EARLY WORD SEGMENTATION IN TYPICALLY DEVELOPING INFANTS AND INFANTS WITH DOWN SYNDROME: A PRELIMINARY STUDY

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ABSTRACT

This paper presents some preliminary data from the first time point of a longitudinal study that is looking at precursors to language development in typically developing infants, and infants with Down syndrome. The skill of interest in this paper is speech segmentation ability, which refers to an infant's ability to segment and recognise words embedded in fluent speech. Using the preferential listening paradigm, the study replicated findings from previous research, showing that typically developing infants are able to segment words with a strong/weak stress pattern by 10 months, but are not able to segment words with a weak/strong stress pattern. Group analysis suggests that at almost twice the chronological age of the typically developing infants in this study, infants with Down syndrome are able to successfully segment words with a strong/weak stress pattern, but are not yet able to successfully segment words with a weak/strong stress pattern. These results are discussed in relation to infants' general cognitive ability. The finding that speech segmentation ability was not found to significantly correlate with general cognitive ability or concurrent language ability is also discussed.

Keywords: language development, Down syndrome, speech segmentation ability

1. INTRODUCTION

Infants with Down syndrome show a delay in their linguistic development right from the onset of meaningful speech. Typically developing children produce their first word at around one year, whereas infants with Down syndrome reach this milestone at around 21 months [5]. This longitudinal project is exploring whether the skills that underpin typical language development also support the language development of infants with Down syndrome.

We are investigating the role of a variety of factors that are known to be related to language and vocabulary development in typically developing infants and infants with various learning difficulties. These factors include hearing, attention-following, the ability to request and comment, parental responsivity, speech segmentation, non-verbal mental ability, object categorisation, and symbolic play. The primary aim of the project is to determine which of these factors are the strongest predictors of later language ability in our two populations, to elucidate potential causes of the language difficulties seen in individuals with Down syndrome.

The focus of this paper is speech segmentation ability, which refers to an infant's ability to segment and recognise words embedded in fluent speech. Since the majority of speech directed towards infants will be in the form of continuous multiword sentences, it is vital that infants can extract and identify individual words in order to begin mapping meaning onto these word forms [4]. Research shows that following familiarisation, 7.5 month old infants (but not 6 month olds) can detect words with a strong/weak stress pattern (which are more common in the English language) when these words are embedded in fluent speech [1]. The ability to detect words with a weak/strong stress pattern however has been shown to develop much later, at 10.5 months of age [1]. Many studies have explored these skills, and in doing so, commented on the theoretical implications of such skills for language acquisition, yet few have actually directly examined the relationship between language acquisition and the presence or absence of these skills in individuals.

Newman and colleagues [4] carried out a retrospective analysis looking at how early speech segmentation ability (at 7.5 months-12 months), language discrimination (at 5 months), and prosody preference (at 6 and 9 months) predicted

later language development. They found that children with larger expressive lexicons at age 2, were the children who performed better on the perceptual language tasks. This association was only significant for the speech segmentation measures. Speech segmentation skills were also found to be associated with language outcomes at age four. This relationship was not mediated by general cognitive function, implying that it appears to be an entirely linguistic relationship. However it should be highlighted that this was a retrospective study.

Nazzi and colleagues [3] tested the ability of infants with Williams syndrome on speech segmentation (using the same procedure as [1]). They found that the development of this skill was seriously delayed in Williams syndrome, which they propose may contribute to the delayed lexical onset in this population. This supports the idea that segmentation may be a necessary precursor to typical language development.

The relationship between speech segmentation skills, and lexical development has not been assessed prospectively, or in infants with Down syndrome. The current study is assessing speech segmentation skills in typically developing infants (aged 9-10 months) and in infants with Down syndrome (aged 18-20 months), as well as assessing the predictive value of this skill in relation to concurrent language ability. In the future, this study will also provide an opportunity to assess the predictive value of this skill in relation to language at two further time points (6 months, and 1 year later).

2. METHOD

The methodology for this task was adapted from Jusczyk and Aslin [1] who used the preferential listening paradigm (headturn preference procedure). This task measures an infant's ability to recognise words embedded in fluent speech that have been familiarised to in isolation.

2.1. Participants

There were 24 typically developing infants (14 girls, 10 boys) with a mean age of 10 months 9 days, and 9 infants with Down syndrome (2 girls, 7 boys) with a mean age of 19 months and 16 days. Average raw scores on the three non-verbal subscales of the Mullens Scales of Early Learning [2] were 46.4 for the typically developing group, and 49.7 for the infants with Down syndrome (a non-significant difference, $t(8.841) = -1.047$, $p = .323$). All participants were selected on the basis that English was their first language.

2.2. Stimuli

The stimuli consisted of eight target words, four nouns with a strong/weak syllable pattern, (kingdom, hamlet, doctor, and candle) and four nouns with weak/strong syllable patterns (guitar, surprise, balloon, and device). Parents all reported that their child did not know any of the target words. A different six-sentence passage was recorded for each of the target words (passages were replicated from [3]). Each noun appeared in each sentence of its appropriate passage. All recording was carried out in a sound-proof booth. The passages were recorded in a lively motherese voice, by a female native speaker of British English. Each target noun was recorded in 15 isolated occurrences, by the same female speaker, in a row for use in the familiarisation phase. These word-lists were all 16.5 seconds long. The average duration of the passages was 14.2 seconds, and the first occurrence of the target word was within the first second of its corresponding passage.

The strong/weak noun lists and corresponding passages were used in the familiarisation and test phase of the strong/weak task respectively. Likewise, the weak/strong noun lists and corresponding passages were used in the familiarisation and test phase of the weak/strong task respectively. These tasks were carried out in two separate experimental sessions.

2.3. Procedure

The strong/weak and weak/strong tasks were carried out following exactly the same procedure. Experiments were conducted in an enclosed booth. The booth had a green light and a loudspeaker mounted at eye-level on each side of the booth, and a red light mounted behind a projector screen at the front of the booth. Three cameras were positioned above the projector screen. These cameras were linked up to a computer outside of the booth, so that the experimenter could monitor infants' headturns. Another computer was connected to the response box, which was set up outside of the booth. The response box had three buttons; one which started the red light flashing, one which stop the red light and started the trials (where one of the green lights flashed, and sounds were played), and another that recorded the

duration of headturns, and terminated the trial if the infant looked away for more than 2 seconds. The computer stored information regarding the direction and duration of headturns for each trial.

Infants were held on the mother's lap, who sat on a chair in the centre of the test booth during trials. At the start of each trial, the red light on the centre panel would start flashing. Once the experimenter could see that the child had orientated to the red light, the experimenter stopped the red light, and a green light above a speaker on one of the side panels would begin to flash. Once the experimenter was sure that the child had made a turn of at least 30˚ in the direction of the speaker, the stimulus for that trial was started. This was played until completion, unless the child failed to maintain the 30˚ headturn for 2 consecutive seconds, in which case the trial stopped. If the child turned away in any direction for less than 2 seconds before returning to the target, the trial continued (and the light remained flashing). The time spent looking away was not included in the orientation time. Therefore, the maximum orientation time for a given trial was 16.5 seconds (the duration of the entire speech sample).

Each experimental session began with a familiarisation phase. During familiarisation, infants heard repetitions of two target words (Kingdom and Hamlet, or Doctor and Candle in the Strong/weak task; Guitar and Surprise, or Balloon and Device in the Weak/strong task), on alternating trials until they accumulated 20 seconds of orientation times to each target word. The side of presentation varied randomly from trial to trial, and the number of trials was dependent upon how long it took for the infants to accumulate 20 seconds of listening time.

The test phase began immediately after the familiarisation phase. This phase involved two presentations of each of the four passages from that condition, making 8 test trials. The trials were split into two blocks of four, with each sentence appearing once in each block. The order of presentation was randomised in each block. As in the familiarisation phase, trials were played until completion, unless the child failed to maintain the 30˚ headturn for 2 consecutive seconds, in which case the trial stopped The direction and duration of infants' headturns were recorded using a response box. The experimenter monitored the infants' headturns from the camera output on the computer screen.

Participants carried out both the strong/weak and weak/strong tasks, with a 5-10 minute break between the two. The order of the strong/weak and weak/strong tasks was counterbalanced. For the strong/weak experiment, half of the participants were familiarized with kingdom and hamlet, and half with doctor and candle. During testing blocks, all the participants heard two blocks of the same four passages (containing the strong/weak target nouns kingdom, hamlet, doctor and candles). Similarly for the weak/strong experiment, half the participants were familiarized with guitar and surprise, and half with balloon and device. Again, during test phase, all the participants heard two blocks of the same four passages.

2.4. Language measures

Vocabulary was measured via parent report using a version of the Communicative Development Inventory. The Preschool Language Scales 4 [6] were used to derive measure of Auditory Comprehension and Expressive Communication, as well as a combined Language Score.

3. RESULTS

For each participant, mean orientation times were calculated for the passages containing familiarized and unfamiliarised nouns in both the strong/weak and weak/strong conditions. A recognition index was calculated for each condition by subtracting the mean orientation times for the passages containing unfamiliarised nouns from the passages containing familiarized nouns. Therefore, a positive recognition index would imply a greater mean listening time to the passages containing familiarized nouns. Data was analysed only for participants who completed both strong/weak and weak/strong tasks.

In the strong/weak condition, 17 out of 24 typically developing infants, and 8 out of 9 infants with Down syndrome had longer orientation times to the passages containing familiarized nouns. One-sample t-tests (comparing the means to 0) revealed this to be a significant pattern for the typically developing group ($t(23) = 2.94$, $p = .004$) (1-tailed), and for the group of infants with Down syndrome ($t(8) = 3.180$, $p = .013$) (2-tailed).

In the weak/strong condition, 14 out of 24 typically developing infants, and 5 out of 9 infants with Down syndrome had longer orientation times to the passages containing familiarized nouns. One-sample t-tests revealed that these patterns

were not significant for the typically developing group ($t(23) = 1.498$, $p = .074$) (1-tailed), or the group of infants with Down syndrome ($t(8) = .885$, $p = .443$) (2-tailed).

For both groups of infants, exploratory correlation analyses revealed no significant positive relationships between recognition indexes and any of the concurrent language or vocabulary measures, or the general cognitive ability scores calculated from the three non-verbal scales of the Mullens Scales of Early Learning [2].

4. DISCUSSION

Data for the typically developing group is in line with previous research, suggesting that this group of infants (with an average age of 10 months and 9 days), can successfully segment words with a strong/weak stress pattern from fluent speech, but cannot yet segment words with a weak/strong stress pattern. Past research has shown that typically developing infants can successfully segment weak/strong words at 10 ½ months. Since the infants in this study were slightly younger on average, and this pattern was near significance, it is likely that some infants in this group are able to successfully segment words with a weak/strong stress pattern.

Group analysis suggests that the infants with Down syndrome (with an average age of 19 months and 16 days) are also able to segment words with a strong/weak stress pattern, but are yet unable to segment words with a weak/strong stress pattern. This would suggest that infants with Down syndrome learn to segment words in a similar, albeit delayed fashion as typically developing infants, as they are able to segment words with a strong/weak stress pattern before those with a weak/strong stress pattern.

Despite the fact that the groups were matched for general cognitive ability, and are performing in a similar manner on the two speech segmentation tasks at this point in time, it would be speculative to claim that this ability is developing in line with general cognitive ability in infants with Down syndrome. It is still unknown at what age the ability to segment strong/weak words appeared in our group of infants with Down syndrome, or at what age the ability to segment weak/strong words will appear. Infants with Down syndrome will be reassessed on this task 6 months following their first assessment. If development is in line with general cognitive ability, we would expect infants to be able to segment weak/strong words well before this time.

Recognition indexes were not found to be related concurrently to either vocabulary or language scores. It is worth noting however that when Newman and colleagues [4] looked at the relationship between speech segmentation and language, they divided infants into those with large and small expressive lexicons, and then looked at the proportion of infants that were successful at the speech segmentation task in these two groups (defined as those with a positive recognition indices). Since this study was designed to assess this skill when the infants were pre-verbal, this would not be a feasible method of assessing this relationship at this stage.

Another finding of interest was that speech segmentation was not related to our measure of general cognitive ability, suggesting that these abilities may develop independently of each other in typically developing infants and infants with Down syndrome at this age.

The study shows that typically developing infants whose native language is English are sensitive to the predominant stress pattern of their native language by age 10 months. In infants with Down syndrome this ability is present at the age of 19 ½ months, if not before. When infants with Down syndrome are able to segment words with a weak/strong stress pattern is still unknown. This finding is similar to the finding for infants with Williams syndrome [3].

5. REFERENCES

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