate phonetically similar names (for example, *bih*, *dih*) with unfamiliar objects and infants did not fully succeed at the task until they were 24 months old. This suggests that an infant with advanced speech discrimination skills might have advanced word learning skills.

In order to recognise and understand a spoken word, the sequence of sounds being heard must be matched to an accurate phonological representation. Auditory discrimination difficulties could lead to the wrong representation being accessed and would therefore affect understanding of spoken language. As well as playing a role in vocabulary acquisition and understanding of language, auditory discrimination skills also impact upon speech output ability. Inaccurate stored motor programs would result in inaccurate pronunciation of words.

- **Investigating the relationship between auditory discrimination and language development in typically developing children**

The relationship between auditory discrimination skills and language development can be investigated by looking at correlations between the two in typically developing children. Auditory discrimination is not easy to assess in young children. When it is measured using complex tasks that require attention and memory, results could be confounded by cognitive ability. In the research, the method used to assess auditory discrimination skills in young preverbal infants involves them making a head turn response to novel speech sounds, which are reinforced by a contingently presented reward. Research studies often use technology that is not readily accessible in clinical contexts and does not necessarily reflect an infant's ability to discriminate speech in 'real-life' contexts.

Several studies have used this method to investigate the relationship over time between auditory discrimination skills and language development. Significant correlations have been found between auditory discrimination in infants under one year and language comprehension and expression at different ages up to three years old (Benasich et al, 2002; Talay, 1996; Tsao et al, 2004). Of these three experiments, only Tsao et al (2004) assessed speech discrimination skills, whereas the other two assessed discrimination of tone stimuli. Discrimination of non-speech sounds involves a lower level of auditory processing. Non-speech discrimination deficits may not help us to understand the nature of a child's individual language difficulty (Vance, 2005).

There have been less studies in typically developing school-aged children and those that exist investigate skills at one age rather than across time. Brown (2005) found a weak but significant correlation between speech discrimination ability and receptive and expressive language at 4-5 years. The largest proportion of variance was accounted for by other factors. Therefore, speech discrimination may not be a strong factor in language ability at this age. Watson et al (2003) found no significant association between auditory and language skills in a large study of 6-7 year olds.

A correlation between auditory discrimination and language has therefore been demonstrated in typically developing children under five years old, but has not been demonstrated in older, school-aged children. The relationship between auditory discrimination skills and language development may only exist in younger children, or early auditory discrimination difficulties may resolve as children get older. Studies in older, verbal children, assess speech discrimination skills using tasks with different demands, which may also account for the differences observed.

- **Investigating auditory discrimination skills in children with language impairments**

The links between auditory discrimination and language development can also be informed by studies that compare the auditory discrimination skills of children with language difficulties to those without language difficulties. The evidence in this area has been inconsistent. Tallal and Piercy (1973), cited in Bishop (1997), found that children with language impairment had difficulty with the discrimination of brief or rapidly changing sounds of different frequencies. Children were required to indicate whether two tones were the same or different, while the inter-stimulus interval (ISI) was gradually decreased. Children with language impairment performed the same as children with normal language when the ISI was long, but significantly worse when the ISI was short. However, Norrelgen et al (2002) found that 5-7 year old children with language impairment performed the same as controls in a same-different task using brief tone stimuli with variable ISIs, but significantly differently with speech stimuli.

The relationship between auditory discrimination skills and language might only exist when assessing higher levels of auditory processing (speech discrimination), and not when assessing low level auditory processing (tone discrimination). This is further backed up in a study using auditory event-related potentials (ERPs). These are evoked by 'deviant' stimuli in a sequence of identical sounds. Uwer et al (2002) elicited ERPs in children with language impairment and normally developing children. They found a significant difference between the groups when using speech stimuli (children with language impairment had attenuated amplitudes), but no difference between groups when using tone stimuli differing in frequency and duration. They concluded that the discrimination of simple tones was unimpaired.

Several studies have confirmed that there are significant differences between the speech discrimination skills of children with and without language difficulties (Stollman et al, 2003; Bernstein and Stark, 1985). These studies include school-aged children up to six years old. These findings could be thought to contradict the lack of evidence of a relationship between speech discrimination skills and language development in typically developing school-aged children discussed earlier. However, studies of large samples of typically developing children may cover up a subset of children that have language difficulties related to speech discrimination difficulties.

It was also suggested earlier that the lack of relationship demonstrated between auditory discrimination and language development in school-aged typically developing children could be due to auditory discrimination difficulties resolving as children get older. Bernstein and Stark (1985) found that speech discrimination abilities at ten years old were at or near ceiling in children with and without language difficulties, even though most of the children in the language impairment group remained language-impaired. They concluded that poor auditory discrimination in early childhood may be implicated in a persisting language deficit even though normal processing may develop in time.

Research that compares children with and without language difficulties remains inconclusive on the relationship between auditory discrimination and language development. It is possible that there is no association between low level auditory

skills such as tone discrimination and language and that an association only begins with speech discrimination at the word level.

- **Can auditory discrimination difficulties cause language difficulties?**

It is important to note that any significant correlation between auditory discrimination and language development is open to more than one interpretation. Rather than language impairment being a secondary consequence of an auditory processing problem, it might be the cause of it. An auditory processing problem might also co-occur with other causative factors that play a role in language development. Gathercole and Baddeley (1990) suggest that memory plays a role in acquiring language. They found that children with language difficulties had poorer non-word repetition and serial recall of words than a younger group of normal language children with equivalent vocabulary.

Briscoe et al (2001) found that children with language impairment and those with moderate sensorineural hearing loss (SNHL) were equally impaired in speech discrimination skills. However, the children with SNHL did not have the language and literacy difficulties that were seen in children with language impairments. They concluded that speech discrimination difficulties were not a sufficient cause of language impairment and that additional impairments must be present for major language difficulties to result.

If auditory discrimination difficulties caused language difficulties we might assume that all children with language difficulties also have auditory discrimination difficulties. However, there are children with language impairment who appear to have completely normal auditory discrimination skills, as well as children with normal language skills that have auditory discrimination difficulties (Bradlow et al, 2003). This could be due to the heterogeneity in children with language impairment and the fact that each research study has slightly different selection criteria for those they consider to have a language impairment. As discussed above, it could also be the case that children with language difficulties had auditory discrimination difficulties in the past that have since resolved.

- **Assessment of auditory discrimination ability**

The research discussed so far has been inconclusive in establishing a relationship between auditory discrimination abilities and language development. This could also be due to the difficulties in assessing auditory discrimination abilities in young children. It is important to have a sensitive enough assessment of speech discrimination skills to identify children who have difficulties and may be at risk of language difficulties, whilst not being so demanding that a child is unable to succeed on the task due to other factors.

Most of the research into auditory discrimination and language has either involved the head turn technique with preverbal infants or an AX task in which the child is required to listen to paired stimuli (speech or non-speech) and report whether or not they were the same or different. According to Locke (1980), children may fail on AX tasks not because they do not perceive differences between items, but because they ignore such differences as unimportant. These assessments also rely on behavioural responses, and it is therefore hard to conclude whether difficulties are purely due to auditory discrimination difficulties, or whether other factors have prevented the child succeeding. Factors such as language ability (understanding the task), cognitive skills (memory and attention) and hearing ability will have an effect on a child's ability to succeed in a task.

Speech discrimination skills are not regularly screened alongside language abilities by speech and language therapists. According to Vance (2005), there is a very limited range of standardised assessments of auditory discrimination in children. The Auditory Discrimination and Attention Test (Morgan Barry, 1988) is a minimal pair picture pointing task that requires children to access their own representations and compare them to the heard word. Only minimal pairs that can be drawn and are familiar to young children can be used (Vance, 1996). The Wepman Auditory Discrimination Test (Reynolds, 1987) requires children to indicate whether verbally presented minimal pairs are the same or different. The word pairs used do not always differ enough for children to have difficulty discriminating between them and therefore might not reveal more subtle difficulties (Vance, 1996).

In this study a non-word XAB discrimination task is used. Children are presented with three stimuli and are required to indicate whether the second or third stimulus sounded the most like the first. The task requires the child to hold and compare three items in short-term memory and therefore has more of a memory demand than an AX task. Unlike the AX task, the XAB task forces the child to acknowledge a distinction and decide which of the two words is most like the first (Baker and Grundy, 1995). The use of non-words assesses the child's ability to discriminate speech sounds without referring to lexical representations. Discrimination has to be carried out using bottom-up auditory processing skills. The increased demands of the task make it more able to reveal more subtle processing difficulties in older children (Vance, 1996).

- **Speech discrimination in noise**

The XAB non-word discrimination assessment can be made more sensitive by including a measure of speech discrimination in the presence of background noise. The ability to discriminate speech in noise is a skill that children need to acquire as they are regularly exposed to noisy environments both in and out of the classroom. The average noise level in empty primary school classrooms in central London is 47dB, which is higher than the recommended upper noise limit of 35dB (Shield and Dockrell, 2004). Most of the research to date has found that children with learning or language difficulties are more disadvantaged in noisy environments than those without such difficulties. The evidence is reviewed below.

Ziegler et al (2005) found that 8-12 year old children with language impairments only showed subtle, non-significant speech discrimination difficulties in a quiet condition, but substantial speech discrimination difficulties compared to age and language controls in the presence of background noise. A similar pattern of results was found with children with learning disabilities (Bradlow et al, 2003; Cunningham et al, 2001). These children performed significantly worse than normal children on speech discrimination in noise, but showed no differences in the quiet condition. These studies have shown that all children have poorer speech perception as background noise level increases, but those with language and learning difficulties are more adversely affected by noise.

Cunningham et al (2001) also found similar representation of speech in both groups of children when measuring evoked responses to speech in the quiet condition, but abnormalities in children with learning difficulties when the speech was presented in noise. People with hearing impairments and those from different language backgrounds are also more adversely affected by noise (Kenyon et al, 1998; Mayo et al, 1997).

There is a lack of difference between speech discrimination skills in children with and without language difficulties when assessed in a quiet condition. This measure appears to be too easy and therefore less sensitive to detecting speech discrimination difficulties than a measure of speech discrimination in noise. The latter seems better able to identify those with speech discrimination difficulties and might therefore be a better predictor of language difficulties.

- **Benefits of making predictions about later language ability**

If there is a relationship between speech discrimination skills at 4-5 years and receptive language ability at 6-7 years, there would be implications for speech and language clinical practice. The most important implication is that it would be appropriate to routinely assess speech discrimination skills in pre-school children who present to speech and language services, or to consider screening these skills as children enter reception class. Having a measure that could predict later language difficulties would enable therapists and teachers to identify children at risk and consider early intervention that might reduce or prevent later language difficulties.

There is evidence to suggest that auditory discrimination training can lead to an improvement in this skill (Crosbie and Dodd, 2001; Hurford and Sanders, 1990). Meaningful minimal contrast therapy (Weiner, 1981) could be used to accompany auditory discrimination training and highlight differences in meaning between a change from one phonological structure to another. This might help prevent a child storing inaccurate phonological representations in their lexicon. In children at risk of language difficulties, it would be important to set language targets as well as speech discrimination targets.

Environmental modifications can help children with speech discrimination difficulties and may therefore contribute towards preventing more serious language difficulties in the future. These include decreasing background noise in classrooms and speech modification techniques. Speech discrimination in noise improved in the presence of 'clear speech' (speech with a decreased rate and increased frequency and duration of pauses), as compared to 'conversational speech' (Bradlow et al, 2003; Cunningham et al, 2001).

Children with language difficulties are vulnerable to literacy difficulties and academic underachievement, and according to Goodyer (2000), they have an increased rate of emotional and behavioural disorders. The benefit of early intervention that reduces or prevents language difficulties includes the reduction of these negative consequences of language difficulties.

Slow development of language is common among 2-3 year olds, but there are poorer long-term outcomes if language delay persists beyond five years (Whitehurst and Fischel, 1994). Ideally an early diagnostic measure would identify children with significant impairments and not those that will spontaneously recover. This study is looking for a predictor of language difficulties at 6-7 years and will therefore be more able to identify children with persisting difficulties.

- **Summary and links up to research question**

Many studies show a correlation between auditory discrimination and later language ability in younger pre-school aged children. However, there is conflicting evidence of a link between auditory discrimination and language abilities in older children. It is possible that school aged children that were identified as having normal auditory discrimination abilities, had difficulties in the past that left them with language difficulties. It is therefore useful to study the relationship between speech discrimination skills and language development further in school aged children, and investigate this relationship over time.

Some of the evidence investigating the relationship between auditory discrimination and language development has involved assessing discrimination of non-speech

sounds. This involves a lower level of processing than speech discrimination and it is not clear whether a difficulty in discriminating tones and other non-speech stimuli has any effect on the ability to process speech (Vance, 2005). From a clinical perspective it is more appropriate to focus on speech discrimination difficulties which can contribute to decision making regarding intervention.

Research into speech discrimination in noisy and quiet conditions has shown that all children have more difficulties discriminating speech as the level of background noise increases, but that children with language difficulties have greater difficulties than those without. Measuring speech discrimination in noise will therefore identify children that have subtle speech discrimination difficulties that may not be identified in a quiet condition. It could be that children with language difficulties do not have a difficulty with speech discrimination in general, but only have a problem with speech discrimination in noise. However, research in this area is inconsistent and there are children with language difficulties that have more difficulty with speech discrimination in a quiet condition than children without language difficulties.

This study poses the question: Do speech discrimination skills at 4-5 years predict receptive language ability at 6-7 years? It is hypothesised that there will be a relationship between speech discrimination scores at 4-5 years and receptive language scores at 6-7 years and that speech discrimination in noise scores at 4-5 years will be a better predictor of receptive language at 6-7 years than speech discrimination in quiet scores.

METHOD

- **Design**

This study aimed to investigate the relationship between speech discrimination skills at 4-5 years and receptive language skills at 6-7 years. The study used a correlational design in which each subject was tested on every assessment and at both ages.

The independent variables were speech discrimination scores in the quiet and noisy conditions at 4-5 years. The dependent variable was the receptive language scores at 6-7 years.

- **Subjects**

54 children were assessed. In the first testing children were aged between 4.33 and 5.33 (mean age 4.88 years, standard deviation 0.27) and in the second testing they were aged between 6.33 and 7.25 (mean age 6.82 years, standard deviation 0.28).

In 2005, all reception class children born between 1/9/2000 and 31/8/2001 in ten schools under the West Sussex Local Education Authority were invited to take part in the study. In 2007 children that had taken part in the first phase of the study were contacted to take part in the second phase. Letters were sent out to parents explaining the 'Listening to Speech' project (Appendix A) and consent forms (Appendix B) were returned. In the second phase of the project children from four of the original ten primary schools, for whom consent forms were received, were assessed.

No exclusion criteria were used. The children that were assessed had a range of abilities, including children with mild learning difficulties, hearing difficulties and those already identified to speech and language therapy services. There were no children with more severe impairments in the sample. This sample of children could be considered as representative of children in mainstream schools.

- **Materials**

The larger 'Listening for Speech' project assessed the following skills. In phase one (4-5 years), children's receptive language, expressive language, speech discrimination skills and non-word repetition were assessed. In the second phase of the project (6-7 years), receptive language, speech discrimination skills, phonological awareness (phoneme isolation and rhyme awareness) and reading were assessed. This study used a selection of data from these assessments. The assessments that were relevant to this study are described below. The procedure for each assessment is included under each description.

Each tester had copies of the assessments to be used, score sheets, a laptop, headphones and a list of children that included their dates of birth and number codes. In phase one testers had a toy to provide a break from testing and in phase two testers had stickers to reward children at the end of testing.

Phase One (4-5 year olds)

Clinical Evaluation of Language Fundamentals Preschool (CELF-P, Wiig et al, 2000): Linguistic Concepts Subtest

The CELF preschool assessment investigates language deficits in children aged 3 years to 6 years 11 months. The linguistic concepts subtest was used in this study as a measure of receptive language. It has 20 items that assess the ability to comprehend oral directions that:

- i) contain early acquired linguistic concepts such as *either/or*
- ii) involve quantifiers and ordinals such as *some* and *first*
- iii) increase in length from one to three level commands.

The examiners manual has directions and procedures for administering and scoring the CELF-P. Stimulus manual one contains the visual picture stimuli for the subtest and answers and scores can be recorded on the linguistic concepts record form.

Procedure

The CELF-Preschool was administered according to guidelines in the examiner's manual. The familiarisation section was presented first to ensure that each child knew the animals presented in the test items. The familiarisation was followed by two trial items that ensured the child understood how to carry out the task, by allowing prompting in various ways. For each test item, the child was asked to point to animals in response to the examiner's direction, for example, "*Look. Point to one of the bears*". For each item, the tester turned to the appropriate stimulus page in the manual and said, "*Look...*" Test items were not repeated.

Responses were recorded on the linguistic concepts record form, numbering the shaded silhouettes of the picture stimuli in the order in which the child pointed to them. A score of one was given for a correct response, zero for an incorrect response and NR for no response. The test was discontinued if a child made four consecutive responses that earned scores of zero (errors or no responses). Raw scores were obtained by adding the scores of the individual items administered.

Speech Input Processing in Children (SIPc, Vance et al, 2005)

The SIPc is a computer based assessment designed to investigate speech discrimination abilities in children from four years old. It has a "mouse test" to familiarise children with the computer and check whether they are able to use the mouse. In this, a cartoon baby appears on the screen and the child has to click on the baby using the mouse, which then jumps to another location on the screen, ready for the child to click again.

The XAB non-word discrimination task requires the child to identify which one of two auditory stimuli (A and B) is the same as the first (X). The task is presented on the computer as a game. The computer screen shows a large spaceship at the top and two smaller spaceships below (Appendix C). An alien appears in the top space ship and says a non-word 'X', e.g. '*pish*'. Another alien appears in the lower left hand ship and says a non-word 'A', that is either the same as X or different, for example, '*vish*'. The second alien then appears and says the other of the two non-words 'B'.

The child is required to click on the alien that said the same as the alien in the top spaceship. The auditory signal is presented through headphones plugged into the laptop.

All the non-words are single syllable and are phonotactically legal (the sound combinations present in the non-words occur in at least one English word). The minimal pairs were created by changing one phoneme in each non-word to create another legal non-word (Appendix D). The minimal pairs include changes in a range of contrasts which might vary the ease with which pairs can be discriminated. The task is presented in two conditions, quiet and with background noise. In the noisy condition, multi-talker babble with a signal to noise ratio of +2dB and no semantic content is used. The speech stimuli were recorded by a female phonetician in an anechoic chamber.

Procedure

The tester adjusted the headphones and ensured the child could hear the stimuli, before clicking on the SIPc icon on the laptop to start the programme. The tester right clicked on the mouse and chose from the menu the task to be carried out ('mouse test' or 'xab'). This menu was used to move onto each block and exit the programme when finished. The tester entered the child's code number into the computer after selecting the task. The mouse test was carried out first. If a child had difficulty using the mouse, or didn't want to do so, they were able to point to the picture on the screen in the mouse test and speech tasks, and the tester made the responses for them.

To select the speech discrimination tasks the tester selected xab (noisy or normal) from the menu and then selected either xabprac, xabblock1 or xabblock2 from the next menu according to which task was to be carried out at the time. In order to maintain attention and motivation, the XAB non-word discrimination tasks were presented in a series of blocks. A practice block was presented first, followed by two test blocks in each of the quiet and noisy conditions. Each block consisted of 15 items. The four test blocks were carried out in a different order for each child and within each block the items were presented in a random order.

The tester introduced the XAB task by saying “ *Now we’re going to play a game on the computer. You will see some aliens that speak their own alien language. The alien at the top (pointing to top spaceship) will say a word and you need to choose which alien from the bottom (pointing to the two spaceships at the bottom) says the same thing. Remember to listen carefully.*”

The practice block enabled each child to learn how to do the task. It was not scored and explanations were provided depending on the child’s level of need. In the practice block, visual support was provided for the first five items. The aliens were accompanied by symbols that matched each word and acted as a visual prompt. The tester didn’t draw the child’s attention to these prompts. For the following five items the symbols only appeared if a child made an incorrect response. For the final five items, the symbols didn’t appear, even if an incorrect response occurred. Six non-word minimal pairs were used in the practice block: for eight of the fifteen items ‘A’ matched ‘X’ and for seven items ‘B’ matched ‘X’. If a child had to repeat more than four or five items on the practice block the whole block was repeated to give them the opportunity to learn how to do the task.

In the test blocks, visual symbols were not used. Before a noisy block, the child was told, “ *This time it’s going to be a bit harder to hear the aliens because there will be some noisy children talking as well, so you need to listen very carefully*”. Of the thirty items in each of the quiet and noisy blocks, ‘A’ matched ‘X’ for fifteen items and ‘B’ matched ‘X’ for the other fifteen. In both practice and test blocks, if the child responded correctly they received spoken feedback, ‘well done’ and a balloon appeared at the side of the screen (the child could see the balloons filling up the left side of the screen to give an indication of how many items they had left to complete). If the child responded incorrectly they heard ‘try again’ and the items were repeated for the child to respond again. The green ‘go’ button in the middle of the bottom of the screen was clicked to proceed to the next item. Between each item the child heard a preparation statement, for example, ‘ready’, or ‘here we go’.

At the end of each block clicking on ‘go’ provided a ‘reward’ screen. In phase one children viewed an on-screen animation involving rapid presentation of cartoon faces and were encouraged to ‘catch’ them. In phase two children viewed an animation in

which they could select one of five doors to find a hidden face. This was not part of the assessment, but was used to increase motivation for the task. Following this the tester clicked on 'OK' to save file data.

The XAB speech discrimination results were saved onto the computer under each child's code number. The results were then accessed through: My computer, C drive, Documents and Settings, New user, Application Data, SIPcFullV1, Results. The results were saved in individual folders for each child in an excel file in which column H provided information on the number of attempts made for each item. A number one in column H meant the child responded correctly first time, and therefore scored one. A two in column H meant the child did not respond correctly the first time and therefore scored zero.

Phase Two (6-7 year olds)

Clinical Evaluation of Language Fundamentals Revised (CELF-R, Semel et al, 1987): Sentence Structure Subtest

The CELF-R assessment investigates language deficits in school-aged children. The sentence structure subtest was used in this study as a measure of receptive language. It has 26 items that assess the acquisition of syntactic structures of increasing complexity in 5-7 year olds, for example, "*The girl is not climbing*". The assessment involves picture identification with one target and three distracters. The examiners manual has directions and procedures for administering and scoring the CELF-R. Stimulus manual one contains the visual picture stimuli for the subtest, and answers and scores can be recorded on the sentence structure record form.

Procedure

The CELF-R was administered according to guidelines in the examiner's manual. The tester first turned to the page in stimulus manual one marked 'sentence structure/ demonstration' before moving to the trial item. During the demonstration and trial items the tester was allowed to prompt the child in various ways to ensure they understood how to carry out the task. Test items were then introduced by the tester

saying, “*Now let’s do some more, listen carefully because I can’t say it again. The man who is carrying his umbrella is walking out the door*”. For each item, the tester turned to the appropriate stimulus page in the manual and said, “*Show me...*”. Test items were not allowed to be repeated.

Responses were recorded on the sentence structure record form, circling the letter corresponding to the student’s response and then circling one for a correct response, zero for an incorrect response and NR for no response. The test was discontinued if a child made four consecutive responses that earned scores of zero (errors or no responses). Raw scores were obtained by adding the scores of the individual items administered.

Speech Input Processing in Children (SIPc, Vance et al, 2005)

The same materials and procedure were used as in phase one.

- **Procedure**

The order of assessment presentation was randomised before the data collection began and score sheets were ordered into pre-prepared packs. The SIPc tasks were copied from a CD onto the hard drive of laptops in advance of testing. Testers involved in data collection at both times were trained in the administration of assessments and had a speech and language therapy background. Children were collected one at a time from their classrooms and taken to a quiet room to complete the assessments, free from excessive noise and visual distractions. The code number for each child was recorded on the first score sheet.

At 4-5 years, children were given breaks if necessary (time to play with a toy) and at 6-7 years children were rewarded with a sticker at the end of testing. Throughout each assessment the testers gave positive reinforcement to the children to maintain their attention and motivation. The testers did not give the children specific feedback on their performance.

All children's codes, ages, scores and school codes were inputted into an SPSS table and data was collated from all testers. A correlational analysis was carried out using Spearman's correlation coefficient to measure the relationship between variables. Linear regression was used to determine how much of the variance in language scores at 6-7 years could be predicted from the variance in speech discrimination scores at 4-5 years.

RESULTS

- **Descriptive Statistics**

Table 1: Mean scores for each assessment at time one (4-5 years) and time two (6-7 years)

Assessments	Mean	Standard Deviation	Minimum	Maximum
T1 XAB speech discrimination (quiet)	22.98	4.68	10	30
T1 XAB speech discrimination (noise)	18.37	4.17	10	27
T1 CELF raw scores	15.94	3.31	2	20
T2 XAB speech discrimination (quiet)	28.20	2.79	18	30
T2 XAB speech discrimination (noise)	23.76	3.13	12	28
T2 CELF raw scores	22.09	3.25	13	26

The speech discrimination measures at time one (4-5 years) had a broad distribution of scores even though they were statistically abnormal. Histograms of these measures can be seen in figures 1 and 2 below. The language measure at time one (4-5 years) and time two (6-7 years) and the speech discrimination scores at time two (6-7 years) were not normally distributed. These measures had distributions that were negatively skewed, suggesting a ceiling effect in children's scores. Histograms of these measures can be seen below in figures 3-6.

Figure 1: Histogram to show the distribution of speech discrimination scores in quiet at 4-5 years.

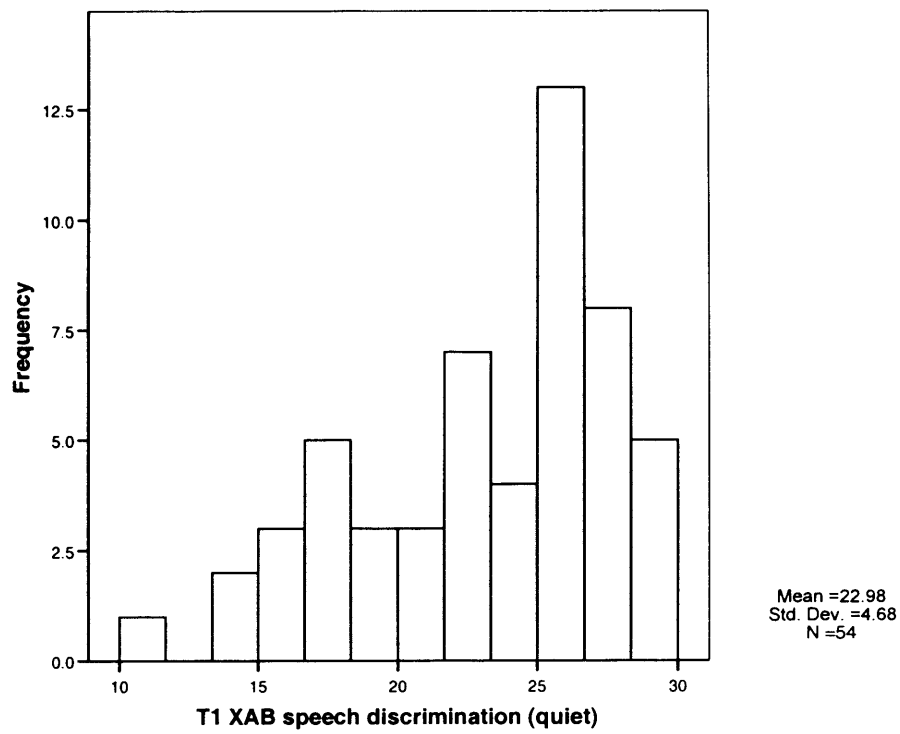


Figure 2: Histogram to show the distribution of speech discrimination scores in noise at 4-5 years.

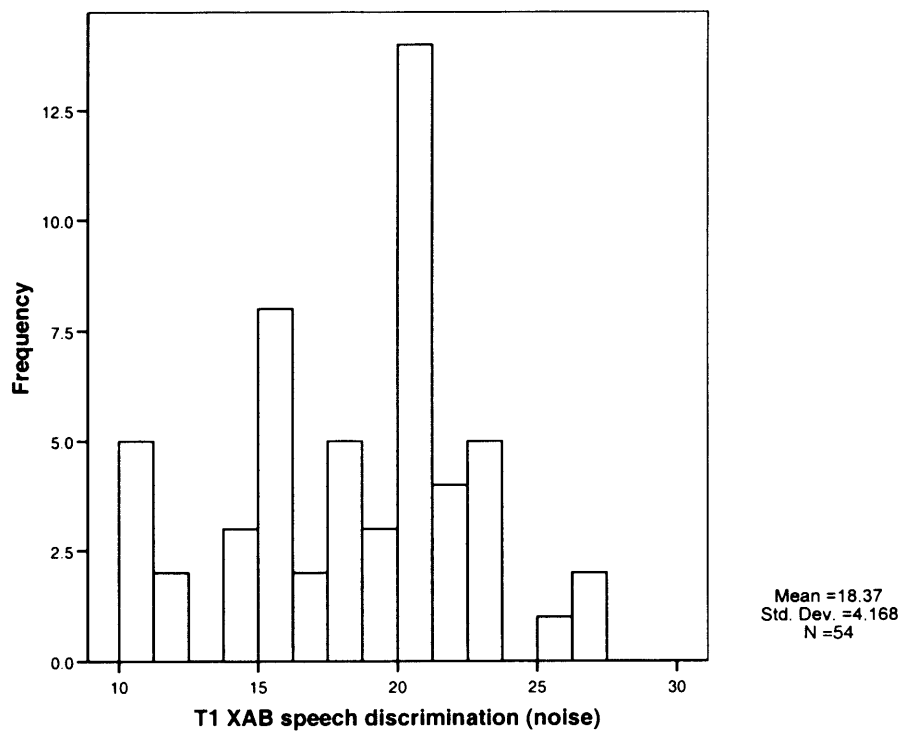


Figure 3: Histogram to show the distribution of CELF raw scores at 4-5 years.

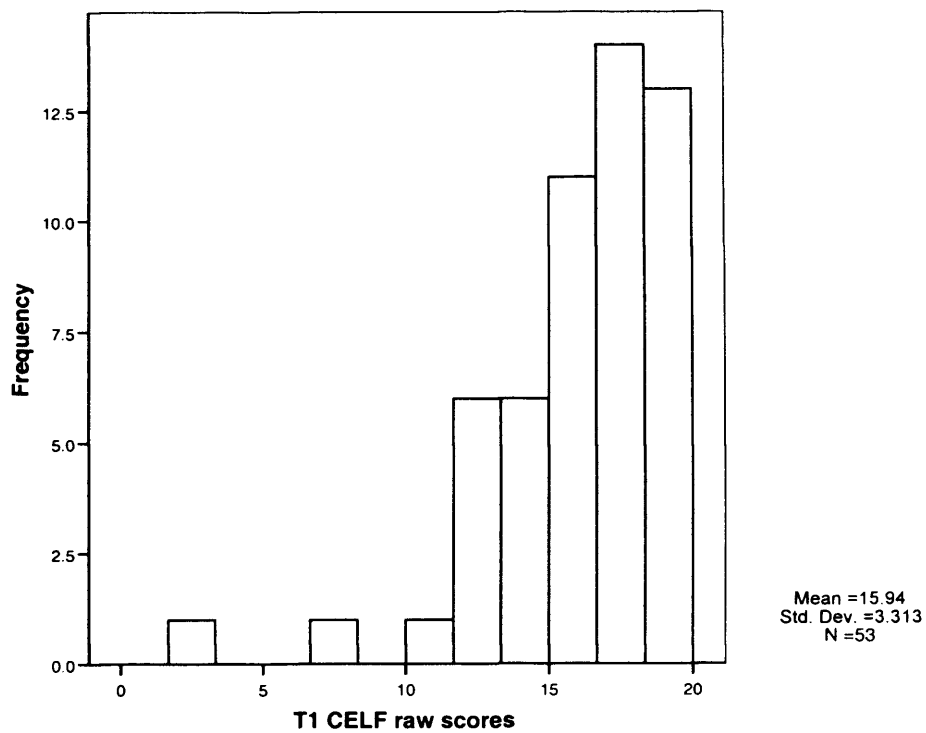


Figure 4: Histogram to show the distribution of CELF raw scores at 6-7 years.

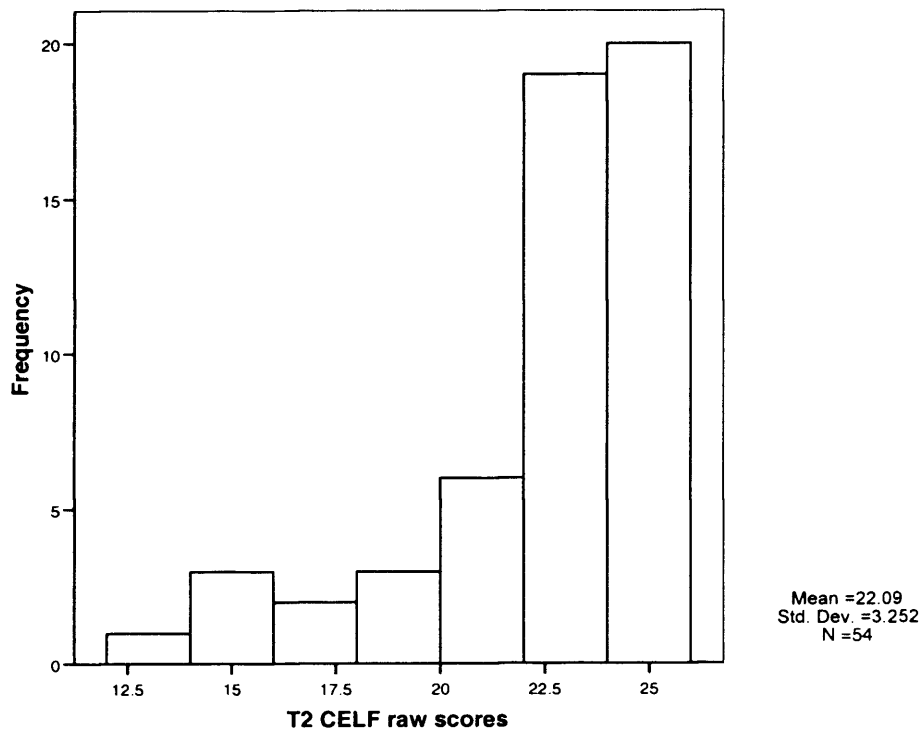


Figure 5: Histogram to show the distribution of speech discrimination scores in quiet at 6-7 years.

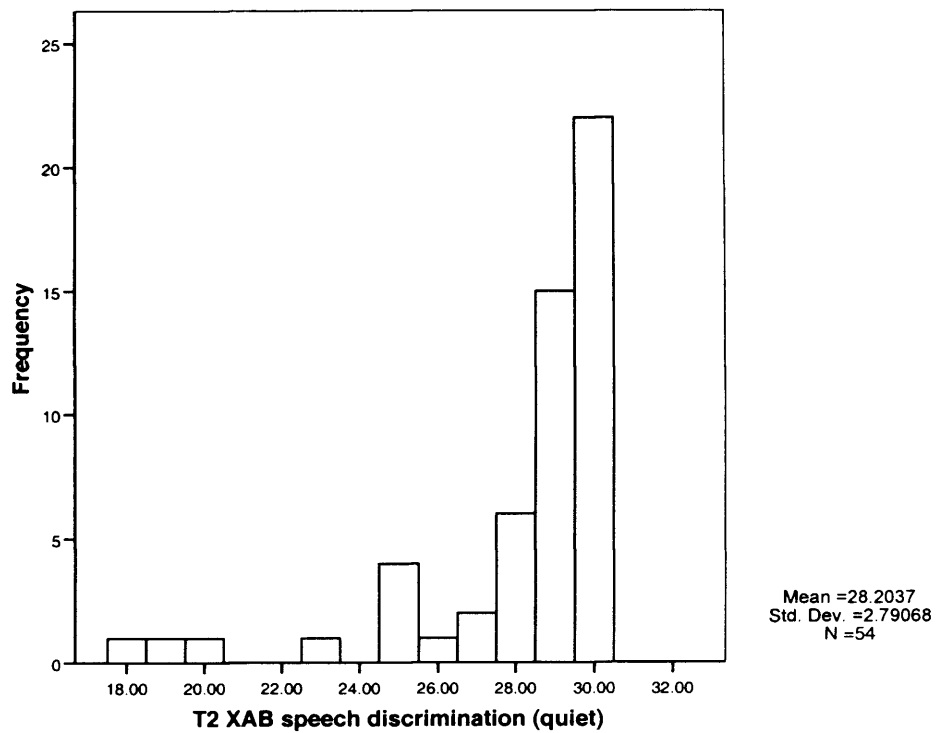
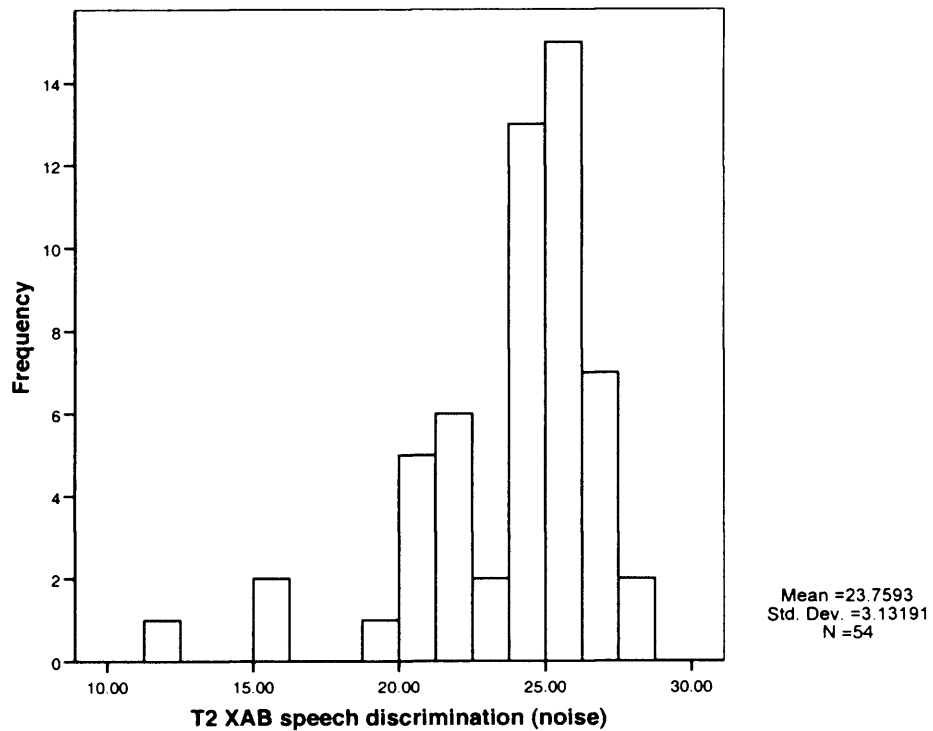


Figure 6: Histogram to show the distribution of speech discrimination scores in noise at 6-7 years.



Statistical Analysis

A correlational analysis was carried out using Spearman's rho correlation coefficient to investigate the relationship between speech discrimination and language variables.

Table 2: Correlations between assessment measures at time one (4-5 years) and time two (6-7 years)

	T1 XAB quiet	T1 XAB noise	T1 CELF	T2 XAB quiet	T2 XAB noise	T2 CELF
T1 XAB quiet	1					
T1 XAB noise	0.710	1				
T1 CELF	0.443	0.459	1			
T2 XAB quiet	0.371	0.322	0.377	1		
T2 XAB noise	0.402	0.515	0.331	0.313	1	
T2 CELF	0.222	0.130	0.143	0.069	0.158	1

A table of all correlations and significance levels can be found in Appendix E.

There was a significant correlation between XAB quiet and CELF scores at 4-5 years ($r = 0.443$, $p < 0.01$), and XAB noise and CELF scores at 4-5 years ($r = 0.459$, $p < 0.01$). However, the correlation between XAB quiet at 4-5 years and CELF at 6-7 years was not significant ($r = 0.222$), and neither was the correlation between XAB noise at 4-5 years and CELF at 6-7 years ($r = 0.130$).

There was a significant correlation between speech discrimination measures at 4-5 years and 6-7 years (XAB quiet, $r = 0.371$, $p < 0.01$ and XAB noise, $r = 0.515$, $p < 0.01$). However, there was no significant correlation between the language

measures (CELF subtests) at 4-5 years and 6-7 years ($r = 0.143$). There was also no significant correlation between CELF at 6-7 years and XAB measures at 6-7 years (XAB quiet, $r = 0.069$ and XAB noise, $r = 0.158$).

Linear regression was used to explore the predictive value of speech discrimination skills at 4-5 years, in relation to language skills at 6-7 years. As described at the beginning of this section, it was noted that the CELF language measure at 6-7 years showed distribution abnormality with some degree of ceiling effect on the scores. Regression analyses were conducted bearing in mind this possible restriction on interpretation. In order to control for the effect of language scores at age 4-5 years, fixed order of entry analyses were used as follows.

Analysis One: language (CELF) at 4-5 years was entered first, followed by speech discrimination in quiet (XAB measure) at 4-5 years, with language at 6-7 years as the outcome.

Analysis Two: language at 4-5 years was entered first, followed by speech discrimination in noise at 4-5 years, with language at 6-7 years as the outcome.

Analysis One

First model (CELF at 4-5 years as predictor):

Analysis of variance found that the regression accounted for a significant proportion of the variance ($F = 7.834$, d.f. = 1,51, $p < 0.01$). The slope was significantly different from zero ($t = 2.799$, d.f. = 51, $p < 0.01$). R -squared = 0.133, which indicates that 13.3% of the variance in the language scores at 6-7 years is predictable from the variance in language scores at 4-5 years.

Second model (XAB in quiet included as an additional predictor):

The change in the ANOVA F ratio was 0.026 and was not significant. The slope for T1 CELF was significantly different from zero ($t = 2.252$, d.f. = 50, $p < 0.05$), however the slope for T1 XAB in quiet was not significantly different from zero ($t = 0.160$, d.f. = 50, $p > 0.05$). Therefore, there was not a significant independent prediction from the speech discrimination in quiet scores.

Analysis Two

First model (CELF at 4-5 years as predictor):

Analysis of variance found that the regression accounted for a significant proportion of the variance ($F = 7.834$, $d.f. = 1,51$, $p < 0.01$). The slope was significantly different from zero ($t = 2.799$, $d.f. = 51$, $p < 0.01$). R -squared = 0.133, which indicates that 13.3% of the variance in the language scores at 6-7 years is predictable from the variance in language scores at 4-5 years.

Second model (XAB in noise included as an additional predictor):

The change in the ANOVA F ratio was 0.483 and was not significant. The slope for T1 CELF was significantly different from zero ($t = 2.837$, $d.f. = 50$, $p < 0.01$), however the slope for T1 XAB in noise was not significantly different from zero ($t = -0.695$, $d.f. = 50$, $p > 0.05$). Therefore there was not a significant independent prediction from the speech discrimination in noise scores.

The results show there is a significant regression-based prediction from language at 4-5 years to language at 6-7 years, despite the lack of a significant correlation between these two measures. Spearman's correlation involves ranking data and the differences between scores are excluded from the analysis, whereas the regression analysis is based on actual scores. This suggests that the significant prediction is driven by the low scores of a minority of children. The effect of these low scores are minimized by rank ordering, causing Spearman's correlation to be non-significant.

In summary, the variance in language at 4-5 years predicts 13.3% of the variance in language at 6-7 years. Speech discrimination measures at 4-5 years do not add to the predictive value of language measures at 4-5 years in predicting language outcome at 6-7 years. These analyses leave open the possibility that a normal distribution of scores at 6-7 years might provide a more sensitive measure to reveal a predictive value.

DISCUSSION

This study has investigated whether speech discrimination skills at 4-5 years predict receptive language ability at 6-7 years. It was hypothesised that there will be a relationship between speech discrimination scores at 4-5 years and receptive language scores at 6-7 years and that speech discrimination in noise scores at 4-5 years will be a better predictor of receptive language at 6-7 years than speech discrimination in quiet scores.

The results showed that there was no correlation between speech discrimination in quiet or noise at 4-5 years and language ability at 6-7 years. Regression analyses indicated that speech discrimination scores in quiet and noise at 4-5 years did not add to the predictive value of the language measure at 4-5 years in predicting language outcome at 6-7 years. The hypotheses can therefore both be rejected. There is no relationship between speech discrimination scores at 4-5 years and receptive language scores at 6-7 years, and neither speech discrimination in noise, nor speech discrimination in quiet scores at 4-5 years predict receptive language at 6-7 years.

- **The relationship between auditory discrimination and language development**

In this study there was a weak, but significant correlation between speech discrimination scores in quiet and noise at 4-5 years and language scores at 4-5 years (as shown in the previous study, Brown, 2005). The largest proportion of variance was accounted for by other factors, therefore speech discrimination may not be a strong factor in language ability at 4-5 years, and this study suggests that it becomes less of a factor over time. Other factors accounting for the variance in language at 6-7 years might become more important over time. This could include memory and cognitive abilities.

As in other studies (for example, Watson et al, 2003), this study found no significant correlation between speech discrimination and language skills in 6-7 year olds. It is possible that children that were identified as having normal auditory discrimination abilities, had difficulties in the past that had since resolved, but left them with language difficulties. There might also be children with more subtle language

difficulties at 6-7 years that are not identified by the sentence structure subtest of the CELF used in this study. As many of the CELF scores were near ceiling, there may be children who score well on this subtest, but would have difficulty with other language assessments. A more sensitive measure of receptive language at 6-7 years might provide a normal distribution of language scores that is more able to identify a correlation and predictive value between speech discrimination difficulties at 4-5 years and language at 6-7 years.

According to this study, speech discrimination skills at 4-5 years are not predictive of language ability at 6-7 years. It could be that speech discrimination skills under four years are more predictive of later language abilities. Many previous studies have shown a correlation between auditory discrimination and later language ability in younger pre-school aged children up to three years old (Benasich et al, 2002; Talay, 1996; Tsao et al, 2004). These studies investigated auditory discrimination skills in infants under one year old. It could be argued that a speech discrimination deficit existed for a crucial period in language development and then resolved (Rosen, 2003). Children with language difficulties at 6-7 years are more likely to have persisting language difficulties (Whitehurst and Fischel, 1994). It could be that speech discrimination difficulties at a younger age result in language delay, but are not an indicator for persisting language difficulties.

- **Assessment of speech discrimination skills**

The clinical implication from the findings discussed above is that assessing speech discrimination skills in 4-5 year old children may only identify those children who will spontaneously recover and not those at risk for persisting language difficulties. However, it is the children that are at risk of significant and persisting language difficulties that it is important to identify in order to provide early intervention for remediation of difficulties. This study has also shown that assessing speech discrimination scores at 4-5 years has no additional benefit to assessing language at 4-5 years in terms of identifying those children that will have persisting language difficulties at 6-7 years. This could lead to the conclusion that it is only necessary for clinicians to assess children's language abilities at 4-5 years and not their speech discrimination skills.

However, this study can not conclude that a speech discrimination measure at 4-5 years has no clinical significance. Although it has been demonstrated that there is no relationship between speech discrimination skills at 4-5 years and receptive language skills at 6-7 years, poor speech discrimination skills at 4-5 years may cause other difficulties, such as expressive language or literacy difficulties (Tsao et al, 2004; Manis et al, 1997). If poor speech discrimination skills lead to inaccurate storage of phonological representations and motor programs (Stackhouse and Wells, 1997), this might lead to poorer expressive language skills (in which language is generated from stored representations) than receptive language skills. Speech discrimination difficulties might also make understanding language and following instructions in class much more effortful.

There was a significant correlation between speech discrimination measures at 4-5 years and 6-7 years. This indicates that the speech discrimination task was a useful measure for identifying children that have speech discrimination difficulties that persist over time. It would therefore be a useful measure to include in speech and language therapy assessment of 4-5 year olds, to identify children that might find understanding language more effortful, even if they do not lead to persisting receptive language difficulties, and who may be at risk for expressive language or literacy difficulties.

Clinically it would be useful for a clinician to use the speech discrimination assessment qualitatively as well as quantitatively. Knowledge of which contrasts a child found harder to discriminate would inform management and enable specific therapy targets to be set. As well as targeting speech discrimination skills in therapy, the speech and language therapist could advise school staff and family of effective environmental modifications, such as using clear speech (Bradlow et al, 2003; Cunningham et al, 2001).

The variance in language at 4-5 years was found to predict 13.3% of the variance in language at 6-7 years. As discussed in the results section, although there was this significant regression-based prediction from language at 4-5 years to language at 6-7 years, there was no significant correlation between the two measures. It could therefore be argued that the prediction of language at 6-7 years from language at 4-5

years is likely to hold for low scoring children, but that there is no evidence for the generality of the prediction to all children. Clinically it is more important to identify children with low language scores, therefore it is useful to measure language at 4-5 years in order to predict which children will have language difficulties at 6-7 years.

- **Speech discrimination in quiet and noisy conditions**

At both 4-5 years and 6-7 years children performed better at speech discrimination in the quiet condition than in the noisy condition. This is in line with previous research that has shown that all children have more difficulties discriminating speech as the level of background noise increases (Ziegler et al, 2005; Bradlow et al, 2003; Cunningham et al, 2001). Measuring speech discrimination in noise will therefore identify children that have more subtle speech discrimination difficulties that may not be identified in a quiet condition. This makes it a more sensitive measure of speech discrimination skills. In this study, it is not possible to say that speech discrimination in noise is a better predictor of language as neither speech discrimination in noise nor quiet were able to predict later language ability.

Previous studies also showed that those with language and learning difficulties are more adversely affected by noise (Ziegler et al, 2005; Bradlow et al, 2003; Cunningham et al, 2001). If this study were to be extended and a larger sample of children assessed, they could be divided into a low language and a normal language group. This might show that speech discrimination skills in 4-5 year old children in the low language group are correlated with language at 6-7 years and that speech discrimination can be used to predict later language difficulties for these children. Based on the previous research, we would then expect speech discrimination in noise to be a better predictor of later language difficulties than speech discrimination in quiet in the low language group.

- **Critical analysis of this study**

It is difficult to assess speech discrimination skills in young children. The speech discrimination task used in this study includes a pre-test training block to ensure that the child understands what to do before they begin the test. However, the assessment

does rely on behavioural responses. Therefore, cognitive skills (memory and attention) and hearing ability will have an effect on a child's ability to succeed. It can be hard to conclude whether difficulties on the task are purely due to auditory discrimination difficulties, or whether one or more of these other factors prevented the child performing well. As no exclusion criteria were used in selecting the sample, the children that were assessed had a range of abilities, including children with hearing, attention, memory or mild learning difficulties. These were not controlled for and could therefore confound the results in a small sample.

Throughout each assessment testers gave positive reinforcement to the children to maintain their attention and motivation and 4-5 year olds were given breaks if necessary. However, the speech discrimination blocks in the assessment were repetitive and children could have lost motivation and not listened as attentively for each trial. Inter-tester reliability was ensured by meeting before testing to discuss consistent procedure, but testers might still have had slightly different interpretations of when a child was losing attention and needed a break.

The study included some children that were already identified to speech and language therapy services, but did not take into account the effects of therapy on children's language or speech discrimination ability between the two times of testing. If language difficulties had resolved by 6-7 years through therapy, this would distort the results. Without therapy, these children may have had persisting language difficulties, and may also be the children that had early speech discrimination difficulties.

The sentence structure subtest of the CELF that was used in this study is only one measure of receptive language and it might not reflect a child's ability to understand language overall. One subtest was used in this study to decrease the time that a child was required to attend to the assessments. If the CELF is being used clinically, a receptive language score is obtained through administering the sentence structure subtest alongside two other subtests; linguistic concepts and oral directions. Each subtest assesses a different area and all contribute to an overall measure of receptive language. The sentence structure subtest assesses the ability to understand sentences and therefore speech processing is aided by the use of real words and context. Speech

discrimination skills might be significantly correlated to other receptive language skills.

A significant correlation between speech discrimination and language at 4-5 years does not mean that there is a causal relationship. Speech discrimination difficulties could co-occur with other causative factors that play a role in language development. For example, Gathercole and Baddeley (1990) suggest that memory plays a role in acquiring language. If a correlation between speech discrimination and language at 4-5 years is not due to a causative relationship, this could explain the lack of predictive value of speech discrimination at 4-5 years on language at 6-7 years. Other factors, such as memory, might be a better predictor of later language ability. The relationship between either language or speech discrimination and an indirect factor might change over time, in turn indirectly changing the relationship between speech discrimination and language.

- **Further research**

In this study speech discrimination of non-words was tested to assess children's ability to discriminate speech sounds without referring to lexical representations. The increased demands of this task made it more able to reveal more subtle processing difficulties in older children (Vance, 1996). Further research could include a measure of real word discrimination at the sentence level, to reflect the speech processing that typically occurs in real life situations. This measure would assess children's ability to use their linguistic knowledge and the context of a sentence to aid speech discrimination.

A larger study in which more children were followed up at 6-7 years would allow the sample to be split into a low language group and a normal language group. The advantage of this would be to analyse whether speech discrimination at 4-5 years is correlated with language at 6-7 years and could be used to predict it, in the low level language group as compared to the normal language group. The two groups could also be compared to investigate whether there are differences in the predictive value of speech discrimination measures in quiet and noisy conditions.

Extending this study to include research into the relationship between speech discrimination at 4-5 years and expressive language and literacy at 6-7 years would also be beneficial. This could provide stronger evidence for the usefulness of a speech discrimination measure being included in speech and language assessment of 4-5 year olds.

- **Summary and Conclusions**

This study found no significant correlation between speech discrimination skills in 4-5 year olds and language skills in 6-7 year olds. It is possible that 4-5 year old children that were identified as having normal auditory discrimination abilities, had difficulties in the past that had since resolved, but had contributed to persisting language difficulties. It is also possible that the language assessment used was not a sensitive enough measure to identify children with more subtle receptive language difficulties.

Speech discrimination in noise was found to be a more sensitive measure of speech discrimination skills than speech discrimination in quiet. Neither speech discrimination in noise, nor speech discrimination in quiet scores at 4-5 years were able to predict receptive language ability at 6-7 years. Measuring speech discrimination skills at 4-5 years could still be a useful clinical tool to identify children that have difficulties that might make understanding language more effortful, even if they do not lead to persisting receptive language difficulties, and who may be at risk for expressive language or literacy difficulties.

Word Count: 9714

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Appendix A: Parent Information Sheet

UCL HUMAN COMMUNICATION SCIENCE

18th September 2006

PARENT INFORMATION SHEET

THE 'LISTENING TO SPEECH' PROJECT – PHASE THREE

Dear Parent,

You may remember that your child took part in our Listening to Speech Project when s/he was in the Reception class at school. Just to remind you, I am a Speech and Language Therapist based at University College, London, and carried out a research project in your child's school in 2005. You are invited to allow your child to take a further part in this project. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully and discuss it with others if you wish. You are welcome to ask me if anything is unclear.

What is the purpose of the project?

We know that some young children find it difficult to hear the small difference between sounds and words that are very similar, for example, 'pin' and 'bin', especially when there is other noise in the background. This may affect their ability to listen in class for example. For this final phase of the project we are looking to see how these skills have developed over the two years that the children have been in school.

Why has my child been chosen?

Your child has been chosen because he / she took part in the first phase of this project.

Does my child have to take part?

It is up to you to decide whether or not to allow your child to take part. If you do decide to allow your child to take part should keep this information letter and sign the attached consent form. If you decide to allow your child to take part you are free to withdraw him/her at any time, and without giving a reason. A decision to withdraw your child at any time, or a decision not to take part, will not affect the standard of care that your child receives. When we go into school to carry out the study, we will also ask your child if he/she would like to take part in the activities. If he/she does not want to, then he/she can stay back in class with the teacher.

What will happen if my child takes part in the project?

We will visit your child's school, and he/she will be taken out of class to a quiet area in school. He/she will be given several tasks. These will include a computer game in which he/she listens to words and selects a picture on screen, listening to sentences and pointing to pictures, and reading some words. We may see your child twice, and each session will not take more than 20 minutes. Some children will be seen by final year speech and language therapy students, and some by myself. We have all had experience of working with young children and have been screened by the Criminal Records Bureau.

What are the possible benefits of taking part?

There is no benefit for your child to take part in this further study, except that s/he will have an opportunity to practise his/her listening skills whilst doing the tasks. There is a benefit for teachers and speech and language therapists, as we will be able to better understand how children's listening and language skills develop whilst children are at infant's school.

Will information about my child be kept confidential?

All information which is collected about your child during the course of the project will be kept strictly confidential. The information will not have your child's names or any other identifying information. Each child will be assigned an identification code and the information collected will be stored under this number. All information will be collected and stored in accordance with the Data Protection Act

What will happen to the results of the research study?

We will send a brief outline of the findings to your child's school. The final-year students will each write up a report on the project and copies of these will be kept in our library. The overall findings will eventually be published for speech and language therapists and teachers to help them in their work.

Who is organising and funding this research?

The research is organised by University College London and is funded by The Health Foundation.

Who has reviewed this study?

This project has been approved by West Sussex Local Research Ethics Committee.

Contact for further information

If you have any questions about this research, or about the rights of participating children, please do not hesitate to contact me now or in the future. You can leave a telephone message for me on and I will phone you back, you can ask your child's teacher to tell me that you would like to see me, or you can send an email to

Thank you for reading this information sheet, and for considering allowing your child to participate. If you are happy to allow your child to participate, please sign one copy of the attached consent form and return it to your child's teacher by

Please keep this information letter and the spare consent form.

Appendix B: Consent Form

UCL HUMAN COMMUNICATION SCIENCE

Centre Number:

Patient Identification Number for this trial:

CONSENT FORM

Title of Project: 'Listening to Speech'

Please initial box

1. I confirm that I have read and understand the information sheet dated
for the above study and have had the opportunity to ask questions.

2. I understand that my child's participation is voluntary and that I am free to
withdraw him /her at any time, without giving any reason, without his/her care or
legal rights being affected.

3. I agree for my child to take part in the above study.

4. I agree for my child's GP to be notified

5. I agree to my child's teacher being informed about his/her progress through
the project.

6. Where applicable, I agree to my child's speech and language therapist being
informed about his/her progress through the project

Name of Patient

Date

Signature

Name of Person taking consent
(if different from researcher)

Date

Signature

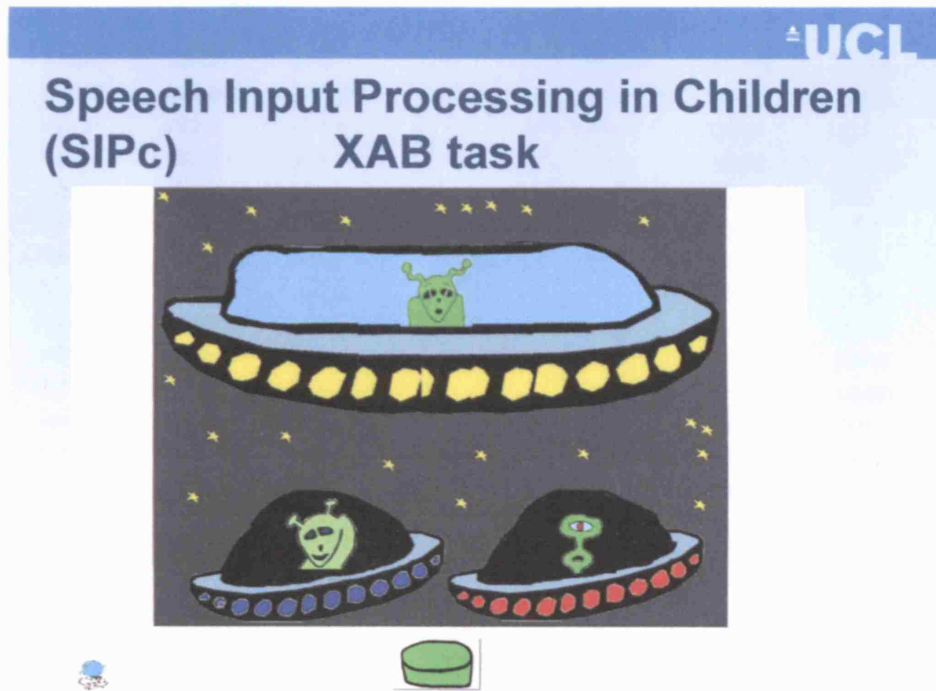
Researcher

Date

Signature

1 for patient; 1 for researcher; 1 to be kept with hospital notes

Appendix C: Picture of the XAB task from the speech discrimination assessment



Appendix D: Word list used in the speech discrimination assessment

<p>XAB Block One Quiet</p> <p>stish spish stish sleen sleen sween mipe nipe mipe parb parb pard geef deaf geef peeg peeg teeg sarp farp sarp kidge kidge gidge veep feep veep son son ton meeg beeg meeg serl serl verl sim bim sim trib trib trif bood zood bood</p>	<p>XAB Block One Noisy</p> <p>skeef skeef steef snig snig smig gite gike gite hees hees heesh plid plig plid bef bef bes kut tut kut dem dem bem sork zork sork chorm chorm jorm deeb neeb deeb lars lars lart farn garn farn tis tis tid mert merz mert</p>
<p>XAB Block One Noisy</p> <p>stish spish stish sleen sleen sween mipe nipe mipe parb parb pard geef deaf geef peeg peeg teeg sarp farp sarp kidge kidge gidge veep feep veep son son ton meeg beeg meeg serl serl verl sim bim sim trib trib trif bood zood bood</p>	<p>XAB Block Two Noisy</p> <p>skeef skeef steef snig snig smig gite gike gite hees hees heesh plid plig plid bef bef bes kut tut kut dem dem bem sork zork sork chorm chorm jorm deeb neeb deeb lars lars lart farn garn farn tis tis tid mert merz mert</p>
<p>XAB Prac</p> <p>sibe sibe gibe fol gol fol pish vish pish dap dap daf darp darp tarp vup vut vup sibe gibe sibe fol fol gol pish pish vish dap daf dap darp tarp darp vup vup vut dap daf dap darp darp tarp vup vup vut</p>	

Appendix E: Table to show the correlational analysis of the data

Spearman's rho		t1xabqui	t1xabnoi	t1celfraw	t2xabqui	t2xabnoi	t2celfraw
t1xabqui	Correlation Coefficient	1.000	.710(**)	.443(**)	.371(**)	.402(**)	.222
	Sig. (2-tailed)	.	.000	.001	.006	.003	.106
	N	54	54	53	54	54	54
t1xabnoi	Correlation Coefficient	.710(**)	1.000	.459(**)	.322(*)	.515(**)	.130
	Sig. (2-tailed)	.000	.	.001	.018	.000	.349
	N	54	54	53	54	54	54
t1celfraw	Correlation Coefficient	.443(**)	.459(**)	1.000	.377(**)	.331(*)	.143
	Sig. (2-tailed)	.001	.001	.	.005	.016	.308
	N	53	53	53	53	53	53
t2xabqui	Correlation Coefficient	.371(**)	.322(*)	.377(**)	1.000	.313(*)	.069
	Sig. (2-tailed)	.006	.018	.005	.	.021	.621
	N	54	54	53	54	54	54
t2xabnoi	Correlation Coefficient	.402(**)	.515(**)	.331(*)	.313(*)	1.000	.158
	Sig. (2-tailed)	.003	.000	.016	.021	.	.255
	N	54	54	53	54	54	54
t2celfraw	Correlation Coefficient	.222	.130	.143	.069	.158	1.000
	Sig. (2-tailed)	.106	.349	.308	.621	.255	.
	N	54	54	53	54	54	54

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).