# Phonological acquisition by children with autism: a case study

**by**

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# Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

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or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

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## Abstract

This thesis investigates the phonological development of children with Autism Spectrum Disorder (ASD) with the goal of identifying autism specific patterns of language development, if any such patterns exist. Previous research into the phonology of children with autism has provided conflicting profiles, arguing that this phonological development is either typical, typical but delayed, or atypical. The current study begins with a pilot study of six children with ASD between 20 months and seven years of age. The children were audio-recorded during play to document their spontaneous speech. All of the children were found to use some age appropriate phonological processes, and some children were also found to use delayed phonological processes. The second part of the study is a case study of the development of the youngest child over the course of eight months because the speech of this child exhibited atypical patterns of infelicitous pauses between and within syllables. The duration, frequency, and decline of these pauses were tracked for the period of the study and analyzed within contemporary phonology and psycholinguistics. While the pilot results show that children with ASD may exhibit both typical and delayed phonological development, the case study documents at least one case of phonological development unique to autism that cannot be characterized as typical or typical but delayed.



**Keywords**: phonological acquisition; phonological delay; autism; minimal word; speech disorders

## Dedication

*This thesis is dedicated to my Uncle David and anyone who has or knows someone with Autism.*

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## List of Acronyms

| | |
|---|---|
| ASD | Autism Spectrum disorder |
| AOS | Apraxia of Speech |
| PDD-NOS | Pervasive Developmental Disorder Not Otherwise Specified |
| CAS | Childhood Apraxia of Speech (or Developmental Apraxia of Speech) |

## Glossary

| | |
|---|---|
| Autism Spectrum Disorder (ASD) | ASD is a developmental disorder, encompassing impairments in cognitive and behavioural flexibility, sociability, and the communicative use of language (American Psychiatric Association, 2000). |
| Childhood Apraxia of Speech (CAS) | CAS is a childhood speech disorder where without any other neuromuscular deficiencies, the child's speech is characterised by a lack of precision and consistency of movements (Flipsen, Bankson, & Bernthal, 2009; The American Speech-Language-Hearing Association 2007) |

# 1. Introduction

This thesis is about the phonological development of a child with Autism Spectrum Disorder (ASD). Specifically, this thesis is a single subject longitudinal study of a high functioning child diagnosed with Autism Spectrum Disorder (ASD) at 11.5 months of age. It provides detailed phonological and phonetic data of this child from 20 months of age to 29 months of age, with the intention to continue to collect data through to 33 months of age. The contribution of this work is both empirical and theoretical. But the primary objective of this thesis is to present detailed linguistic documentation of the speech of the child, hereafter referred to as 'Participant 114', over an extended period of 8 months. In doing so, I address the fundamental question of whether or not there is a phonological impairment in ASD.

The main question of this thesis is whether children with ASD demonstrate autism specific deficits in their phonological development. Specifically, do they follow the same phonological development pattern or trajectory that typical children do? Are they delayed in their phonological acquisition? Do they demonstrate unique phonological patterns during their development?

## 1.1. Motivation

The research goal of this thesis is motivated empirically, methodologically, and theoretically.

Autism Spectrum Disorder (ASD) is defined as a developmental disorder which includes impairments in cognitive and behavioural flexibility, sociability, and the communicative use of language (American Psychiatric Association, 2000). There have been several studies since it was first documented in Kanner (1943 as cited in Ozonoff, Pennington, & Rogers, 1991) pertaining to the linguistic abilities and disabilities of children and adults with ASD. Semantics and pragmatics have been cited as major linguistic impairments in children with ASD (Tager-Flusberg, Paul, & Lord, 2005). Phonological structure is also referred to, but the findings pertaining to the nature of the phonological and phonetic development of children with ASD have been inconsistent.

Phonology and phonetics have been found to be either unaffected (Kjelgaard & Tager-Flusberg, 2001) or typical of the general population but delayed in development (Bartak, Rutter, & Cox, 1975; Bartolucci, Pierce, Streiner, & Eppel, 1976; Bartolucci & Pierce, 1977; Pierce & Bartolucci, 1976). That is, autistic children have been found to produce phonological patterns that are characteristic of younger typically developing children, or to continue to produce certain processes past the chronological age by which the majority of typically developing children would stop. Bartolucci and colleagues (Bartolucci et al., 1976; Bartolucci & Pierce, 1977; Pierce & Bartolucci, 1976) found that when matched for non-verbal mental age with mentally retarded children, children with autism demonstrated a phonological delay similar to that of mentally retarded children. Autistic children produce an amount of phonological errors equivalent to mentally retarded children (Pierce & Bartolucci, 1976). Furthermore, they produce the same types of phonological errors as mentally retarded children (Bartolucci et al., 1976). Moreover, according to Pierce and Bartolucci (1976), children with autism do not demonstrate any atypical traits in the production of speech sounds. Additionally, autistic children were found to have difficulty in the production and perception of fricatives and liquids (Pierce & Bartolucci, 1976). The researchers cite these as sound classes that are mastered later in typical phonological development (Menyuk, 1971 as cited in Pierce & Bartolucci, 1976); therefore, they propose that this supports the claim that autistic children are phonologically delayed.

However, autistic children have also been found to demonstrate atypical phonological processes (Cleland, Gibbon, Peppé, O'Hare, & Rutherford, 2010; Rapin, Dunn, Allen, Stevens, & Fein, 2009; Wolk & Edwards, 1993) in conjunction with normal, but delayed phonological development (Cleland et al., 2010; Wolk & Edwards, 1993; Wolk & Giesen, 2000). Cleland et al. (2010) found non-developmental errors in the speech of children with autism. For example, two children produced phoneme specific nasal emission, where air is emitted from the nose instead of the mouth during phoneme production (Cleland et al., 2010). This process is not found in the speech of typically developing children, and is rarely found in the speech of children with articulatory or phonological disorders (c.f. Bauman-Waengler, 2004; Peterson-Falzone & Graham, 1990 as cited in Cleland et al., 2010). Moreover, some children with autism demonstrate a chronological mismatch in their phonological acquisition (Wolk & Edwards, 1993; Wolk & Giesen, 2000). A chronological mismatch is the acquisition of later developing sounds in the absence of sounds that are typically acquired earlier in development (Grunwell, 1981 as cited in Wolk & Edwards, 1993). For example, in Wolk and Edwards (1993), a child with autism consistently produced the voiced alveolar fricative /z/ word-initially, and inconsistently produced the voiced palatal fricative /ʒ/ word-initially. But, their voiceless counterparts, the voiceless alveolar fricative /s/, and the voiceless palatal fricative /ʃ/, were almost completely absent from his phonological inventory (/s/ was produced once word-initially and once word-finally, and /ʃ/ was completely absent) (Wolk & Edwards, 1993). This is evidence of a chronological mismatch, according to the researchers, as the voiceless fricatives are acquired before the voiced fricatives (Edwards & Shriberg, 1983 as cited in Stoel-Gammon & Dunn, 1985; Wolk & Edwards, 1993) A chronological mismatch was also found in three children in Wolk and Giesen (2000)'s study. For example, one of the children had a phonemic inventory that lacked many nasals and voiceless stops, relatively early sounds, but included later developing sounds like the voiceless interdental fricative /θ/. Thus, the research demonstrates both typical but delayed, and atypical phonological development in children with autism.

The methodological motivation for this thesis stems from the changing nature of the definition of autism, and the fact that different types of autism were pooled together in previous research.

The definition of autism or the criteria for diagnosis has changed over the years. The criteria were originally laid out by Kanner in 1948 (Kanner, 1948 as cited in Pierce & Bartolucci, 1976). However, it was not included as a separate disorder in either the *Diagnostic and Statistical Manual* (DSM) (American Psychiatric Association, 1952), nor in the DSM-II (American Psychiatric Association, 1968). The only mention of autism in both of these editions of the DSM is in reference to childhood schizophrenia (American Psychiatric Association, 1952, 1968). Pierce and Bartolucci (1976) included children in the autism group of their study based on the co-occurrence of three diagnostic characteristics: lack of responsiveness or an avoidance of the "human figure", fixation on sameness in the environment or surroundings, and language deficits (including delayed development or the loss of previously acquired speech capacities, echolalia, and pronoun reversal). These characteristics were in accordance with those set out by Kanner (1948 as cited in Pierce & Bartolucci, 1976). These same criteria are used in further studies by Bartolucci and colleagues with the addition of the requirement that the age of onset of autism or the onset of symptoms be prior to 30 months (Bartolucci et al., 1976; Bartolucci & Pierce, 1977). With the publication of the DSM-III (American Psychiatric Association, 1987), autism, or infantile autism as it was referred to at the time, was subsumed under the subclass of disorders known as pervasive developmental disorders (PDD), which involve deficits in the development of many psychological areas.

The criteria set forth for a diagnosis of autism were similar to those set forth by Kanner. They included onset prior to 30 months of age, (major) deficits in language development, odd speech patterns, like echolalia and pronoun reversal, and strange responses to the environment (American Psychiatric Association, 1987). Two forms of autism were recognised in the DSM-III : infantile autism where the full disorder is present, and infantile autism where the child no longer exhibits all the characteristics necessary for diagnosis. In the DSM-IV-TR (American Psychiatric Association, 2000), the related diagnoses of autistic disorder, Asperger's disorder, and pervasive developmental disorder not otherwise specified (PDD-NOS) (which includes atypical autism) were all included as PDDs (along with Rett's disorder, and childhood disintegrative disorder). The criteria for the diagnosis of autistic disorder encompass three main areas of behaviours: impairments in social interaction, deficits in communication, and restricted, repetitive and stereotyped behaviours (American Psychiatric Association, 2000). In order to obtain a diagnosis a child needs to present with a minimum of six characteristics, with two coming from the impairment in social interaction, one from the deficit in communication, and one from restricted repetitive and stereotyped behaviours (American Psychiatric Association, 2000). Moreover, the onset must be prior to 3 years of age, and the child must also demonstrate a delay or deficit in social interaction, language used for social communication, or imaginative or symbolic play (American Psychiatric Association, 2000). Thus, the definition or diagnosis of autism has changed over the years. It is, therefore, difficult to compare the results from studies published in different years. Even studies from the same year may be using different definitions of autism unintentionally, depending on the ages of the children in the study, and when they were diagnosed with autism or ASD.

As the current definition of autism spectrum disorder (ASD) indicates, there is more than one type of autism. Each type of ASD potentially presents with its own unique language characteristics (pragmatic, semantic, syntactic, or phonological) or profile. However, some studies do not distinguish between different types of ASD when interpreting results or do not indicate the specific diagnosis of the children in the study (Cleland et al., 2010; McCleery, Tully, Slevc, & Schreibman, 2006; c.f.Rapin et al., 2009; e.g.Wolk & Edwards, 1993; Wolk & Giesen, 2000). This is problematic when attempting to determine if children with ASD do or do not exhibit atypical phonological patterns, as they are not a heterogeneous group. That is, both comparison between studies and generalization about results from children with different diagnoses is challenging.

The theoretical motivation comes from the fact that there is no unifying theory of autism. There are in fact many theories that attempt to account for the deficits present in autism: Theory of Mind (or Mindblindness) (Baron-Cohen et al., 2005), Executive Function (or Executive dysfunction) (Ozonoff et al., 1991), Weak Central Coherence (Frith & Happé, 1994), and Fractionability of the Autism Triad (Happé & Ronald, 2008). As previously mentioned, autism is diagnosed based on impairments in social interaction, impairments in communication, and the presence of repetitive behaviours and interests (American Psychiatric Association, 2000). This is referred to by some as ‘the triad’ (Happé & Ronald, 2008). Theory of Mind (Baron-Cohen et al., 2005), Executive Function (Ozonoff et al., 1991), and Weak Central Coherence (Frith & Happé, 1994), attempt to account for all the deficits associated with autism with one common cause.

According to Theory of Mind, individuals with ASD have a deficit in the process of empathizing (Baron-Cohen et al., 2005). Empathizing is defined as the ability to attribute mental states to one’s self and others (Baron-Cohen, 1994 as cited in Baron-Cohen et al., 2005), and the ability to have an appropriate emotional reaction to another person’s mental state (Baron-Cohen et al., 2005). It is suggested that this deficit can explain the social impairments, and the communication impairments characteristic of ASD (Baron-Cohen et al., 2005). The Executive Function theory states that some of the characteristics of ASD can be explained as deficits in executive functions (Ozonoff et al., 1991). Some executive functions are planning, mental flexibility (the ability to switch to a different thought or action as a consequence of situational changes), and inhibition (the ability to overcome an automatic response so as to implement a less automatic one) (Hill, 2004). Deficits in these functions are related to some behaviours exhibited by individuals with ASD (Ozonoff et al., 1991). For example, children with ASD exhibit rigid and inflexible behaviours, insist on following specific routines, and fixate on restricted interests or engage in stereotyped behaviours repeatedly (Ozonoff et al., 1991). However, executive function deficits have been found in individuals with other developmental disorders, and individuals with neurodevelopmental disorders (Hill, 2004; Ozonoff, 1997 as cited in Ozonoff & Jensen, 1999). Thus, deficits in executive function are not specific to ASD. However, there have been studies that have found a specific pattern of executive function deficits that affect individuals with ASD (Pennington & Ozonoff, 1996 as cited in Hill, 2004; Ozonoff & Jensen, 1999). That is, they focus on the details, but are unable to use the details to build a global picture. These theories are not able to address all the behaviours exhibited by individuals with ASD, and they do not all address the same behaviours.

However, the theory of Fractionability of the Autism Triad suggests that there is no single cause or deficit that can account for both the social and non-social impairments exhibited in ASD (Happé & Ronald, 2008; Happé, Ronald, & Plomin, 2006). That is, no primary deficit that has been proposed has been able to account for the whole triad (Happé et al., 2006). Social explanations are unable to account for restrictive and repetitive behaviours and interests because they cannot simply be due to an inability to understand the social world as even high-functioning children with autism exhibit them. And, the domain general explanations have been unable to explain impairments in social interaction and communication because social interaction is said to be the most complex thing that the brain processes, but there is no way to measure it (Happé et al., 2006). Thus, the theory suggests that ASD is the result of the co-occurrence of independent impairments (Happé & Ronald, 2008; Happé et al., 2006).

The results of this thesis may lend support to one of these theories. A typical, but delayed phonological development would be suggestive of the Fractionability of the Autism Triad. That is, if the children with ASD were to demonstrate a typical phonological development that is simply chronologically delayed, then they would be exhibiting an impairment that is characteristic of other children who have different disorders. Thus, the phonological delay could be viewed as one of the independent impairments that co-occur to produce autism. Additionally, a pattern of phonological acquisition that is typical of another disorder, but not solely a phonological delay, would also be suggestive of the Fractionability of the Autism Triad. This is because once again the children with ASD would be displaying an impairment that was characteristic of an impairment of another disorder. Therefore, the given pattern of phonological acquisition could be regarded as one of the impairments that co-occur to create autism. However, an autism specific phonological pattern would not truly be suggestive of any particular theory of autism. An autism specific phonological pattern could be caused by a single deficit that causes autism, in that it is exclusive to autism. This could possibly support Theory of Mind, or the Executive Function theory. But, the autism specific phonological pattern could also be an independent impairment that is exclusive to autism, and co-occurs with other impairments to create autism. Specifically, the phonological pattern being limited to children with ASD does not prove that it is not independent of the other impairments of ASD.

## 1.2. Synopsis

The remainder of this thesis is structured as shown below.

2. Background

   2.1 Typical phonological development: A description of typical phonological development

   2.2 Atypical phonological development: A description of atypical phonological development including the motivation for candidates for an autism specific phonological pattern.

   2.3 Methods: A description of the methods employed in this thesis, including the pilot study, and motivation for a single subject case study

3. Results from the Pilot Study

A description of the results from the six children in the pilot study, and motivation for the choice of the subject for the longitudinal case study.

4. Extended case study of Participant 114's Infelicitous Pauses

5. Discussion

A discussion of the link between infelicitous pauses and childhood apraxia of speech. And, a discussion of Participant 114's possible analysis of the syllable as a prosodic word.

# 2. Background

## 2.1. Typical Phonological Development

As discussed above, the phonological development of children with ASD has been found to be typical (Kjelgaard & Tager-Flusberg, 2001), typical but delayed (Bartak et al., 1975; Bartolucci et al., 1976; Bartolucci & Pierce, 1977; Pierce & Bartolucci, 1976), and atypical (Cleland et al., 2010; Rapin et al., 2009; Wolk & Edwards, 1993; Wolk & Giesen, 2000). Therefore, in order to be able to determine the nature of the phonological and phonetic development of children with ASD, it is first necessary to outline typical phonological development.

Below, research is summarised in order to establish a basis for the order and age of acquisition of consonants by English speaking children. The exact order and ages of acquisition of the consonants are not constant across studies, due to differences in sample sizes, age ranges of the participants, elicitation methods, the criteria determining mastery of a phoneme, and the methods of presenting the data (Dodd, Holm, Hua, Crosbie, & Broomfield, 2006). For example, Arlt and Goodban (1976) found /z/ to be acquired at 4;0 before /ð/ at 5;0. However, Smit et al. (1990 as cited in McLeod, 2009) found both female and male children to acquire /z/ (5;0 for females and 6;0 for males) after /ð/ (4;0 for females and 5;6 for males).

However, there are trends present in the order of acquisition of consonants. In terms of articulation, labials, which children are able to see as well as hear, are more common in their early words than in their babbling (Vihman et al., 1985 as cited in Vihman, 2014). Moreover, stops are more common in the early words of children than in their babbling as stops are produced by simple ballistic movements (Vihman, 2014). Also, fricatives, whose production requires precise control of articulators in order to maintain a narrowed passageway for the air, are less common in children’s early words than in their babbling (Vihman, 2014). Dodd et al. (2006) states that based on the findings of Wellman et al. (1931 as cited in Dodd et al., 2006), Poole (1934 as cited in Dodd et al., 2006), Templin (1957 as cited in Dodd et al., 2006), Olmsted (1971 as cited in Dodd et al., 2006), Prather, Hedrick, and Kern (1990), and Smit et al. (1990 as cited in Dodd et al., 2006) children generally acquire /m, n, p, b, w/ earlier than other segments, and they generally acquire /θ, ð, z, ʒ, ʤ, ŋ/ later than other segments. The majority of the early sounds identified by Dodd et al. (2006) are non-fricative labials, and the majority of the late sounds are non-labial fricatives (alveolar and further back in the mouth). Stoel-Gammon and Dunn (1985) examined similar studies (Prather et al., 1975; Poole, 1934; Templin, 1957; Wellman et al., 1931), and found that stops, nasals, and glides are acquired first, then liquids are acquired, and finally fricatives and affricates are acquired. But, in both cases the studies did not all employ the same criterion of mastery. Upon examination of Prather et al. (1990), Arlt and Goodban (1976), and Smit et. al. (1990 as cited in McLeod, 2009), all of which used a criterion of mastery of the sound being correctly produced by 75% of the children at a given age and examined children acquiring relatively the same English dialect (American English), a similar trend can be seen. From these studies, it seems that stops, nasals, the glide /w/, and the fricative /h/ are acquired earlier (before and up to and including the age of 3;0). Fricatives (with the exception of /h/), affricates, and liquids are acquired later (after the age of 3;0). But, the phonemes /s, f, j, ŋ/[1] are, according to the studies examined, acquired both earlier and later in development.

Researchers vary in what they consider to be typical or common processes in the phonological development of children (Bankson & Bernthal, 2004). Bankson and Bernthal (2004) consider the following 21 phonological processes in Tables 1, 2, and 3 to be common in the speech of young children. The processes are divided into whole word processes (see Tables 1 and 2 below) and segmental processes (see Table 3 below). Whole word processes are further divided into assimilation (Table 2) and other syllable based processes (Table 1). The descriptions of the process are derived from descriptions provided by Bankson and Bernthal (2004). In the tables, there is an upper age at which each process is still considered to be age appropriate or an age by which

[1] Fricatives have a long developmental trajectory. That is, the time between production and mastery spans a long length of time. For example, mastery of /s/ can take up to 5 years (Stoel-Gammon & Dunn, 1985).

each process disappears. However, based on the studies and the literature examined, no age limit for coalescence or for densalisation was found.

***Table 1*** ***Normal Processes in Phonological Development: Syllable Based Processes***

| Process | Notes |
|---|---|
| Consonant cluster simplification | • a cluster of consonants is simplified by the omission of one or more consonants or by a substitution of one or more segments in the cluster<br>• reduction of two-consonant consonant cluster age appropriate until after 3;11 (Dodd et al., 2003 as cited in Dodd, Holm, Crosbie, & Hua, 2005)<br>• reduction of three-consonant consonant cluster age appropriate until after 4;11(Dodd et al., 2003 as cited in Dodd et al., 2005)<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 3;0 (James, 2001 as cited in McLeod, 2009) |
| Epenthesis | • a segment is inserted, usually the vowel [ə]<br>• disappears after 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 5;0 (James, 2001 as cited in McLeod, 2009) |
| Metathesis | • two segments in the same word are reversed<br>• declining at 2;6 and 5;0 (James, 2001 as cited in McLeod, 2009) |
| Coalescence | • features of two adjacent sounds are combined and the resulting segment replaces the two sounds |
| Unstressed syllable | • an unstressed syllable is omitted often at the beginning of a word and sometimes in the middle of a word<br>• age appropriate until after 3;11 (Dodd et al., 2003 as cited in Dodd et al., 2005)<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 3;0 (James, 2001 as cited in McLeod, 2009) |
| Reduplication | • a syllable or a portion thereof is produced twice, usually creating a CVCV structure<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985) |
| Final consonant deletion | • word-final consonants are deleted<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 3;0 (James, 2001 as cited in McLeod, 2009) |

***Table 2 Normal Processes in Phonological Development: Assimilation Processes***

| Process | Notes |
|---|---|
| Velar Assimilation | • a non-velar segment becomes a velar in the presence of a velar<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985) |
| Nasal Assimilation | • a non-nasal sound becomes a nasal in the presence of a nasal consonant<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985) |
| Labial Assimilation | • a non-labial sound is assimilated to the labial place of articulation in the presence of a labial consonant<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985) |

*Table 3* ***Normal Processes in Phonological Development: Segmental Processes***

| Process | Notes |
|---|---|
| Velar Fronting | • velar sounds are replaced by sounds that are articulated further forward in the oral cavity<br>• fronting of velar stops age appropriate until after 3;11 (Dodd et al., 2003 as cited in Dodd et al., 2005)<br>• fronting of velar nasal age appropriate until after 5;0 (Dodd et al., 2003 as cited in Dodd et al., 2005) |
| Stopping | • stops replace either fricatives or affricates<br>• declining at 3;0 (James, 2001 as cited in McLeod, 2009) |
| Gliding of Liquids | • prevocalic liquids are replaced by glides<br>• age appropriate until after 5;11 (Dodd et al., 2003 as cited in Dodd et al., 2005)<br>• disappears after 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 2;6 and 4;0 (James, 2001 as cited in McLeod, 2009) |
| Affrication | • affricates replace fricatives<br>• disappears after 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 2;6 and 4;0 (James, 2001 as cited in McLeod, 2009) |
| Vocalization | • liquids or nasals are replaced by vowels<br>• disappears after 3;0 (Stoel-Gammon & Dunn, 1985) |
| Denasalization | • nasal phonemes are replaced by stops with a similar place of articulation |
| Glottal Replacement | • glottal stops replace sounds that are intervocalic or word-final<br>• declining at 4:0 (James, 2001 as cited in McLeod, 2009) |
| Prevocalic Voicing | • voiceless obstruents are voiced before a vowel<br>• disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 2;6 (James, 2001 as cited in McLeod, 2009) |
| Devoicing of final consonants | • voiced obstruents are devoiced word-finally<br>• disappears after 3;0 (Stoel-Gammon & Dunn, 1985)<br>• declining at 3;0 (James, 2001 as cited in McLeod, 2009) |

There is a great amount of individual variation in the phonological processes that children employ during their development (Bankson & Bernthal, 2004). Not all children use all of the processes listed above. Moreover, children have been found to produce unusual or idiosyncratic phonological patterns that differ from those that are commonly found in child language (Bankson & Bernthal, 2004). Moreover, these patterns have been found to be produced by both phonologically delayed or disordered children and typically developing children (Bankson & Bernthal, 2004). That is, the use of individual uncommon patterns alone cannot be considered sufficient to classify a child as phonologically delayed or disordered. However, when these patterns persist in the speech of children after the ages of 3;0 to 3;5, they are most likely due to a phonological delay (Bankson & Bernthal, 2004). Yet, there is a lack of consensus regarding the age at which normal processes in phonological development cease being employed by typically developing children (as can be seen in the above Tables 1-3). Nonetheless, the production of these processes past given ages remains an indicator of atypical or delayed phonological development (Leonard, 1992).

However, it should be noted that despite the main focus of the thesis being on Participant 114's production of infelicitous pauses (introduced in section 3), there is no research pertaining to what constitutes the typical frequency and the typical duration of intra-syllabic and inter-syllabic pauses in typical first language acquisition.

## 2.2. Atypical Phonological Development

There has been research that has found atypical phonological patterns in children with ASD (Cleland et al., 2010; Rapin et al., 2009; Wolk & Edwards, 1993; Wolk & Giesen, 2000). The patterns found by Cleland et al. (2010), Wolk and Edwards (1993), and Wolk and Giesen (2000) are categorised below in Tables 4 to 7 as to their viability as candidates for an autism specific pattern in phonological development.

***Table 4*** ***Phonological Processes Found in Children with ASD: Unclear likely without Potential***

| Process | Explanation |
|---|---|
| Dentalization of Sibilants | • found in study conducted by Cleland et al. (2010)<br>• no explanation given<br>• Smit (1993a as cited in McLeod, 2009) states that /s/ is realised as a dentalised segment by some children<br>• it is not clear how commonly this occurs in typically developing children<br>• most frequent misarticulation of /s/ (Bauman-Waengler, 2004) |
| Palatalization | • found in Cleland et al. (2010)<br>• no explanation given<br>• occurs in the speech of typically developing children (James, 2001 as cited in McLeod, 2009) |
| Friction of Stops | • found in Wolk and Giesen (2000)<br>• e.x. /krejɔn/→ [fwejɔn]<br>• change from stop to fricative is known as spirantization and occurs in some adult languages (Kenstowicz, 1994)<br>• thus, it probably isn't unique to ASD |

The above table, Table 4, contains the phonological processes that have been considered in previous research to be atypical of the speech of normally developing children, and found in the speech of children with ASD. Why these processes were considered to be atypical of normal phonological development was not explained in their respective research articles. Despite this fact, it is clear, as both palatalization and affrication occur in the speech of typically developing children (James, 2001 as cited in McLeod, 2009), that these two processes are not candidates for an autism specific phonological process. The process of dentalization of sibilants was not explained in the Cleland et al. (2010) article and no example was provided. It is unclear what occurs during this process. Bauman-Waengler (2004) describes two misarticulations that can occur in a child's production of the /s/ and /z/ involving a dental placement of the tongue: addental and interdental. Addental production of /s/ is the most frequently occurring misarticulation of /s/ (Bauman-Waengler, 2004). It involves the tongue being placed against or too close to the back of the upper incisors during the production of /s/ or /z/ (Bauman-Waengler, 2004). An interdental production of /s/ or /z/ involves the tongue being placed between the upper and lower incisors (Bauman-Waengler, 2004). This is also a common misarticualtion of /s/ and /z/. Both misarticulations may sound like the dental fricatives /θ/ and /ð/ (Bauman-Waengler, 2004). None of the other sibilants are listed as having an interdental type of misarticulation (Bauman-Waengler, 2004). The sibilants /ʃ/ and /ʒ/ can also be produced addentally when the tongue is placed closer to the alveolar ridge than the palate (Bauman-Waengler, 2004). The resulting consonants can be transcribed as [s] and [z] respectively (Bauman-Waengler, 2004). However, Bauman-Waengler (2004) does not attribute an addental misarticulation to the last two sibilants: /tʃ/ and /dʒ/. On the other hand, Bauman-Waengler (2004) does describe a [s] and [z] substitution for /tʃ/ and /dʒ/. The substitutions are produced without a stop portion, yet the fricatives that are produced are more anterior than those for which they are being substituted (Bauman-Waengler, 2004). That is, the fricative portion of the affricates /tʃ/ and /dʒ/, is produced closer to the alveolar ridge which accounts for their replacement by the fricatives [s] and [z]. This is the same as the addental production of the fricatives /ʃ/ and /ʒ/ which is to be expected as these fricatives form the fricative portion of the aforementioned affricates. So, this may in fact be addental production of the affricates. Therefore, if dentalisation of sibilants is the same process as the addental articulation of sibilants, then it cannot be considered a candidate for an autism specific process as it would not be specific to children with autism. However, it is not clear if this is what is referenced by ‘dentalisation of sibilants’.

***Table 5 Phonological Processes Found in Children with ASD: Unclear with Potential***

| Process | Explanation |
|---|---|
| Denasalisation | • the nasal consonants /m/ and /n/ are replaced by the stops /b/ and /d/ (Ohde & Sharf, 1992)<br>• if there is no nasal blockage, denasalisation is due to a phonological process (Ohde & Sharf, 1992)<br>• according to Ohde and Sharf (1992), it is not a very common phonological process<br>• according to Bankson and Bernthal (2004), it is a common process in child language development |
| Phoneme Specific Nasal emission | • found in Cleland et al. (2010)<br>• nasal emission instead of oral emission for a typically oral phoneme<br>• Ex. /haʊs/→[haʊfŋ]<br>/swImIŋ/→[fŋImIn]<br>• according to Cleland et al. (2010), rarely occurs in children with phonological or articulatory disorders<br>• according to Ohde and Sharf (1992), characteristic of speakers with a cleft palate<br>• Bauman-Waengler (2004) state that nasal problems with /s/ and /z/ can stem from physical or neuromotor difficulties or functional problems (like articulatory dyspraxia)<br>• Cleland et al. (2010) describe this as emission from the nasal cavity instead of the oral cavity<br>• Ohde and Sharf (1992) describe this as occurring when air cannot be stopped from escaping through the nasal cavity in addition to air being released through the oral cavity |

The phonological processes in Table 5 were found in the speech of children with ASD and thought to be atypical. These processes have the potential to be specific to autism, but there are sources that would appear to refute this. Phoneme specific nasal emission is presented by Cleland et al. (2010) as being almost unique to children with ASD as it is said to be rare in children with both phonological and articulatory disorders. But, Ohde and Sharf (1992) and Bauman-Waengler (2004) cite phoneme specific nasal emission as occurring in children with physical problems (speakers with a cleft palate), neuromotor problems, or functional problems like articulatory dyspraxia. Thus, they place phoneme specific nasal emission in the sphere of more than one possible etymology. A reason for this may be found in the definitions of phoneme specific nasal emission to which they refer. Cleland et al. (2010)'s definition explains it as emission from the nasal cavity instead of the oral cavity; whereas, Ohde and Sharf (1992) explain it as nasal emission in addition to oral emission. It is possible that they are not referring to the same process. In that case, phoneme specific nasal emission would represent a candidate for an autism specific phonological process as the phoneme specific nasal emission cited in other populations of atypical phonological development may be the process referred to by Ohde and Sharf (1992), and not the one found in children with ASD by Cleland et al. (2010). Additionally, no explanation or example is provided of the denasalisation found by Cleland et al. (2010) in the speech of children with ASD. Ohde and Sharf (1992) describe denasalisation as a replacement of the bilabial and alveolar nasals with homorganic stops. It is not clear if the denasalisation found by Cleland et al. (2010) only affects these two places of articulation. It is also not clear whether denasalisation is common among typically developing children. Ohde and Sharf (1992) state that it is not a very common phonological process, but Bankson and Bernthal (2004) cite denasalisation as a process that commonly occurs in children's phonological acquisition, and they do not limit the process to the labial and alveolar places of articulation.

***Table 6 Phonological Processes Found in Children with ASD: Unclear***

| Process | Explanation |
|---|---|
| Debucalisation | • found in Cleland et al. (2010)<br>• no explanation given |
| Friction of Liquids | • no description given<br>• e.x. /bal/→[bæɵ]<br>• unclear what is happening in the example as the fricative doesn't have the same place of articulation as the liquid |
| Backing of Alveolar Stops to the Velar Place of Articulation | • found in Cleland et al. (2010)<br>• ex. /bɹʌʃ/→[gwʌs]<br>• no explanation given<br>• the example shows this process occurring in the presence of another velar<br>• the example demonstrates it happening to a labial stop<br>• the process of velar assimilation is the process where an alveolar consonant becomes a velar in the presence of another velar consonant (Ohde & Sharf, 1992)<br>• velar assimilation commonly occurs in children with severe articulatory disorder and normally developing children (Ohde & Sharf, 1992)<br>• Bauman-Waengler (2004) states that backing of stops is uncommon in the speech of typically developing children and found in children with phonological disorders<br>• Bankson and Bernthal (2004) cite backing as a common process in young children and in children with phonological disorders |
| Velarization | • found in Wolk and Giesen (2000)<br>• a segment is realised as the corresponding velar sound with the same manner of articulation<br>• ex. /now/→[ŋʌŋ]<br>• the example provided shows the velarization of an alveolar nasal, but the final sound also becomes a velar nasal and there is no way to determine which process occurred first<br>• Is this a case of velar assimilation?<br>• velar assimilation is relatively common among children with the most severe articulatory disorders (Ohde & Sharf, 1992)<br>• velar assimilation is a common process in child language (Bankson & Bernthal, 2004)<br>• this may be backing, which is a common process in the language of children (Bankson & Bernthal, 2004)<br>• in the Wolk and Giesen (2000) study, this occurred in the speech of one child who could only produce two consonants and one child with a limited consonantal inventory |

The processes listed in Table 6 are unclear. Wolk and Giesen (2000) found velarization in the speech of 2 of the 4 children with ASD in their study. Their description of velarization does not mention a necessary environment, but the example that they provide from a child's speech (1) (also shown in Table 6) shows velarization of the word-initial alveolar nasal /n/ in the presence of the word-final labio-velar glide /w/.

1. /now/→ [ŋʌŋ] *now*

An alveolar consonant becoming the corresponding velar consonant in the presence of another velar consonant is velar assimilation (Ohde & Sharf, 1992). And, according to Ohde and Sharf (1992), velar assimilation is a common process in both children with severe articulatory disorders and typically developing children. So, the question becomes does 'velarization' only occur in the presence of another velar consonant. If it occurs when there is not another velar consonant, it would not be velar assimilation. And, then it may not be common among children with other phonological disorders, or typically developing children. In that case, it would be a possible candidate for an autism specific phonological process. However, it is not clear whether 'velarization' and velar assimilation are the same process based on a single example. Cleland et al. (2010) found that some children with ASD backed alveolar stops to the velar place of articulation. This is unclear because they did not provide an explanation of this process, but their example (2) (also shown in Table 6) shows the backing possibly occurring in the presence of a velar consonant. It is also occurring to a labial stop not an alveolar.

2. /bɹʌʃ/→[gwʌs] *brush*

Specifically, this could be a case of velar assimilation if the gliding of the liquid /ɹ/ occurs before the process that causes /b/ to be produced as [g]. Velar assimilation is a common process found in the speech of young children (Bankson & Bernthal, 2004). Nevertheless, if the gliding of the liquid /ɹ/ occurs prior to or simultaneously with the process causing /b/ to be articulated as [g], then this would be a case of backing, but of a labial consonant, not an alveolar stop. In that case, there is some controversy regarding the classification of 'backing of alveolar stops to velar place of articulation'. According to Bauman-Waengler (2004), backing of stops is a process that is uncommon in the speech of typically developing children and that it is found in the speech of children with phonological disorders. However, Bankson and Bernthal (2004) see backing as a common process in the speech of young children. Consequently, 'backing of alveolar stops to velar place of articulation' is probably not a candidate for an autism specific process, but it remains unclear.

Debuccalisation was a process found in the speech of children with ASD by Cleland et al. (2010). This process is unclear as no explanation or example was provided. Thus, it is not possible to determine if this is a candidate for an autism specific process. Additionally, it would not be possible to determine whether or not the children in the present study presented this process in their speech as it is not clear what occurs in the process.

***Table 7 Phonological Processes Found in Children with ASD: Clear without Potential***

| Process | Description |
|---|---|
| Affrication | • found in Cleland et al. (2010)<br>• afficates replace fricatives (Bankson & Bernthal, 2004)<br>• a process that occurs in the speech of typically developing children (Bankson & Bernthal, 2004; James, 2001 as cited in McLeod, 2009) |
| Initial Consonant Deletion | • found in Cleland et al. (2010)<br>• no explanation given, but self-explanatory<br>• segment deletion is possible in all positions of a word in child language, but is more common word-finally (Johnson & Reimers, 2010)<br>• occurs in the speech of typically developing children (James, 2001 as cited in McLeod, 2009) |
| Glottal Replacement | • found in Wolk and Edwards (1993)<br>• intervocalic consonants are replaced by the glottal stop /ʔ/<br>• glottal replacement is a common process among typically developing children (Bankson & Bernthal, 2004) |
| Segment Coalescence Used 20% of the Time to Reduce Consonant Clusters | • found in Wolk and Edwards (1993)<br>• features of two adjacent segments in the target word are merged resulting in another segment that has features of both the segments<br>• ex. /swiŋ/ → [w̥In]<br>• coalescence is a common process in the speech of young children (Bankson & Bernthal, 2004) |

The processes in Table 7 are all found in the speech of typically developing children. Both coalescence and glottal replacement are processes that are commonly found in the speech of typically developing children (Bankson & Bernthal, 2004). Thus, they are not good candidates for autism specific phonological processes. Initial consonant deletion is not as common in the speech of typical children as final consonant deletion (Johnson & Reimers, 2010). And, it isn't apparent how often affrication occurs in the speech of typically developing children. Nonetheless, none of these four processes are candidates for an autism specific phonological process because they can all be said to be characteristic of typical development.

No clear candidate for an autism specific phonological pattern can be identified in these studies. Many processes found in these studies are actually common processes in the speech of typically developing children. And, others may have been common processes, but they were not explained very well. However, some abnormal phonological patterns were present in the speech of the children with ASD. But, these processes were not unique to children with ASD. Thus, unless they pattern in a unique way in the speech of children with ASD, the processes found in other children with phonological disorders or delays cannot be seen as proof of an autism specific pattern of phonological development.

## 2.3. Methods

In order to document and analyse the phonological development of children with ASD, I conducted a two stage study. Stage one was a pilot study that involved 7 children with ASD. They were recorded during a word naming task and during free play with the researcher. Stage two was a longitudinal study of one child with ASD over the course of eight months. In stage two there were only recordings of free play sessions.

The pilot study involved the recording and analysis of the speech of seven children with ASD. The children were between the ages of 20 months and 7 years. All the children in the study had been diagnosed with ASD by a registered psychologist, and their diagnoses was confirmed with the Autism Diagnostic Observation Schedule (ADOS). Six of the seven children received the same variety of behavioural intervention

(Reference and Regulate) from the same provider (Loyst and Associates Autism Services). The one child who received a different form of therapy (Applied Behavioural Analysis) was eventually excluded from the analysis in order to avoid any confounding variables arising from therapy type. That is, it was not the intention of this study to examine the influence that different types of intervention have on phonological development.

As all the children received behavioural intervention, they were accustomed to people coming into their homes or daycares to play with them for a period of up to two hours a day. Therefore, the children were not expected to feel uncomfortable playing with a stranger in a familiar setting. The recordings were conducted in a quiet room of the children's homes. One child was recorded at his daycare in a quiet room.

In this stage of the study, the children were audio recorded while engaging in a word naming task. A word naming task was employed in order to be able isolate specific phonemes in various positions within a word. The words in the word naming task were a subset of the word list from the Phonological Knowledge Protocol (PKP) (Gierut, 1985 as cited in Gierut, 2008). Fifty-three words were chosen. This was done in an attempt to have two probe words for each English consonant in word initial, medial, and final positions, while keeping the task short in order to maintain the attention of the children. All the consonants had two probe words for each word position except for /ŋ/, /g/, /Ɵ/, /ð/, /j/, and /h/. Two probe words were used to elicit two different target phonemes in different positions in the word at the same time (e.g. gum and dog are used for /g/ and /m/, and /d/ and /g/ respectively). The pictures of the probe words (Appendix B) were gathered from Google Images ("Google Images,"), Royalty Free Stock Photos website ("Royalty Free Stock Photos,"), Green Pack website ("Green Pack,") and Microsoft Office Clip Art (Microsoft Corporation, 2010b). They were presented to the children on an iPad. It was assumed that an iPad may be able to hold the interest of the children for a fair amount of time. This was based on my past experience working with children with ASD. In my experience, a lot of children with ASD seem to enjoy playing with electronic devices. Each picture was used to represent only one target word. This was to avoid any possible practice effects (Gierut, 2008). The children were presented the picture and asked to name the picture or a part of the picture. If the child was unable to name the item, delayed imitation was employed. That is, the researcher would say the word, and then ask the question again. And, if the child still could not name the item, direct imitation was used. This is where the researcher would ask the child to say the given word after him or her. The word naming task didn't prove to be effective as only 3 of the 6 children in the study completed the task. The other 3 either refused to engage in the activity at all or only completed a small subset of the words. Since not all of the children were able to complete the word naming task, the data from the word naming task for those who did complete it, was not included in the overall analysis.

The children were also recorded during free play with the researcher. That is, the children played with many different toys (like a train set, a puzzle that makes noises, or pretend food) that the researcher brought to the session. Free play was used to provide the children with a chance to produce spontaneous and connected speech. This was desirable because samples of spontaneous connected speech are the most natural samples of a child's phonological performance (Bankson, Bernthal, & Flipsen, 2009). Connected speech would also aid in circumventing any problems of vocabulary, where the child might not know the word that is being prompted in an elicitation task as he or she would only use words he or she knows. The children were recorded for one hour (including the word naming task), and twenty minutes of free play were analysed.

The crux of the study is a longitudinal examination of the phonological development of one child with ASD. The child was chosen from among the 6 children who participated in the pilot study. The longitudinal case study involved audio recordings of said child during free play sessions with the researcher. The study was designed in order to be able to examine in greater detail the patterns of phonological development and their trajectory in a child with ASD. A longitudinal study lends itself to the analysis of the sequence of development, as the child or children are being studied at repeated intervals (McLeod, 2009). And, the majority of previous studies of the phonological development of children with ASD were all done at one point in time (see Bartolucci & Pierce, 1977; Boucher, 1976; Cleland et al., 2010; Rapin et al., 2009; Wolk & Edwards, 1993; Wolk & Giesen, 2000). To my knowledge, there has yet to be an indepth longitudinal study. The use of a single participant allowed for a greater examination of the data. And, due to the heterogeneous nature of ASD (Hill & Frith, 2003), and individual differences in child development (McLeod, 2009), a larger study may mask certain phonological patterns.

The child was recorded between twice a month and four times a month. I attempted to have a session once a week or once every other week. However, there were times where this was not possible due to the child being ill, the family being busy for Christmas, or the researcher being sick.

The sessions from both the pilot and the longitudinal studies were recorded using Zoom H2n Handy Recorder recording device. The recordings were analysed in WaveLab LE (Goutier, 2011) and Praat (Boersma & Weenink, 2011). The speech of the children was transcribed by the researcher. For the longitudinal study, the first twenty minutes of each session were analysed and the child's utterances were transcribed using the International Phonetic Alphabet (IPA). The transcribed utterances were inputted into an Excel spreadsheet (Microsoft Corporation, 2010a) in order to perform calculations and comparisons across recording sessions or dates.

In order to understand what some of the children were saying at a later point, especially Participant 114, I recasted, whenever possible, what was said by the child when I was recording him. This is due to the fact that in the moment it was a lot easier to understand what a given child was attempting to say as I had access to the environment surrounding the child (e.g. toys, furniture, people).

So that I could accurately transcribe the speech of Participant 114 and the other children with ASD, I was required to develop some of my own transcription conventions. A pause within a word is marked by square brackets *[ ]*, with the length of the pause indicated in ms within the parenthesis. A pause between words is marked by braces *{ }*, with the length of the pause indicated in ms within the braces.

When transcribing the speech of the children in the study, I employed the entire IPA chart, not just the IPA symbols that are said to be found in English. Thus, if one of the children produced a sound that was not a sound of English, I would be able to transcribe the sound as accurately as possible. When a distortion in the recording made it impossible to be completely sure if a sound was present or not, the word was omitted from certain counts. That is, if a distortion were to cover the end of a word and it was not possible to make out whether or not a word-final consonant was present, that word was neither counted as a word with a word-final consonant nor as a word without a word-final consonant. Or if there was a possibility that there was a consonant cluster it was neither counted as a consonant cluster nor as a single consonant. If it wasn't possible to determine the target word for a given token, the token was omitted.

However, when the target for a given token was possible to determine, but some of the specific sounds weren't clear, I followed some of the tips for transcribing indistinct productions laid out by Stoel-Gammon (2001). When it wasn't possible to determine the exact segment that a child produced, but it was possible to determine certain features of the segment, I used a "cover symbol" to indicate the manner of production. For example, if I could determine that the segment was a nasal, but not where it was produced, I used the symbol *N* to represent the sound. Additionally, when a sound that a child produced seemed weak or very short, I transcribed it as a superscript. For example, if a [t] was released somewhat like a fricative, [s], I would transcribe it as [t$^{s}$]. If a particular segment seemed to be produced between two phones, then I indicated that it was ambiguous, and wrote down both IPA symbols. Moreover, when I wasn't confident that the segment I transcribed was correct, I indicated this in the transcription with a note.

Due to the sheer size of this study, I was not able to run a test of inter-rater reliability because it wasn't practical to get another person to transcribe all of the speech samples. However, another phonologist did transcribe one recording session. No reliability rate was calculated, but the two transcriptions were quite similar. Furthermore, no intra-rater reliability was calculated, but I did transcribe some of the sessions twice (quite a few months apart). And, the two transcriptions were quite comparable.

# 3. Results from Pilot Study

The recordings from 6 children with ASD were analysed. The age appropriateness and the presence of some of the processes, identified as common by Bankson and Bernthal (2004), in the speech of the 6 participants is indicated in Table 8. A blank cell in the age appropriateness row signifies that that process was not found in the speech of that particular participant.

*Table 8* ***Pilot Study: Phonological Processes Found in the Children with ASD***

| | Participant 110 | | Participant 111 | | Participant 113 | | Participant 114 | | Participant 115 | | Participant 116 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Process | Age appropriateness | Number of Instances in 20mins | Age appropriateness | Number of Instances in 20mins | Age appropriateness | Number of Instances in 20mins | Age appropriateness | Number of Instances in 20mins | Age appropriateness | Number of Instances in 10mins | Age appropriateness | Number of Instances in 10mins |
| Initial consonant deletion | Un | 2 | | | Un | 1 | Un | 1 | | | | |
| Backing | Un | 4 | | | | | | | | | | |
| Final consonant devoicing | Un | 1 | | | | | | | | | | |
| Final consonant deletion | D | 15 | | | D | 10 | T | 45 | No | 17 | Un | 12 |
| Prevocalic voicing | | | | | D | 1 | T | 2 | | | D | 2 |
| Gliding of liquids | T | 7 | T | 14 | | | T | 1 | Y | 4 | T | 1 |
| Stopping | Un | 12 | D | 9 | | | | | Un | 11 | | |
| Velar fronting | | | | | | | | | | | | |
| Unstressed syllable | | | | | | | | | | | | |
| Epenthesis | | | | | | | T | 2 | | | T | 40 |
| Consonant cluster resolution | D | 7 | D | 6 | D | 7 | T | 8 | No | 9 | Un | 3 |

Short hand forms are used in the table to save on space. *T* means that the process is typical at that age or age appropriate. *D* means that the process is delayed or not age appropriate. *Un* means that it is unclear whether or not the process is age appropriate.

Each participant, with the exception of Participant 114, exhibited language profiles that included both phonological processes that are considered typical of normally developing children of their chronological age and those that are considered delayed if still produced by a child of their chronological age. Participant 114 didn't demonstrate the use of any phonological processes whose usage would be deemed delayed for his chronological age, as he was only 1;8 years old at the time of the pilot study. That is, he was at such an early stage of phonological acquisition that the use of most of the phonological processes documented in child language acquisition would not be characteristic of delayed phonological acquisition for quite some time. The rest of the participants ranged in age from 3;9 to 5;9 years of age, so the processes that were age appropriate and those that were not age appropriate varied from child to child.

The participants demonstrated some age inappropriate phonological processes in common. All of the participants produced examples of final consonant deletion. The participants also demonstrated consonant cluster resolution. This process is interesting in that there are two different ages at which this process ceases to be age appropriate: 3;11 for consonant clusters composed of two consonants and 4;11 for those composed of three consonants (Dodd et. al., 2003 as cited in Dodd et al., 2005). So the degree to which this process was age inappropriate varied among the participants. And, in the case of this process, Participant 113, at the age of 5;9, did produce one instance of it despite both resolution of two-consonant consonant clusters and three-consonant consonant clusters being age inappropriate. This may be evidence that he was in the process of eliminating this process from his speech.

Three of the participants, Participant 111 (age: 5;1), Participant 110 (age: 4;4) and Participant 115 (age: 4;8) employed the phonological process of stopping. This process was not age appropriate for Participant 111, but it is not clear if it was age appropriate or not for Participants 110 and 115. But, notably, both Participant 110 and 115's use of stopping only targeted interdental fricatives. That is, they produced the interdental fricatives /θ ð/ as their alveolar stop counterparts [t d]. For example (3), Participant 110 produced the voiced interdental fricative /ð/ as the voiced alveolar stop [d].

3. [dæt] *that*

All the participants, with the exception of Participant 113, demonstrated the age appropriate phonological process of gliding of liquids. The fact that Participant 113 did not demonstrate this age appropriate process is interesting, as he was the oldest participant, being 5;9. It may appear that Participant 113, being older than the other participants, had already outgrown the process, and was thus, not going to be employing this process past the appropriate age. However, it is not possible to determine if this process was no longer present in his speech based on the limited data.

Some of the children also produced sound patterns that may be considered abnormal. Participant 110 and Participant 113 produced instances of the typical process epenthesis that could be considered atypical. Epenthesis usually involves the insertion of a vowel (Bankson & Bernthal, 2004), but both children demonstrated the insertion of one consonant or more segments. For example, Participant 110 inserted a voiced velar stop [g] at the beginning of the single syllable word /ɹʌn/ *run* (4).

4. [gɹʌn] *run* (Participant 110)

This type of epenthesis can be classified as initial consonant adjunction (Grunwell, 1997), where a consonant is added to the beginning of a word. Consonant adjunction is one of the processes that Leonard (1985) categorized as an addition of a segment or a sound to the target adult form which is subsumed under his classification of 'Salient but unusual sound changes with readily detectable systematicity'. Thus, this type of sound change or pattern in a child's speech is atypical (Grunwell, 1997; Leonard, 1985). Instead of simplifying a target form, a child using consonant adjunction is actually making it more complex. Participant 113 produced two different patterns of epenthesis that could be characterised as consonant adjunction, and, therefore, atypical. One was a simple case of consonant adjunction where he produced the word *are* by adding a /w/ word-initially (5).

5. [wɑɹ] *are* (Participant 113)

The other pattern involved the addition of both a vowel and a consonant. Interestingly, the vowel and consonant that were inserted did not form a syllable. That is, Participant 113 produced the word *room* (6) with a schewa /ə/ following the word-initial /ɹ/ and an /h/ between the schewa /ə/ and the high back rounded vowel /u/.

6. [ɹə.hum] *room* (Participant 113)

Despite being very interesting, these abnormal epenthesis patterns were not very common in the speech of these two participants. Participant 110 had only one instance of consonant adjunction, and Participant 113 demonstrated two instances of straightforward consonant adjunction and only one instance of vowel and consonant epenthesis.

The most salient 'abnormal' phonological process was produced by three participants: 114, 115 and 116. They all produced pauses of a considerable length either within syllables or between syllables or both. This will be explored in the sections below along with a more in depth examination of some of the processes that were used by each of the participants of the pilot study.

## 3.1. Profile of Participant 110

Participant 110 was a four year old male native English speaker. He was diagnosed with autism at the age of 3;3. He began receiving behavioural intervention at the age of 3 and a half years (3;6). He said his first word at approximately 12 months of age. He began to produce 2 word utterances between the ages of 20 months (1;8) and 2 years. Participant 110 had normal hearing. He saw a speech and language pathologist on a regular basis. He was 4;4 at the time of the recording session.

In the 20 minute period of the recording that was analysed, Participant 110 produced 24 utterances. His MLU was 2.3. This was calculated based on 42 utterances instead of 100, and 20 minutes instead of 30 as indicated by Brown (1973 as cited in Tager-Flusberg & Zukowski, 2009).

Participant 110 was found to produce both age appropriate and age inappropriate typical phonological patterns. The only common pattern found in Participant 110's speech that was age appropriate was gliding of liquids. This pattern disappears, according to Dodd et al (2003 as cited in Dodd, 2005), after the age of 5;11. Therefore, Participant 110's replacement of /l/ by [w] in the word *letter* (7) is age appropriate.

7. [wɛdəɹʃ] *letter*

He produced two patterns that were not appropriate for his age: consonant cluster simplification and final consonant deletion. Consonant cluster simplification can involve clusters of two or three consonants (Dodd et al., 2003 as cited in Dodd et al., 2005). All of the target consonant clusters that Participant 110 simplified contained two consonants (8).

8. [sɪk] *six* -the word-final /s/ was deleted

Consonant cluster simplification is an age appropriate phonological pattern until after the age of 3;11 for target consonant clusters containing two consonants, and after the age of 4;11 for target consonant clusters containing three consonants (Dodd et al., 2003 as cited in Dodd et al., 2005). Thus, his use of consonant cluster simplification can be deemed inappropriate for his chronological age.

Final consonant deletion (9) is not very common after the age of 3;0 (James, 2001 as cited in McLeod, 2009; Stoel-Gammon & Dunn, 1985). It is not clear in the research whether it disappears from the speech of typically developing children by the of 3;0 (Stoel-Gammon & Dunn, 1985) or declines at the age of 3;0 (James, 2001 as cited in McLeod, 2009). Nonetheless, this process is probably not age appropriate in the speech of Participant 110.

9. [wʌ] *one* – the word-final consonant /n/ was deleted

A pattern of stopping was also found in the speech of Participant 110. He replaced the interdental fricatives with alveolar stops. That is, he replaced the voiceless interdental fricative /θ/ with the voiceless alveolar stop [t], and the voiced interdental fricative /ð/ with the voiced alveolar stop [d] (10).

10. [dæt] *that*

This pattern was used consistently in place of the interdental fricatives. But, it seems that other fricatives were not targeted by this pattern. He produced the target word-initial voiceless alveolar fricative /s/ in the word *see* (11), and the target word-final voiceless alveo-palatal fricative /ʃ/ in the word *crash* (12).

11. [si] *see*
12. [gɹæʃ] *crash*

It is unclear whether or not this pattern is age appropriate. As stated above, this pattern has been found to decline at the age of 3 years, but it is not clear whether stopping would still be present in the speech of typically developing children at the age of 4;4. However, the pattern may have been in the process of declining in his speech as only the interdental fricatives were stopped. It may be that early in his phonological development, Participant 110 replaced all fricatives with stops.

Participant 110 produced a number of processes about which age appropriateness is unclear.

Backing (of a consonant) was found in his speech (13).

13. [wɛdəɹʃ] *letters* – the voiceless alveolar fricative /s/ was backed to the alveo-palatal [ʃ]

This process only targeted the voiceless fricatives /v/ and /s/. And, it wasn't used consistently or abundantly in his speech. This process is found in the speech of typically developing children (Johnson & Reimers, 2010), and is found to be in the process of declining at the age of 3;0 (James, 2001 as cited in McLeod, 2009). Despite this fact, it is not entirely clear if it was age appropriate for Participant 110 to still be employing this pattern. It is also not clear if this pattern was declining in his speech as he was only recorded at one point in time.

Participant 110 also used the phonological pattern of initial consonant deletion (14).

14. [ʊk] *look* – the word-initial alveolar liquid /l/ was omitted

There were very few examples of this process in his speech during the recording session. This pattern has also been found in the speech of typically developing children (Johnson & Reimers, 2010), and has been found to be declining at the age of 3;0 (James, 2001 as cited in McLeod, 2009). It is not evident whether or not the presence of this pattern in the speech of Participant 110 can be deemed age inappropriate as there were so few examples of it.

Participant 110 produced two instances of final consonant devoicing (15).

15. [bwejtʃ] *bridge* – the word-final affricate /ʤ/ was devoiced

    [wajt] *ride* – the word-final voiced alveolar stop /d/ was devoiced

It is unclear if this is age appropriate or not because the research presents differing ages at which the process is no longer found in a typically developing child's speech (at 3 (James, 2001 as cited in McLeod, 2009) or sometime after 3 (Stoel-Gammon & Dunn, 1985)). Moreover, only one example of this process was found in his speech, so it is not clear if this pattern can be deemed productive in his speech at that point in time.

Two of the processes that were present in his speech, fronting and epenthesis, are considered to be common typical patterns (Bankson & Bernthal, 2004), but the way in which they were employed could be considered atypical. Specifically, the fronting that he produced was dental not velar, velar being the form cited in the literature as common (Bankson & Bernthal, 2004) (16).

16. [fɹi] *'three'* –the voiceless interdental fricative /θ/ was fronted to the labial fricative [f]

It is unclear whether or not the fronting of the voiceless interdental fricative /θ/ to the labial position [f] is age appropriate. Velar fronting of /k/ and /g/ would not be age appropriate for Participant 110 as this pattern is only age appropriate until 3;11 (Dodd et al., 2003 as cited in Dodd et al., 2005). Moreover, epenthesis usually involves the insertion of a vowel (Bankson & Bernthal, 2004), but Participant 110 inserted a voiced velar stop [g] at the beginning of the single syllable word /ɹʌn/ *run* (17).

17. [gɹʌn] *run*

There was only one example in the recording session of each of these processes. The epenthesis Participant 110 employed can be classified as initial consonant adjunction

(Grunwell, 1997), where a consonant is added to the beginning of the target word. As previously mentioned, this can be considered atypical.

## 3.2. Profile of Participant 111

Participant 111 was a five year old male. He was diagnosed with PDD-NOS at the age of 4 and half years (4;6). He began to receive behavioural intervention at the age of 4;8. He said his first word at approximately 2 years of age. Participant 111 had no hearing loss. He was 5;1 years old at the time of the recording session.

In the 20 minute period of the recording that was analysed, Participant 111 produced 44 utterances. His MLU was 2.9. This was calculated based on 44 utterances instead of 100, and 20 minutes instead of 30 as indicated by Brown (1973 as cited in Tager-Flusberg & Zukowski, 2009).

Participant 111 produced phonological patterns that are commonly found in typical acquisition. For example, he was quite consistent in his use of the pattern of stopping (replacement of a fricative by a stop) (Bankson & Bernthal, 2004) to deal with the more difficult production of fricatives. The patterns that he used were mainly delayed (or inappropriate for his age). The only age appropriate process used by Participant 111 was gliding (18). Gliding has been found to be age appropriate until after 5;11 (Dodd et al., 2003 as cited in Dodd et al., 2005), and at the age of 5;1, Participant 111's use of this process is, therefore, typical of children his age.

18. [gwin] *green* – the alveolar liquid approximate /ɹ/ was replaced by the labio-velar glide /w/

Participant 111 produced liquids as glides often during the 20 minute session. The gliding of the liquids always occurred before a vowel, as is the common developmental pattern. For instance, he replaced the lateral liquid /l/ with the labio-velar glide [w] in the word *listen* (19)

19. [wɪsɪn] *listen*

He produced 14 instances of this pattern. However, he was able to produce prevocalic liquids as liquids. For example, he produced the words *look* (20) and *friends* (21) with the target glides before the target vowels.

20. [lʊk] *look*

21. [frɛns] *friends*

Both of those words were also produced with a glide in place of the target liquid at other times during the session. Therefore, Participant 111's use of the pattern of gliding was not consistent, and most likely not lexically specific. It may be that this pattern was in the process of declining.

The patterns that were indicative of delayed phonological development or not age appropriate were stopping, consonant cluster resolution, and final consonant deletion. Participant 111 consistently replaced the voiced interdental fricative /ð/ word-initially with the voiced alveolar stop [d] (22). Eight instances of this pattern were produced.

22. [dɪs] *this*

23. [tiːs] *these*

In one instance of the word *these* (23), he stopped the interdental fricative /ð/ and devoiced it, giving him a voiceless alveolar stop [t] in it's place. Nonetheless, Participant 111 did produce the voiced interdental fricative word-initially a couple of times during the recording session. For example, in one instance of his production of the word *this*, he did not stop the /ð/ (24).

24. [ðɪs] *this*

As stopping typically declines in a child's speech at 3;0 (James, 2001 as cited in McLeod, 2009), at the age of 5;1, this pattern was probably delayed in the speech of this participant.

Consonant cluster resolution was used quite often; over half of the consonant clusters in the target words underwent consonant cluster resolution. An example of consonant cluster resolution in the speech of participant 111 would be one of the instances of the word *fly* where he omitted the /l/ from the onset consonant cluster /fl/ (25).

25. [faj] *fly*

The instances of consonant cluster resolution word-finally may in fact be cases of final consonant deletion. For example, he omitted the word-final /d/, part of the consonant cluster /nd/, in his production of the word *friend* (26) (he also omitted the /ɹ/ from the word-initial consonant cluster /fɹ/).

26. [fɛn] *friend*

It is not possible to determine if this is a case of final consonant deletion or consonant cluster resolution due to the fact that the consonant that was omitted from the consonant cluster was word-final in the target word. Resolution of target clusters of two consonants is age appropriate until after 3;11, and resolution of target clusters of three consonants is age appropriate until after 4;11 (Dodd et al., 2003 as cited in Dodd et al., 2005). As such, the reduction of target clusters of both two and three consonants in the participant's speech is indicative of delayed phonological development.

Final consonant deletion was not very common in the speech of Participant 111. In fact, only one of the instances of final consonant deletion cannot also be classified as consonant cluster resolution. Final consonant deletion has been found to decline at the age of 3;0 (James, 2001 as cited in McLeod, 2009), so it was most likely not age appropriate for the child.

Participant 111 produced one instance of a word that doesn't follow the phonotactics of English. For one of his pronunciations of the word *zoom*, he replaced the /z/ with the voiced postalveolar fricative [ʒ] (27).

27. [ʒum] *zoom*

This is atypical because the postalveolar fricative does not occur word-initially in English. However, this may not be prevalent in the speech of Participant 111 as there was only one example of this 'error'. Further examination and testing would be required.

## 3.3. Profile of Participant 113

Participant 113 was a five year old male. He was diagnosed with ASD and began receiving behavioural intervention at 3 years of age. Participant 113 received ABA therapy to begin with and then switched to Reference and Regulate. He said his first word at approximately 16 months and began producing two word utterances at 2 years. He saw an SLP once a week. He took a hearing test, but refused to participate in the entire process. His parents reported that on the portion of the test that he did do his hearing was normal. He was 5;9 at the time of the recording session.

His parents spoke Mandarin; however, Participant 113 did not. His first language was English. It may be that he understood spoken Mandarin, but this was not specifically indicated by his parents.

In the 20 minute period of the recording that was analysed, Participant 111 produced 35 utterances. His MLU was 2.7. This was calculated based on 35 utterances instead of 100, and 20 minutes instead of 30 as indicated by Brown (1973 as cited in Tager-Flusberg & Zukowski, 2009).

Only one phonological pattern was used frequently by Participant 113: final consonant deletion. For example, he omitted the final consonant /t/ in the word *hint* (28).

28. [hɪn] *hint*

Nevertheless, he did not use this pattern consistently. He was able to produce word-final consonants, and even produced the same words both with and without a final consonant. For instance, he produced the word *aeroplane* once including the final consonant /n/ (29) and once omitting it (30).

29. [æɹplejn] *aeroplane*

30. [æɹplej] *aeroplane*

This pattern is said to disappear by (Stoel-Gammon & Dunn, 1985) or decline by (James, 2001 as cited in McLeod, 2009) 3;0. At 5;9, this pattern was most likely delayed in Participant 113's speech. The inconsistent use of the pattern may indicate that it was in the process of declining. But, it is not possible to determine at what age the pattern started to decline.

Participant 113 produced single instances of some common phonological patterns. He used the process of prevocalic voicing once in the production of the word *put*, where he voiced the voiceless bilabial stop /p/ before the vowel /u/ (31).

31. [bʊt] *put*

Additionally, consonant cluster resolution was used only once in his production of the word *let's* to resolve the word-final consonant cluster by deleting the /t/ (32).

32. [lɛs] *let's*

This is simply a case of consonant cluster resolution as long as the child is treating *let's* as a single morpheme and not analysing it as *let us* (which is highly unlikely).

Participant 113 also produced one instance of initial consonant deletion. He omitted the word-initial /k/ from the word *candy* (33).

33. [æn] *candy*

This is not a common phonological pattern produced by typically developing children (Bankson & Bernthal, 2004), but it does occur in the speech of some typically developing children (Johnson & Reimers, 2010). None of these patterns are clearly age appropriate for a child of 5;9. However, they could have been in the process of declining from his speech as exhibited by their low number of instances. Thus, the presence of these patterns may not have been indicative of delayed phonological development. And, they should not, due to their low numbers of occurrence, be used as evidence of phonological delay.

Participant 113 used three phonological patterns that may not be produced by typically developing children. He produced two words with the epenthesis of a consonant. One instance involved the epenthesis of an initial consonant or consonant adjunction. He produced the word *are*, adding the consonant /w/ word-initially [wɑɹ]. This type of pattern is considered by Leonard (1985) to be atypical in child language development. The other example of epenthesis involved the addition of both a vowel and a consonant. Participant 113 produced the word *room* (34) with a schwa /ə/ following the word-initial /ɹ/ and an /h/ between the schwa /ə/ and the high back rounded vowel /u/.

34. [ɹəhum] *room*

It is interesting that despite adding both a consonant and a vowel to the word, he did not insert a syllable. With the addition of the segments, an additional syllable was produced, but these segments were placed in different syllables.

Participant 113 produced one instance of internal consonant deletion. He omitted the word-internal /t/ in the word *accidentally* (35).

35. [æksɪdwɛnli] *accidentally*

The only other time that he produced the word, he produced it with the word-internal /t/ (36).

36. [æksɪdɛntli] *accidentally*

The analysis of the first example of accidentally (35) as word internal consonant deletion is assuming that the child is not analyzing the word as the noun 'accident' plus the suffix 'ly'. It is assumed that he is treating the two morphemes as one. If, however, he was treating the morphemes separately, then it may be that he deleted the final consonant /t/ prior to adding the suffix 'ly'. In that case, he would be employing a phonological pattern that disappears by age 3;0 (Stoel-Gammon & Dunn, 1985), and would, therefore, be, at 5;9, demonstrating delayed phonological development.

At first glance, participant 113 employed an abnormal process in the production of one instance of the word *one*. He substituted the word-initial glide /w/ for a liquid [ɹ] (37).

37. [ɹʌn] *one*

It appears to be the opposite of the common and typical process 'gliding of liquids' where liquids preceding a vowel are replaced by glides (Bankson & Bernthal, 2004). In this case, a prevocalic glide is replaced by a liquid. However, this may be a case of a perseveration speech error as the utterance was *dry one*. That is, there was a [ɹ] produced in the first word of the utterance (38) which may have triggered the replacement of the glide /w/ with the liquid [ɹ].

38. [dɹɑj ɹʌn] *dry one*

It is not possible to determine whether this was a speech error or a phonological pattern as there was only one example of this utterance

## 3.4. Profile of Participant 114

Participant 114 was a 1 year old male. He was diagnosed with ASD at 11 and a half months (0;11). He began receiving behavioural intervention at the age of 13 months (1;1). He had no hearing impairment. He was 20 months old at the time of the recording session (1;8).

He said his first word at approximately 16 months of age. At the time of the parent interview, Participant 114 was not yet producing two word utterances, and was only producing monosyllabic words. However, shortly before the recording session, he began producing some two word utterances and disyllabic words. Participant 114 did not see a speech and language pathologist on a regular basis. His parents had not noticed any consistent errors in his pronunciation, as he barely produced any sounds. He was simultaneously acquiring both English and Cantonese. However, only his grandmother, who lived with the family, spoke Cantonese to him. His mother, his father, and his behavioural interventionists spoke English to him.

As Participant 114 was 1;8 at the time of the recording session, all of the common, typical phonological patterns (Bankson & Bernthal, 2004), found in his speech were age appropriate. They are listed below in Table 9.

***Table 9. Common Typical Phonological Processes in the Speech of Participant 114***

| Phonological Process | Examples | Disappears after/declining at |
|---|---|---|
| Final consonant deletion | ʌ (on)<br>pʰə (push)<br>pʰʊ (push<br>bʌ tʰɪ (button)<br>pɹɛ (press)<br>tʰɪ (turn)<br>tʰə (turn | -disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>-declining at 3;0 (James, 2001 as cited in McLeod, 2009) |
| Consonant Cluster resolution | ɸɛ (press) | -age appropriate until after 3;11 for 2 consonants and after 4;11 for 3 consonants (Dodd et al., 2003 as cited in Dodd et al., 2005)<br>-declining at 3;0 (James, 2001 as cited in McLeod, 2009) |
| Epenthesis | ə[]dɐ (down)<br>ənow (no) | -disappears after 3;0 (Stoel-Gammon & Dunn, 1985)<br>-declining at 5;0 (James, 2001 as cited in McLeod, 2009) |
| Gliding of liquids | pwɛ (press) | -disappears after 5;11(Dodd et al., 2003 Dodd et al., 2005)<br>-declining at 2;6 and 4;0 (James, 2001 as cited in McLeod, 2009) |
| Prevocalic voicing | ow[]bwə (open)<br>dɐ (top) | -disappear by 3;0 (Stoel-Gammon & Dunn, 1985)<br>-declining at 2;6 (James, 2001 as cited in McLeod, 2009) |

The most prevalent pattern was final consonant deletion as Participant 114 only produced open syllables (CV). Thus, every word-final target consonant was omitted. The rest of the patterns were not very common in his speech. This was probably not indicative of advanced phonological development, but due to the fact that he didn't produce a great variety of words. There was only one instance of gliding of a liquid and one instance of consonant cluster resolution. This may be due to the fact that very few of the target words that he produced contained a liquid or a consonant cluster. The only target word produced that contained a liquid was *press*. He produced it three times. One time he produced the target liquid /ɹ/ (39).

39. [pɹɛ] *press*

In one instance, he omitted the target liquid /ɹ/ (40).

40. [ɸɛ] *press*

And, in the third iteration, he produced a glide, /w/, instead of the target liquid (41).

41. [pwɛ] *press*

*Press* was also the only target word with a consonant cluster that Participant 114 produced. Out of the three instances of production, he only simplified the cluster once, replacing the cluster /pɹ/ with voiceless bilabial fricative [ɸ] (40). Thus, he maintained the bilabial place of articulation and voicelessness of the voiceless bilabial stop /p/. Additionally, as the [ɸ] is a fricative, he maintained the continuant nature of /ɹ/. However, this is an interesting coalescence of the segments /pɹ/, as [ɸ] is not a sound of English.

He produced one instance of both initial consonant deletion and final consonant deletion. He omitted the word-initial /s/ and word-final /n/ and /d/ in his production of the word *sound* (42)

42. [ɐ] *sound*

Both of these patterns are present in typical phonological development (final consonant deletion: Bankson & Bernthal, 2004; initial consonant deletion: Johnson & Reimers, 2010).

Participant 114 also demonstrated an unusual pattern where /t/ was replaced by [tʃ]. That is, in many instances of the word *turn*, he replaced the voiceless alveolar stop /t/ with the voiceless postalveolar affricate [tʃ] (43).

43. [tʃɪ] *turn*

This is unusual as it cannot be classified as affrication, which is a common phonological pattern in the speech of typically developing children (Bankson & Bernthal, 2004). Affrication is a process where fricatives are replaced by affricates. But, in this case a stop is being replaced by an affricate. This pattern only occurred word-initially and before the vowel [ɪ]. This environment was only present in four instances of the production of the target word *turn*.

Participant 114 produced one instance of an atypical pattern. He attached the consonant [h] to the beginning of the word *yeah* (44).

44. [hjæ] *yeah*

This is a case of initial consonant adjunction, which is an unusual sound change in child speech (Grunwell, 1997; Leonard, 1985). However, this cannot be used to determine whether or not Participant 114 was employing atypical phonological patterns in his speech as there was only one example of this pattern.

Additionally, Participant 114 produced an instance of what appears to be unusual deletion. In one instance of his production of the word ‘open’, he omitted the final consonant /n/ and the preceding vowel /ɛ/ (45).

45. [ow[]p] *open*

Thus, he omitted the nucleus and the coda of the second syllable of the word, but preserved the onset, /p/, of that second syllable. As the first syllable of the word /ow/ does not contain a coda consonant, /p/ could be syllabified as the coda consonant of that first syllable. However, it appears that Participant 114 may be treating the /p/ as the onset of the second syllable despite the lack of a nucleus since there is a pause between the vowel or the nucleus of the first syllable and the /p/. Therefore, he seems to have omitted the rime of the second syllable.

The most salient characteristic of Participant 114’s speech was the fact that it was quite slow. There were long pauses between words. Moreover, pauses of a comparable length to the pauses between words were found between syllables in multisyllabic words. For example, in one instance of the sentence *open turn* (46), he produced a pause of 460ms between the two words (marked by {} with a number inside indicating the length of the pause in ms). And, in one instance of the word *button* (47), he produced a pause of 472ms between the two syllables (marked by square brackets [] containing the length of the pause in ms).

46. [ʌ {460} tʃɪ] *open turn*

47. [bɐ[472]tɪ] *button*

The addition of a pause between syllables was a pattern that was used frequently by Participant 114. That is, most words that he produced with more than one syllable contained a pause between the syllables (16 out of 31 multisyllabic words). However, he did not produce all multisyllabic target words as multisyllabic. He omitted either the first or second syllable in some of them. For example, he produced the word *open* by omitting either the first syllable (48) or the second syllable (49).

48. [pʰə] *open*

49. [ow] *open*

The use of either the addition of a pause between syllables or the omission of one syllable did not appear to be lexically specific as both patterns were used for different instances of the same words. This can be demonstrated through the use of the above example of the word *open*. Participant 114 also produced this word with a pause between the two syllables (50).

50. [ow[ ]pʰə] *open*

## 3.5. Profile of Participant 115

Participant 115 was a 4 year old male. He was diagnosed with autism at the age of 18 months (1;6). According to his parents, his results on the ADOS were on the border line between ASD and PDD-NOS. He began receiving behavioural intervention at the age of 3;3. His hearing had been tested and was found to be typical. Participant 115 was 4;8 at the time of the recording session.

Participant 115 was approximately 9 months old when he said his first word. He began producing two word utterances at some point before his first birthday. He had been seeing a speech and language pathologist, but at the time of the recording session he was no longer receiving speech therapy. According to his parents, he was taking a yearlong break from speech therapy. His parents noted that Participant 115 slurred his words. They mentioned that he produced his /s/ with his teeth parted. They found that he spoke very softly, and it was often difficult to understand his pronunciation of certain words. But, his pronunciation had improved.

Only 10 minutes of Participant 115's session were analysed due to time constraints placed on this study. Thus, in the 10 minute period of the recording, he produced 22 utterances. His MLU was 5.4. This was calculated based on 22 utterances instead of 100, and 10 minutes instead of 30 as indicated by Brown (1973 as cited in Tager-Flusberg & Zukowski, 2009).

Participant 115 produced both age appropriate and delayed common typical phonological processes. The most consistently employed process, when compared to the number of possible applications of the process, was stopping. Participant 115 replaced the voiced interdental fricative /ð/ with the voiced alveolar stop [d] in his production of almost every target word that contained that fricative. For example, he replaced /ð/ with [d] in the word *this* (51).

51. [dɪs] *this*

However, he did not produce many words where the target contained the voiced interdental fricative /ð/. And, there was one instance of the word *this* where he devoiced the /ð/ instead of stopping it (52).

52. [θɪs] *this*

No other fricatives were targeted by this pattern. Nonetheless it is interesting that this pattern was the most consistent in his speech as it is not clear if it is age appropriate for him. Stopping declines at 3;0 (James, 2001 as cited in McLeod, 2009). As the participant was 4;8 at the time of the recording session, and it is not clear how long it takes for stopping to completely disappear from a typically developing child's speech, it is not apparent if Participant 115's consistent but narrow use of this pattern (only targeting one fricative) is delayed or age appropriate. Due to the fact that the pattern only targets one fricative, it may be that stopping was in the process of declining in his speech, but without prior knowledge about which fricatives he stopped at an earlier point in time, it is not possible to definitively declare that this pattern was declining in his speech.

Gliding of liquids, disappearing after 5;11 (Dodd et al., 2003 Dodd et al., 2005), was certainly age appropriate. However, despite this fact, there were very few instances of gliding. Participant 115 was able to produce the alveolar liquid /ɹ/. Only the lateral liquid /l/ underwent gliding, as in the word *blocking* where the /l/ was replaced by the labio-velar glide [w] (53).

53. [bwɑkɪŋ]  *blocking*

However, this pattern was not used consistently as he was able to produce the lateral liquid /l/. This can be demonstrated by his production of the word *cool* (54).

54. [kowl]  *cool*

Final consonant deletion was not used very often by the child; less than half of the possible final consonants were deleted. It was, however, still employed by Participant 115 despite not being age appropriate, typically disappearing by 3;0 (Stoel-Gammon & Dunn, 1985).

Most notably, Participant 115 produced word internal pauses. He produced pauses over 100ms within a syllable before a word-final consonant. The pauses only came before word-final voiceless alveolar stops (55) and voiceless velar stops (56).

55. [dæ[150]t]  *that*

56. [bʊ[157]k]  *look*

This was not used consistently; Participant 115 was able to produce word-final voiceless alveolar stops (57) and voiceless velar stops (58) without a preceding pause.

57. [wʌt]  *what*

58. [wəɹk]  *work*

However, he did not produce pauses between syllables. That is, he produced words like *blocking* (59), and *Percy* (60), without pausing between the syllables.

59. [bwɑ.kɪŋ] *blocking*

60. [pƐɹ.si] *Percy*

## 3.6. Profile of Participant 116

Participant 116 was a 3 year old male. He was diagnosed with ASD at 3;3. He began receiving behavioural intervention at 3;6. His hearing was tested and found to be typical. At the time of the recording session Participant 116 was 3;9.

He said his first word at approximately 10 or 11 months of age. At the time of the recording session he was still not consistently producing two word utterances. He was seeing a speech and language pathologist on a regular basis. His parents mentioned that he had a tendency to make unusual vocalisations (squeaks and shrieks). The vocalisations may have been self-stimulatory. Participant 116's parents noticed that he consistently replaced /θ/ with [d]. In addition to having ASD, Participant 116 was born with a high palate. He had difficulty nursing, and he had to use a special nipple adapter. His parents have discussed with his speech and language pathologist regarding the possibility that his high palate may make it hard for him to produce sounds properly. At the time of the recording session, they were still waiting to get Participant 116 tested.

Due to time constraints placed on this study, only 10 minutes of Participant 116's session were analysed. In the 10 minute period, he produced 31 utterances. His MLU was 1.1. This was calculated based on 31 utterances instead of 100, and 10 minutes instead of 30 as indicated by Brown (1973 as cited in Tager-Flusberg & Zukowski, 2009).

Participant 116 produced words employing common and typical age appropriate patterns. Those patterns are listed below in Table 10.

*Table 10. Common Age Appropriate Phonological Processes in Participant 116's Speech*

| Phonological Process | Examples | Disappears after/declining at |
|---|---|---|
| Gliding | wɐk (truck) | -age appropriate until after 5;11 (Dodd et al., 2003 as cited in Dodd et al., 2005)<br>-declining at 2;6 and 4;0 (James, 2001 as cited in McLeod, 2009) |
| Epenthesis | ənɐ (no)<br>ijɐ (yeah) | -disappears after 3;0 (Stoel-Gammon & Dunn, 1985)<br>-declining at 5;0 (James, 2001 as cited in McLeod, 2009) |

Neither pattern was particularly common in the speech of 116. There was only one instance of gliding in the session. In the one instance, as can be seen in Table 10 above, a liquid /ɹ/ in an onset was replaced by a glide [w]. There were no cases of an /ɹ/ in the onset of a word. And, for the pattern of epenthesis, there were only two examples.

There were some common and typical patterns that Participant 116 produced that may or may not have been age appropriate. Those patterns are listed below in Table 11.

***Table 11. Common phonological process that may not be age appropriate in Participant 116's speech***

| Phonological Process | Examples | Disappears after/declining at |
|---|---|---|
| Final consonant deletion | daw (down)<br>kʰɐ (car)<br>gɐ (car)<br>bɐ (ball)<br>gaw (close) | -disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>-declining at 3;0 (James, 2001 as cited in McLeod, 2009) |
| Consonant cluster resolution | gaw (close) | -age appropriate until after 3;11 for 2 consonants and after 4;11 for 3 consonants (Dodd et al., 2003 as cited in Dodd et al., 2005)<br>-disappears by 3;0 (Stoel-Gammon & Dunn, 1985)<br>-declining at 3;0 (James, 2001 as cited in McLeod, 2009) |

Final consonant deletion was quite common in the speech of Participant 116. However, it was not used consistently. He produced almost an equal number of target words containing a word-final consonant with and without a word-final consonant. In fact, he produced instances of the same word with and without a word-final consonant. For example, he produced the word *car* with a word-final consonant [kaɹ] and without a word-final consonant [kʰɐ]. As Participant 116 was 3;9, this could mean that this pattern is not age appropriate. However, if this pattern is found to be declining at the age 3;0 in typically developing children, then it is possible that it continues to decline at the age of 3;9. It is not apparent from the literature. On the other hand, there were very few examples of consonant cluster resolution. All of the examples were clusters composed of 2 consonants in the target word. As noted in the table, consonant cluster resolution has been found to disappear by (Stoel-Gammon & Dunn 1985) or be declining at (James as cited in McLeod, 2009) 3;0. But, it has also been found to be age appropriate for the resolution of 2 consonants in a target cluster until after 3;11 (Dodd et al., 2003 as cited in Dodd, 2005). So, it is both possible that this pattern was age appropriate and that it was not age appropriate for Participant 116.

Additionally, Participant 116 demonstrated the use of a common and typical phonological pattern that was not age appropriate for him: prevocalic voicing. Prevocalic voicing has been found to disappear by 3;0 (Stoel-Gammon & Dunn, 1985) and to decline at 2;6 (James, 2001 as cited in McLeod, 2009). The pattern was neither used abundantly nor consistently. For example, he produced the word *car* both with the target voiceless obstruent /k/, [kaɹ], and with the voiced obstruent /g/, [gɐ].

Participant 116 produced notable pauses of more than 100ms between syllables and within syllables. He produced pauses between the syllables of tri-syllabic words. For example, he produced the word *open* (61) with three syllables, and paused for 144 ms between the first and second syllable, and paused for 300 ms between the second and third syllables.

61. [ɐ[144]ow[300]ɪn] *open*

However, he did not produce many tri-syllabic words. Participant 116 did not produce pauses between the syllables of the disyllabic words that he produced. For example, both *no* [ənɐ] and *ball* [bawwɑ], single syllable target words produced as disyllabic words, were produced without a pause. This may be due to a functional load difference between disyllabic and tri-syllabic words. Participant 116 also produced pauses within syllables before a word-final voiceless velar stop /k/. That is, he produced the word *truck* with a pause of 163ms before the word-final /k/ (62), and the word *truck* with a pause of 255ms before the word-final /k/ (63).

62. [kʰɐ[163]k] *truck*

63. [wɐ[255]k] *truck*

The only two examples of this phenomenon did come from instances of the same word, but they were the only instances of word-final /k/ produced by Participant 116 in the session.

# 4. Extended case study of Participant 114's Infelicitous Pauses

The most salient feature of Participant 114's speech or phonology was the existence of infelicitous pauses. The pauses were found both between syllables and within syllables. According to Fletcher (2013), pauses that occur during speech production can be filled or unfilled. Unfilled pauses, also known as silent pauses, are pauses that do not contain a voiced portion in their acoustic waveforms. Research has found that pauses that occur between segments within a word (inter-articulatory pauses) have an upper threshold of around 100ms, and pauses that occur between words (inter-lexical pauses) are generally longer than 100ms. The 100ms threshold corresponds to the closure phase during a voiceless stop consonant. The inter-articulatory pauses below 100ms found in typical speech are not audibly perceivable. The pauses of interest to the present study were silent inter-articulatory pauses produced either between syllables (inter-syllabic) or within syllables (intra-syllabic). As with previous research into pause durations in adults and in children, a pause was defined as a silent portion of recording between segments that was longer than 100ms (milliseconds) (Fletcher, 2013; Shriberg, Green, Cambell, McSweeny, & Scheer, 2003). The pauses produced by Participant 114 were analysed in WaveLab LE 7 (Goutier, 2011) and Praat (Boersma & Weenink, 2011). All words produced during a 20 minute period of a given session were coded in an Excel Spreadsheet (Microsoft Corporation, 2010a) for the number of syllables, the presence or absence of a pause, and the length of the pause in milliseconds if present.

## 4.1. Inter-syllabic Pauses

At the time of the first recording session Participant 114 was 20 months (1;8) of age, and he produced between word pauses and inter-articulatory pauses that were often of the same length. For example, he produced the sentence *turn open* (64) with a pause between the two words of 304ms, and a pause between the two syllables in the word *open* of 311ms.

64. [tsə {304} ow[311]pʰwə]  *turn open*

However, not all disyllabic or multisyllabic words spoken had pauses between the syllables. During the first session, Participant 114 produced the word *no* with two syllables (65) by epenthesizing a schwa to the beginning of the word (a period indicates a syllabic boundary when there is no pause between the syllables).

65. [ə.now]  *no*

He produced this instance of *no,* a mono-syllabic word, as a disyllabic word and he produced it without a pause between the two syllables.

Moreover, pauses were not used consistently. That is, the same two syllable word, such as *button* (66) or *open* (67), was produced with a pause between the two syllables, without a pause (as early as October 25, 2012 for *open*, and April 5, 2013 for *button*), and as a single syllable word by omitting one of the syllables. Sometimes all three ways of producing a two syllable word were used in the same recording session.

66. [bʌ[499]tʰɛ]  *button*

[bɐtʰɪn]  *button*

[bɐ]  *button*

67. [ɐ[351]pwɛ]  *open*

[ɑwpʰwə]  *open*

[ʌ]  *open*

In examining the pauses produced by Participant 114, the goal was to determine if the production of the pauses remained consistent throughout the duration of the study, or if it changed. And, if the production changed, the goal would then become to establish if the change or changes demonstrated a developmental trajectory or not. Children's phonological development can be either gradual or sudden, in terms of the suppression of phonological process (Stoel-Gammon & Dunn, 1985). Thus, a phonological developmental trajectory of inter-articulatory pauses would be evidenced by a decrease in the use of pauses by Participant 114 during the course of the study, whether sudden or gradual, or by the complete suppression of the use of pauses. An increase in the use of pauses produced by Participant 114 as he aged would indicate that this “atypical” process was not in the process of being phased out of his speech.

In order to determine if there was a change in the use of pauses by Participant 114, it was necessary to look at the frequency of production and the duration of the pauses. A decrease in the proportion of pauses produced over the course of the study may demonstrate that the child was in the process of eliminating this process from his speech. Additionally, a decrease in the length of pauses would demonstrate that they were approaching the 100ms threshold of an inter-articulatory pause (Fletcher, 2013), and thus, that they were becoming imperceptible and what is considered typical.

One of the characteristics of the inter-syllabic pauses that I tracked was the duration of the pauses. The duration of inter-syllabic pauses in disyllabic words was tracked twice a month, and comparisons were made between the first month of the study (20 months of age) and the last month analysed for the current study (27 months). Additionally, comparisons were made between the pauses produced below the age of 2 years (20 months to 23 months or October to January) and those produced at and above the age of 2 years[2] (24 months to 27 months or February to May). Two years of age was chosen as a distinction point around which comparisons in Participant 114’s phonological development should be made because children’s transition from having no speech to having the foundations of a linguistic system, including a phonological system, occurs within the first two years of their life (Vihman, 2014). Moreover, it is at the age of 2 that children with delayed or late speech are identified (Vihman, 2014). Furthermore, the durations of the pauses were compared across all of the months of the study.

All of these measurements and comparisons were conducted in order to determine if there was a developmental trajectory in Participant 114’s production of inter-

[2] In the rest of the thesis, I refer to the period of February to May as above or after the age of 2;0 for ease of writing.

syllabic pauses in disyllabic words. That is, as the use of inter-syllabic pauses of over 100ms in duration is atypical, it was my conjecture that Participant 114's production of the pauses would become more and more typical as his speech developed, the duration of the pauses decreasing until they were 100ms or less.

In the two sessions that were analysed in the month of October 2012, Participant 114 produced 26 disyllabic words with an inter-syllabic pause. The mean duration of these inter-syllabic pauses was 429.73ms, with a standard deviation of 232.37. In the month of May 2013, he produced 12 disyllabic words with inter-syllabic pauses. And, the mean duration of the pauses was 150.75ms, with a standard deviation of 40.34. This demonstrates that there was a fairly large decrease in the duration of the inter-syllabic pauses that Participant 114 produced in disyllabic words at some point over the course of the study.

Additionally, the duration of inter-syllabic pauses in disyllabic words produced before the age of 2;0 was compared to the duration of those produced after the age of 2;0. Before the age of 2;0, Participant 114 produced 119 disyllabic words with an inter-syllabic pause. The mean duration of the pauses was 285.31ms with a standard deviation of 176.48. After the age of 2;0, he produced an inter-syllabic pause in a total of 76 disyllabic words. And, the mean duration of these pauses was 160.86ms with a standard deviation of 96.36. This implies that there may have been development, in terms of the decrease in the duration of the inter-syllabic pauses that co-occurred with the aging of the child, and the phonological development that happens around two years of age.

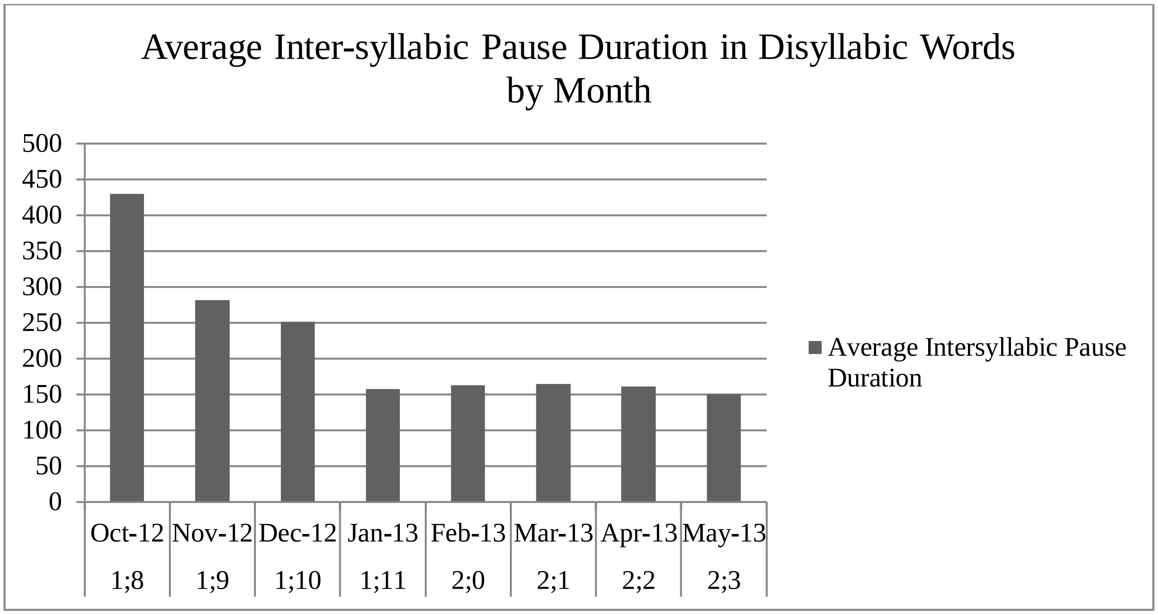


***Figure 1. Graph of The Average Inter-syllabic Pause Duration in Disyllabic Words by Month and Age of the Child.***

When the durations of the inter-syllabic pauses are examined by month, there appears to be a developmental trajectory where the durations of the pauses decrease as the child ages. Figure 1 (above) shows the mean durations of inter-syllabic pauses in disyllabic words by month (with the corresponding age of the child). The graph demonstrates that there was a decline in the duration of these pauses between October 2012 and January 2013. The mean durations of those months are listed in Table 12 (below).

***Table 12. Mean Durations of Inter-syllabic Pauses in Disyllabic Words Produced by Participant 114 by Month between October 2012 and January 2013***

| Month | Number of disyllabic words with a pause | Mean duration of pause (in ms) | Standard deviation |
|---|---|---|---|
| October 2012 | 26 | 429.73 | 232.38 |
| November 2012 | 45 | 281.76 | 126.04 |
| December 2012 | 27 | 251.63 | 151.21 |
| January 2013 | 21 | 157.43 | 75.77 |

Another way to track Participant 114's phonological development through pauses is the trajectory across the months of the study of the frequency of pauses that he produced in two syllable words. Again, it was theorised that as Participant 114 developed, the production of pauses would become more and more typical. That is, the number of pauses produced would decrease. The number of two syllable words that were produced with an inter-syllabic pause was studied in relationship to the number of two syllable words produced without an inter-syllabic pause, and to the total number of disyllabic words produced during a given period of time. A decrease in the proportion of disyllabic words produced with an inter-syllabic pause would coincide with an increase in the proportion of disyllabic words produced without an inter-syllabic pause. If this were found to occur during the study, it would possibly indicate the elimination of this process from the child's speech. This was examined via comparisons between the first month of the study (20 months or October 2012) and the last month analysed for the current study (27 months or May 2013), between the pauses produced below the age of 2 years (October 2012 to January 2013) and those produced above the age of 2 years (February 2013 to May 2013), and the proportion of pauses produced across the months of the study.

***Table 13.*** ***Frequency of Inter-syllabic Pauses Produced in Disyllabic Words by Month***

| Month | Number of disyllabic words produced | Number of inter-syllabic pauses in disyllabic words | % of disyllabic pauses produced |
|---|---|---|---|
| October, 2012 | 36 | 26 | 72.22 |
| November, 2012 | 72 | 45 | 62.50 |
| December, 2012 | 95 | 27 | 28.42 |
| January, 2013 | 72 | 21 | 29.17 |
| February, 2013 | 67 | 26 | 38.81 |
| March, 2013 | 76 | 16 | 21.05 |
| April, 2013 | 98 | 22 | 22.45 |
| May, 2013 | 88 | 12 | 13.64 |

As can be seen in Table 13 (above), 72.22% of disyllabic words produced in October of 2012 contained an inter-syllabic pause. And, 13.64% of disyllabic words produced in May of 2013 contained an inter-syllabic pause. Thus, there seems to be a great decrease in the proportion of disyllabic words with an inter-syllabic pause produced at the beginning of the study as compared to the end of the study. This decrease corresponded with the child's aging, and the language development that goes along with it.

When the proportion of inter-syllabic pauses produced in two syllable words by Participant 114 below the age of 2;0 and above the age of 2;0 was analysed, a decrease in the proportion of pauses corresponding to an increase in the age of the child was once again observed. Participant 114 produced 119 words with an inter-syllabic pause (43.27%) out of a total of 275 disyllabic words produced below the age of 2;0. Above the age of 2;0, he produced 76 (23.10%) of the 329 disyllabic words with an inter-syllabic pause. Thus, as Participant 114 got older, the proportion of the number of inter-syllabic pauses produced decreased.

The proportion of disyllabic words with an inter-syllabic pause produced in each month of the present study does not provide a clear developmental trajectory, as can be seen in Figure 2. There appears to be points throughout the study where Participant 114's proportion of disyllabic words with an inter-syllabic pause plateaus and points where instead of continuing to decrease, the proportion actually increases. That is, the proportion of disyllabic words that the child produced with a pause between the two syllables decreases from October (72.22%) through to December (28.42%). But, the proportion remains roughly the same in January (29.17%), and actually increases in February (38.81%). Then, the proportion decreases in March (21.05%). In the next month, the proportion remains about the same (April 22.45%). And, finally, the proportion decreases in the final month of the study (May 13.64%). Thus, there may have been periods of time where Participant 114 was undergoing changes in his disyllabic word production, and periods of time where he was in a state of hemostasis.

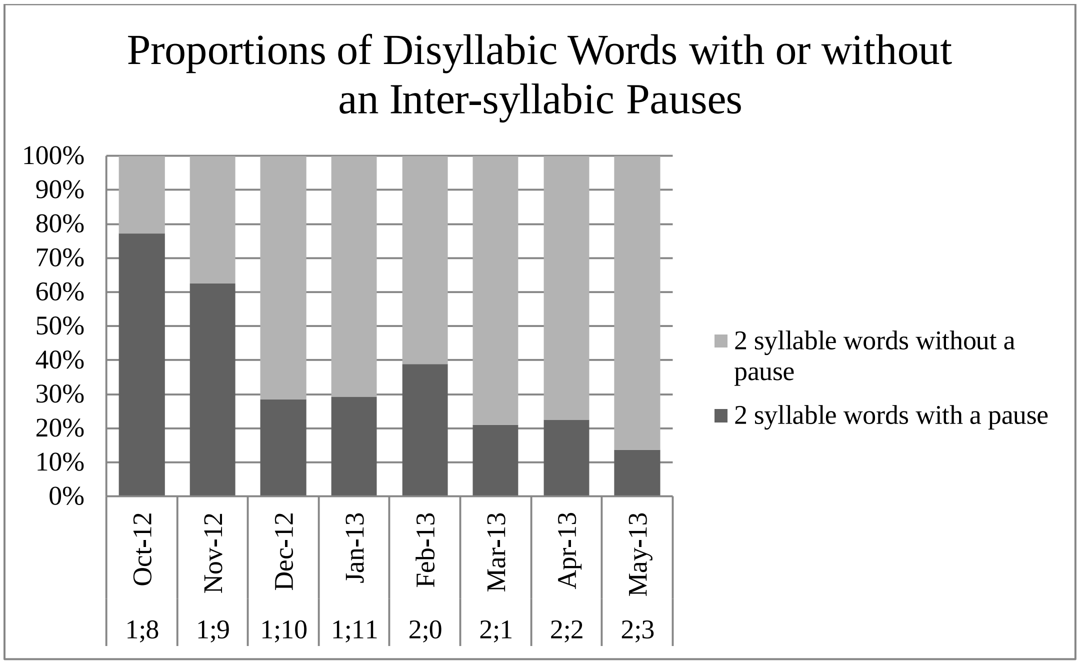


***Figure 2.*** ***Graph of the Proportions of Disyllabic Words with or without an Inter-syllabic Pause.***

Another way to examine Participant 114's production of inter-syllabic pauses in disyllabic words is to consider the disyllabic words that he produced without a pause. There were a small number of disyllabic words that Participant 114 was producing before the commencement of the study. Interestingly, in October 2012, Participant 114 was producing these words without an inter-syllabic pause. The group of words was composed of three words formed by reduplication *mama*, *baba* (his name for his dad), and *nene* ([nejnej], his word for his bottle with milk). The other word in this group was *baby* (Participant 114's name for himself). As Participant 114 was quite adept at producing these words, they were always, save for a very limited number of instances of the word *baby*, and one instance of the word *baba*, produced without an inter-syllabic pause. As such, the proportion of the disyllabic words without an inter-syllabic pause that instances of these four words accounted for in each month was examined (Figure 3). The proportion varied across the months of the study. It demonstrated a decrease from one month to another and then an increase from that month to the next, and finally ending at a proportion less than that of the beginning of the study. For example, the proportion of disyllabic words without a pause between syllables accounted for by mama, baba, nene ([nejnej]), and baby decreased from 60% to 44% between October 2012 and November 2012, and then increased from 44% to 63% between November 2012 and December 2012. With the exception of December 2012, where the proportion of disyllabic words produced without an inter-syllabic pause that was accounted for by these words actually demonstrated an increase from the proportion at the beginning of the study in October 2012 (60% to 63%), there was an overall decrease over the course of the study. That is, Participant 114, over the eight months of the study, was able to produce more and more disyllabic words without including a pause in between the syllables, and these words were not necessarily those that he had been producing without a pause since he was 20 months old. Consequently, this can be seen as phonological development.

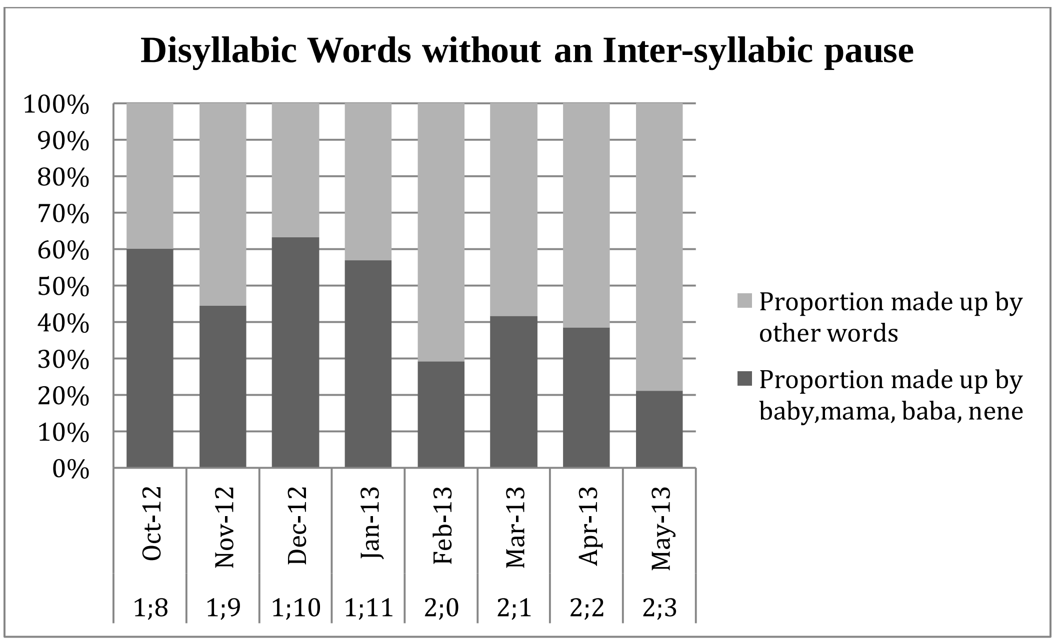


***Figure 3.*** ***Graph of the Proportion of Disyllabic Words without an Inter-syllabic Pause Accounted for by the Words 'Baby', 'Mama', 'Baba', and 'Nene' by Month and Age of the Child.***

## 4.2. Syllable structure of disyllabic words produced with and without a pause

The syllable structure of the disyllabic words produced with and without a pause between the syllables was examined in order to determine if the structure of the syllables was a factor that triggered the production of an inter-syllabic pause. It was determined that the majority of disyllabic words produced with an inter-syllabic pause contained an initial open syllable as in (68).

68. [ʃɑ[207]wi]  CV.CV  *sorry*

But, not all of the disyllabic words with an inter-syllabic pause contained an initial open syllable; some of them contained an initial closed syllable (69).

69. [nɪn[141]$t^h$ɪ]  CVC.CV  *knitted*

Additionally, the majority of two syllable words without an inter-syllabic pause were also found to have an initial open syllable (70).

70. [bi.bi]  CV.CV  *baby*

Syllable structure does not appear to be an environmental trigger to Participant 114's production of an inter-syllabic pause. The graph below (Figure 4) depicts the percentage of two syllable words produced with an inter-syllabic pause that have an initial open syllable as compared to the percentage of two syllable words without an inter-syllabic pause that have an initial open syllable. The first month where 'pause' and 'no pause' are both at 100% exemplifies the fact that at that time Participant 114 was producing mainly open syllables (in fact, he only produced one word with a closed syllable during the October 4, 2012 session). The graph demonstrates that the presence of an initial open syllable in Participant 114's production of a word does not necessarily mean that there will be a pause between the two syllables. This may be due to the fact that during the course of the study, Participant 114 continued to produce mainly open syllables, using simplifying processes like final consonant deletion to deal with a coda consonant. As Participant 114 was 1;8 at the beginning of the study and 2;3 at the end of the study, his use of final consonant deletion was age appropriate since this process typically begins to disappear from a child's speech between the ages of 2;6 and 3;0 (Bankson & Bernthal, 2004).

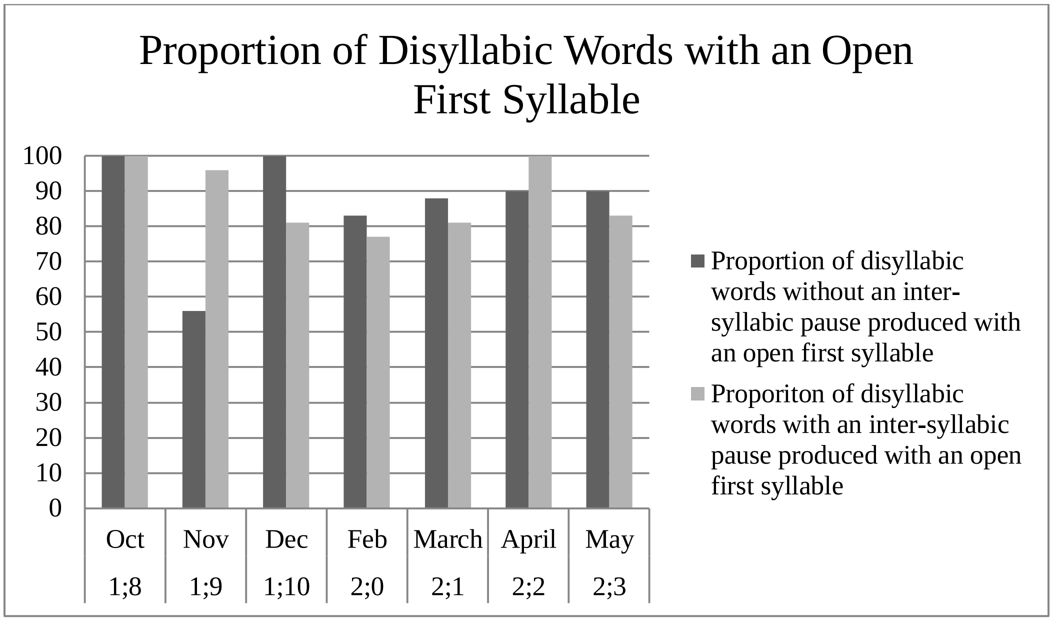


***Figure 4. Graph of the Proportion of Disyllabic Words with an Open First Syllable Produced with and without an Inter-syllabic pause by Month and Age of the Child.***

## 4.3. Words with more than two syllables

Participant 114 produced very few words with more than 2 syllables. He only produced words with one or two syllables during the first recording session on October 4, 2012. According to his mother, Participant 114 had just begun to produce two syllable words prior to that session. Therefore, it is plausible that at that time he was not yet able to produce words with more than two syllables. But, it is not possible to definitively state this, as he was not tracked prior to that date. However, during the following recording session on October 25, 2012, Participant 114 produced one word with three syllables (71) and one word with 4 syllables (72).

71. [ə.wɐ.wə] *roll*

72. [sɪ[290]bej[143]a.lej] *spinning*

Both words were produced with more syllables than their respective target words contained. It is interesting that the word *roll* produced with three syllables contained no pauses, but had the possibility of containing two pauses and that the word *spinning* produced with four syllables only contained two pauses (between syllables 1 and 2, and 2 and 3), but there was the possibility of it containing three pauses (another one between syllables 3 and 4).

The number of three syllable words produced by Participant 114 during a single recording session varied from 0 to 12. Participant 114 only produced four syllable words during 3 of the 16 recording sessions analysed in this study. Thus, it is not beneficial to attempt to track the pauses in the same way that they were tracked for two syllable words. Nevertheless, it is interesting to examine the position and length of pauses within the same three or four syllable words. Specifically, the three and four syllable words produced during the sessions were not that varied and when a couple were produced they were usually multiple instances of the same word. This made it possible to determine if the positioning of pauses, the length of pauses, and the inclusion of pauses in multisyllabic words was consistent. None of these factors were consistent in multisyllabic words. This can be demonstrated using multiple instances of the word *helicopter* produced by Participant 114 during the session that occurred on January 25, 2013. Example (73) illustrates that the position of the pause could vary, as the first instance of *helicopter* has a pause between syllables 1 and 2, and the second has a pause between syllables 2 and 3.

73. [heɪ[133]kʰɑ.tʰʌb] *helicopter*

    [hæn.kʰʌp[255]tʰə] *helicopter*

The length of the pauses was also inconsistent as can be seen in (74) where the length of the first pause is considerably shorter than the length of the second pause.

74. [hæm[146]kʰʌ[381]tʰə] *helicopter*

However, the above examples (73) and (74) could also be seen as evidence that a pause between syllables 1 and 2 is shorter than 200ms and a pause between syllables 2 and 3 is longer than 200ms. But, this is not the case. The second instance of *helicopter* in (75) demonstrates that a pause between syllables 1 and 2 can be both longer than

200ms and longer than a pause, present in the same instance of the word, between syllables 2 and 3.

75. [he.kʰɑ.tʰə]  *helicopter*

[he[266]kʰɐ[209]tʰə]  *helicopter*

A pause between syllables 2 and 3 can also be shorter than 200ms, as evidenced by the instance of *helicopter* in (76).

76. [he[142]kʰɑp[134]dɐ]  *helicopter*

Moreover, the two instances of the word *helicopter* above in (75) also demonstrate that the inclusion of pauses isn't consistent. The first instance of *helicopter* was produced without pauses and the second instance of *helicopter* was produced with a pause between syllables 1 and 2 and 2 and 3.

Therefore, based on the limited number of multisyllabic words over two syllables in length, it can be concluded that Participant 114 was able to produce some two and three syllables consecutively without any perceivable pause by January 25, 2013. Before that date, the majority of three syllable words were produced with at least one pause, suggesting that before January 25, 2013, Participant 114 had difficulties producing three syllables consecutively. It can be deduced from the limited data that the position of the pauses is not fixed. The lack of consistency in use, and position of the pauses within instances of the same words suggests that they are not lexical in nature. The variation in the length of the pauses both in multisyllabic words and disyllabic words actually mirrors the variation in the length of pauses that he produced (or the lack of pause) between words (77-80 below; {} with a number inside indicates the length of a pause between words; # indicates a word boundary that does not contain a pause of more than 100ms).

77. [ɑl#ðə#wej {260} fɪt {176} ɑn]  *all the way fit on*  (May 10, 2013)

78. [ɑl#ðə#wej#fɪtʰ#ɑn]  *all the way fit on*  (May 10, 2013)

79. [bæ[156]tʰə.wis]  *batteries*  (May 10, 2013)

80. [bæ.tʰə.ɹis]  *batteries*  (May 10, 2013)

Examples (77) and (78) demonstrate that Participant 114 can produce the same multi-word utterance with and without pauses between the words. Examples (79) and (80) show that he can produce the same three syllable word both with and without pauses between the syllables. It can be seen through examples (77) and (79) that the pauses that Participant 114 produces between words and within words are similar: the utterance in (77) contains a pause of 176ms between the words *fit* and *on*, and the three syllable word in (79) contains a pause of 156ms between syllables 1 and 2.

## 4.4. Intra-syllabic pauses before word-final consonants

Participant 114 also produced pauses within a syllable either before a word-final consonant or after a word-initial consonant. Over the course of the eight month study, the child produced pauses in the coda of words with one, two, and three word-final consonants (81).

81. [ilɑ[378]kʰ] *lock* (1 word-final consonant)

    [æn[134]tʰ] *end* (2 word-final consonants)

    [ʤejm[349]ps] *James* (3 word-final consonants)

Data regarding the intra-syllablic pauses was collected and analysed for October 2012, November 2012, December 2012, February 2013, March 2013, April 2013, and May 2013. For each month, two recording sessions were analysed. January 2013 was not included in this analysis due to time constraints.

The greatest number of coda pauses (or intra-syllabic pauses in a coda) was produced before a single coda consonant. This was most likely due to the fact that the majority of his words did not contain word-final consonant clusters, which was age appropriate as he was of an age where the process of final consonant deletion is still considered to be typical (Bankson & Bernthal, 2004), and by the age of 24 months children are typically only producing a few word-final consonant clusters (Stoel-Gammon, 1987). The graph (Figure 5) below illustrates the change in the average duration of intra-syllabic pauses before a single coda consonant over the course of the study. The month of October is not included in the graph because in the October 4, 2012 session only one word with a word-final consonant was produced, and in the October 25, 2012 session no pauses were produced prior to a word-final consonant.

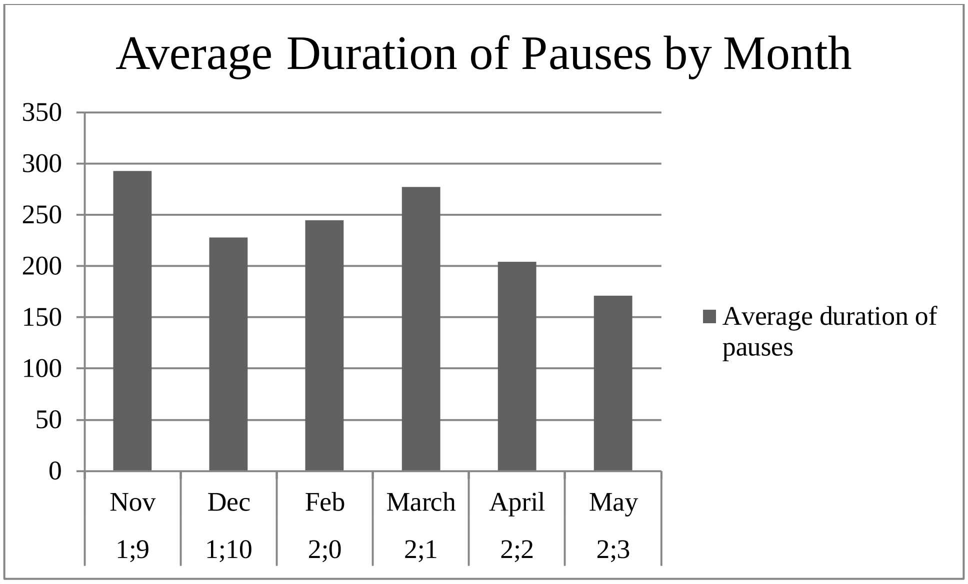


***Figure 5.*** ***Graph of Average Duration of Intra-syllabic Pauses before a Single Word-Final Consonant by Month***

As with the inter-syllabic pause durations in disyllabic words, the duration was analysed through comparisons made between the first month of examination (in this case November, as October only had one intra-syllabic pause before a single word-final consonant) and the last month analysed for the current study (May), between the pauses produced below the age of 2 years and those produced above the age of 2 years, and across all the months of the study.

In November of 2012, Participant 114 produced 17 words with an intra-syllabic pause before a single word-final consonant. The mean duration of these pauses was 292.63ms with a standard deviation of 155.57. And, in May of 2013, he produced 37 words with an intra-syllabic pause before a single word-final consonant. The mean duration of the pauses in May 2013 was 171.16ms with a standard deviation of 47.95. The difference between these two mean durations seems to be a fair size. Therefore, it may be safe to state that the mean duration of the pauses that Participant 114 produced within a syllable before a single word-final consonant decreased from the beginning of the study to the end of the study. Thus, Participant 114 demonstrated the occurrence of phonological development during the time period covered by the study.

The mean duration of the intra-syllabic pauses occurring before a single word-final consonant were examined for the sessions that took place before the child turned 2;0 and after the child turned 2;0. As there were no measurements for January, the months examined before the child turned 2;0 were October (with the one pause), November, and December. In order to balance the number of months examined both above and below the age of 2;0, February was excluded. Thus, the months examined where the child was 2;0 or older included March, April and May. Before the age of 2;0, Participant 114 produced 32 words with an intra-syllabic pause before a single word-final consonant. The mean duration of these pauses was 266.34ms with a standard deviation of 124.80. And, after the age of 2;0, he produced 350 words with an intra-syllabic pause before a single word-final consonant. The mean duration for the pauses produced after the child turned 2;0 was 220.19ms with a standard deviation of 97.02. Therefore, there was a decrease in the mean duration of the pauses after the age of 2;0; however, the decrease was very small.

However, a clear developmental picture does not emerge when the intra-syllabic pauses produced before a single word-final consonant are compared month by month. As demonstrated in the graph (Figure 5), the average length of a pause before a word-final consonant did not gradually decrease over the course of the study. The mean duration of the intra-syllabic pauses produced before a single word-final consonant increased from February 2013 to March 2013, and then decreased in April 2013. The mean pause duration in March 2013 was also larger than it was in December 2012. The rest of the mean durations seem to follow a descending progression over the course of the months of the study. Thus, Participant 114's intra-syllabic pause productions before a single word-final consonant do undergo a progression towards shorter pause durations over the course of the eight months of the present study. This may or may not be due to his increase in age.

As with inter-syllabic pauses, the child did not produce a pause preceding a word-final consonant in all instances where he produced a word-final consonant. Figure 6, below, demonstrates the proportion of pauses produced before a word-final consonant in codas composed of one consonant as compared to the proportion of instances where one word-final consonant was produced without a pause over the course of the study. The trajectories of both the number of words produced with a coda pause and those produced without a coda pause did not gradually change. What's more, the proportion of words with a single word-final consonant produced with a pause before said word-final consonant does not decrease as would be predicted. That is, it would be expected that as Participant 114 got older, and developed his phonological abilities, he would have a better grasp of the structure of a syllable and be able to produce more syllables in their entirety without need of recourse to the production of a pause. However, at first, as the number of words with a single word-final consonant increases, so does the proportion of words produced with a pause before a single word-final consonant. That is, the proportion of words with a single word-final consonant produced with a coda pause increased from 9% in October of 2012 to 27% in November of 2012. Then, the proportion decreased in December of 2012 to 23%, and once again increased in February of 2013 to 24%. It increased greatly in March of 2013; the proportion rose to 42% of the words with a single word-final consonant. And, finally the proportion of words with a single word-final consonant that Participant 114 produced with a coda pause decreased in the month of April to 25% and once again in the month of May to 20%. Interestingly, the proportion of words with a single word-final consonant produced with a coda pause in the final month of the study, despite decreasing over the final two months of the study, was higher than the proportion at the beginning of the study (20% compared to 9%). It bears noting that this may be a case of 'U'-shaped development, where, as more words are produced with a final consonant, Participant 114 may have needed to use the strategy of putting a pause before the word final consonant. Then, as he got more practice producing words with a word final consonant, he may not have needed to use the strategy as much.

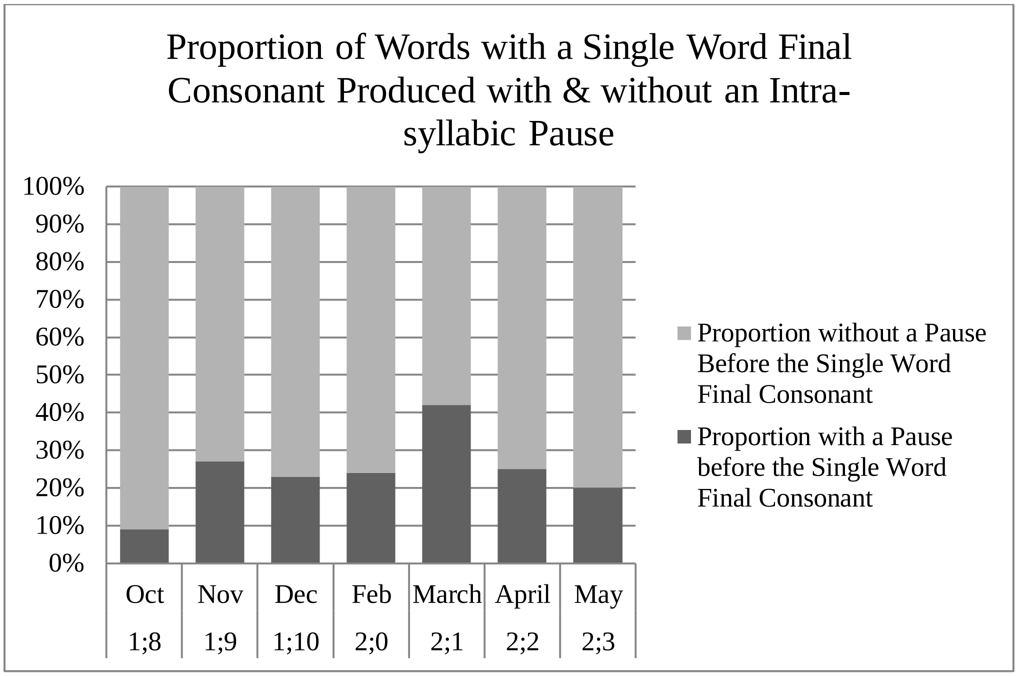


***Figure 6. Graph of Proportion of Words with a Single Word-Final Consonant Produced with or without an Intra-syllabic Pause***

As with the inter-syllabic pauses, the frequencies of words with a single word-final consonant that the child produced with a coda pause were examined for those produced before the age of 2;0 and those produced after the age of 2;0. As there was no data pertaining to pause length before a single word-final consonant in January and there was only one instance of a word produced with a pause intra-syllabically before a word-final consonant in October, only November and December were examined for the pauses produced prior to the age of 2;0. And, in order to keep the number of months examined balanced, only April and May were analysed for the pauses produced above the age of 2;0. The percentage of intra-syllabic pauses produced before a single word-final consonant before the age of 2;0 was 24.80 (31 of 125). And, the percentage of those produced after the age of 2;0 was 22.79 (80 of 351). The two percentages appear to be almost the same. There isn't much difference between the two. This may imply that no great change in frequency occurred around 2;0.

Consequently, it appears that Participant 114's production of coda pauses does not follow a developmental trajectory. However, his use of coda pauses may have been in the process of decreasing. The proportion may have continued to decrease over the next few months. At the age of 2 years and 3 months, his acquisition of the phonology and the phonological structure of English was hardly finished.

The previous graph (Figure 6) was an examination of the presence or absence of coda pauses in all words produced with a single word-final consonant. However, upon further examination, it is apparent that the presence of just any coda consonant was not always a sufficient environment to induce Participant 114 to produce a pause. That is, he was found to only produce a pause prior to obstruent coda consonants. But, they did not occur preceding all obstruent consonants. In fact, the consonants before which the pauses were produced do not form a natural class (82).

82. /p b t d k s tʃ/

Examination of the natural class of obstruent phonemes does not provide a succinct analysis. This is demonstrated in Table 14 (below). The horizontal lines in the table divide the phonemes into natural classes by manner of articulation. And, the vertical lines in the table divide the phonemes into natural classes by place of articulation. The phonemes in bold, in italics, and underlined are those that were produced following a coda pause by Participant 114.

***Table 14. Word-Final Obstruent Consonants Following a Coda Pause by Natural Class***

| | Place of Articulation | | | |
|---|---|---|---|---|
| | Labial | Coronal | Velar | Laryngeal |
| Obstruents | ***<u>pb</u>*** | ***<u>td</u>*** | ***<u>k</u>***g | |
| | fv | θð ***<u>s</u>***z ʃʒ | | h |
| | | ***<u>tʃ</u>*** dʒ | | |

The pauses were produced before a subset of the English stops: the voiced and voiceless bilabial stops /b/ and /p/, the voiced and voiceless alveolar stops /d/ and /t/, and the voiceless velar stop /k/. They were also produced before one fricative: the voiceless alveolar fricative /s/. However, there were only four instances of a pause being produced before a word-final /s/ out of a total of 61 instances of word-final /s/ in single consonant codas. Moreover, it is interesting to note that two of the four instances were actually cases where the word-final /s/ was serving as the plural marking morpheme /–s/ (83).

83. [wiu[173]s] *wheels* March 22, 2013

[how[224]s] *holes* May 24, 2013

But, not all instances of a word-final /s/ in a single consonant coda where /s/ is serving as the plural marking morpheme are preceded by a pause. The voiceless affricate /tʃ/ is also found following a pause, but not the voiced affricate /dʒ/. Despite these facts, the pauses cannot be said to be induced only by the presence of a voiceless obstruent as they are produced before both voiced and voiceless stops in all places of articulation with the exception of the voiced velar stop /g/. Furthermore, not all voiceless fricatives were found after a pause within the syllable. In terms of place of articulation, if the consonants found after a pause were analysed based on distinctive features, the pauses cannot be explained as resulting from a certain place of articulation or set of distinctive features because multiple places of articulation induce the production of pauses and diverse and multiple places of articulation do not induce the production of the pauses.

It is possible that the absence of certain consonants from the list of those that may trigger the production of a pause could be due to the fact that they were not yet being produced as coda consonants by Participant 114. Therefore, an analysis of the coda consonants produced during each recording session was undertaken. Table 16 lists all the coda consonants produced by Participant 114 and those produced following a pause on a given date. A phoneme in bold face indicates that it was only produced once. A phoneme remains in bold face until it is produced more than once in one session.

***Table 15.*** ***Coda Consonants the Child was Able to Produce and Those Produced as a Single Coda Consonant Following a Pause by the Date of Session and the Age of the Child.***

| Date (Age) | Coda Consonants Produced | Coda Consonants Following a Pause |
|---|---|---|
| Oct 4, 2012 (1;8) | /**p**/ | /**p**/ |
| Oct 25, 2012 (1;8) | /n f/ | N/A |
| Nov 16, 2012 (1;9) | /n f p t k **l**/ | /p t k/ |
| Nov 22, 2012 (1;9) | /n f p t k l **tʃ ʃ ɹ ŋ**/ | /p t k **tʃ**/ |
| Dec 7, 2012 (1;10) | /n f p t k **tʃ** ʃ **ŋ d s z**/ | /p t k **tʃ s**/ |
| Dec 21, 2012 (1;10) | /n f p t s **m** h/ | /p t s/ |
| Feb 1, 2013 (2;0) | /f t k tʃ ɹ m **b v**/ | /k tʃ/ |
| Feb 15, 2013 (2;0) | /n f p t k l tʃ **ʃ ɹ ŋ d** b/ | /p t k **d**/ |
| March 8, 2013 (2;1) | /n f p t k **ʃ d** s **z** m/ | /p t k **d**/ |
| March 22, 2013 (2;1) | /n p t k l ʃ ɹ **ŋ** d s m h b **g**/ | /p t k s d/ |
| April 5, 2013 (2;2) | /n f p t k l tʃ ʃ ɹ **ŋ** d s **z** m **v**/ | /p t k tʃ d/ |
| April 19, 2013 (2;2) | /n f t k **l** tʃ ʃ ɹ ŋ d s z m h b/ | /t k tʃ s d b/ |
| May 10, 2013 (2;3) | /n f p t k l ʃ ɹ ŋ d s z m h v **g θ**/ | /p t k/ |
| May 24, 2013 (2;3) | /n f p t k l tʃ ɹ ŋ d s z m h v **g θ**/ | /p t k tʃ s/ |

It is apparent that the absence of certain obstruents from the set of coda consonants that trigger the production of a pause within a syllable cannot be attributed to Participant 114 not yet producing them in the coda position. That is, the bilabial voiceless fricative /f/ was being produced in the coda position since the second session in October of 2012, but it was not produced after a coda pause during the course of the study. By the session on May 24, 2012, Participant 114 had produced almost all obstruent consonants in a coda more than once during at least one session, with the exception of /g/ and /θ/ which had been produced during multiple different sessions, but only one time each, and /ð/, /ʒ/, and /dʒ/ which he had not produced a single time in the coda position. Thus, the absence of certain obstruent consonants from the set of consonants that trigger the production of a syllable internal pause does not seem to be due to the order of acquisition of coda consonants.

However, the intra-syllabic pauses before a word final consonant could be seen as being triggered by stop consonants. That is, the pauses occur before all the voiced and voiceless stop consonants except for the voiced velar stop /g/. But, this could be the case of an accidental gap. It could be that the fact that Participant 114 didn't produce a pause prior to a single word final /g/ was a phonological accident and not systematic. It is worth noting that he hadn't produced /g/ word-finally more than once in any given session by the end of the study. Additionally, there were very few cases of pauses before a word-final /s/ or /tʃ/. So, it may be possible to state that word-final stops have the possibility of triggering an intra-syllabic coda pause[3].

The coda consonants that did trigger a syllable internal pause did not do so all the time. For example (84), the coda consonant /t/, in two words with a syllable structure of CVC (consonant-vowel-consonant) from the same recording session, followed a pause in one word (*light*) and did not follow a pause in the other one (*fit*).

84. [lej[112]tʰ] *light*

[fɪtʰ] *fit*

## 4.5. Intra-syllabic pauses in words with two and three word-final coda consonants

Participant 114 did not produce many pauses in words with two word-final coda consonants. This may be due to the fact that he did not produce many words with two word-final coda consonants. The number of words produced with two word-final consonants in one session ranged anywhere between 0 and 13. Pauses occurred before the first consonant (85), before the second consonant (86), and before both the first and second consonants (87). However, there was a very limited number of words produced with an intra-syllabic pause before the first word-final consonant and of words produced with an intra-syllabic pause before both the first and second word-final coda consonants.

[3] The word possibility is used here because pauses were not always produced before word-final stops.

85. [$t^h$aw[176]ks] *taxi*

86. [en[142]$t^h$ ] *and*

87. [fɪ[157]s[696]$t^h$] *fixed*

In all five of the words that included an intra-syllabic pause before the first coda consonant, the coda was composed of a stop, either /t/ or /k/, followed by the fricative /s/ or the stop /k/. There is actually only one instance (88) where the second coda consonant is /k/ when a pause is produced before the first coda consonant, and that interestingly occurs when the first coda consonant is also /k/. It is possible that it was a geminate.

88. [kɫɑ[222]kk] *clock*

Similarly, only three words were produced with two intra-syllabic pauses in coda position. All three of the words contained the voiceless alveolar stop /t/ in the second coda position. The first coda consonant was either the voiceless alveo-palatal affricate /tʃ/ (89) or the voiceless alveolar fricative /s/ (90).

89. [gi.æ[177]tʃ[243]$t^h$] *scratched*

90. [fɪ[157]s[696]$t^h$] *fixed*

However, both of the above examples (89 and 90) are instances of the past tense. As such, they are morphologically complex, and it may be the case that the second pause, the one before the phoneme serving as the morphological marker marking the past tense (in both cases the voiceless alveolar stop /t/), may be a different type of pause. That is, it may not be a coda pause; it may actually be a pause occurring across a morphological boundary. When past tense or past participle marking is examined in words in which Participant 114 produced 2 word-final coda consonants, there seems to be a progression from the use of at least one intra-syllabic pause before the second consonant to no intra-syllabic pauses. That is, in March 2013, he produced seven instances of words marked in the past participle with two word-final coda consonants. Each of these seven instances contained a pause before the second consonant which was used to mark the past participle (91).

91. [dʌm[477]$t^h$] *dumped*

In the above example (91), the phoneme /t/ is being employed as the past tense or past participle marker (in the case of this verb and the other one produced in the given month, the past tense and the past participle are produced in phonetically and phonologically the same way). Six of the seven instances in March 2013 were instances of the word *dumped*, which Participant 114 was using as an adjective. The other instance was an instance of the word *knitted*. In April 2013, he produced three instances of words in the past tense with two word-final consonants. All three of these instances contained a pause before the second word-final coda consonant, and the second coda consonant was once again serving as a morphological marker of the past tense. And, finally in May 2013, he produced one word in the past tense with two word-final coda consonants where the second coda consonant was marking the past tense. The word didn't contain a pause before the second consonant. However, a different pattern emerges if past tense marking is examined overall and not by the number of consonants at the end of the word. That is, in November of 2012, Participant 114 produced two instances of the word *knitted* that were marked for the past participle by a word-final consonant that was the only word-final consonant (92). And, neither instance of the word had an intra-syllabic pause preceding the final consonant.

92. [nɪn[121]dɛn] *knitted*

[mɪ[142]dɪn] *knitted*

And, in May of 2013, he produced a word marked with the past tense, containing one word-final coda consonant, and an intra-syllabic pause before the word-final coda consonant (93).

93. [bi.ej[209]$t^h$] *braked (broke)* an irregular past tense treated as regular

Thus, the marking of past tense doesn't appear to be the cause of the use of a pause before a word-final coda consonant.

Over the course of the study, Participant 114 only produced 60 instances of words with 2 coda consonants. And, of those 60 instances, 22 were instances of words that he produced with a pause before the second word-final coda consonant. In these words, the second coda consonant was one of the following consonants: the voiceless alveolar stop /t/ (94), the voiced alveolar stop /d/ (95), the voiceless velar stop /k/ (96), or the voiceless alveolar fricative /s/ (97).

94. [wan[152]tʰ] *want*

95. [howl[196]d] *hold*

96. [pɑɹ[336]kʰ] *park*

97. [wiəl[124]s] *wheels*

It should be noted that all three cases where a pause was produced before a second coda consonant and where the coda consonant was the voiceless alveolar fricative /s/ were instances of the word *wheels*. And, the /s/ was a morpheme marking the plural. All three of those instances of *wheels* were produced during the same session in March 2013. As with the past tense, these are cases of morphologically complex words, and the pause before the /s/ may be different from others that occur in the same position. However, Participant 114 produced two instances of the word *wheels* with two word-final coda consonants without a pause between them, where the second coda consonant was the voiceless alveolar fricative /s/ in April 2013, and another two instances without a pause in May 2013. Additionally, in March 2013 and May 2013, he produced four more plural words, like *blocks* (98), containing two word-final consonants without a pause between them. And, the second coda consonant was the voiceless alveolar fricative /s/.

98. [blɑ[303]ks] *blocks*

As the plural can be marked by /s/ with and without a pause between the first coda consonant and the /s/ in a word produced with two coda consonants by Participant 114, the morphological complexity resulting from the plural marking on the word *wheels* is most likely not the trigger for the presence of a pause. Moreover, the plural was also marked by Participant 114 with the phone [z] (99)

99. [ʌmz] *arms*

The word in which Participant 114 marked the plural with the phone [z] did not have a pause between the first and second word-final coda consonants. Furthermore, over the course of the study, the child only produced 10 instances of words where the second of two word-final consonants was /s/ and the /s/ marked the plural. And, of those 10 tokens, only 3 (30%) contained a pause between the first and second word-final consonants.

There does not seem to be a succinct analysis of the environments in which the pauses are present when there are two coda consonants. Additionally, the environments that can yield a within syllable pause with two coda consonants do not always do so.

Only two words were produced with three word-final coda consonants and an intra-syllabic pause in the coda over the eight month study. This number is quite small, but Participant 114 only produced a total of four words with three word-final coda consonants during the study. And, two were instances of the same word during the same session. As such, not much can be stated about intra-syllabic pauses with three coda consonants. No pattern can be seen with the limited amount of data. It is possible that the two words (100) produced with pauses could be the only instances that ever occur of intra-syllabic pauses with three coda consonants in Participant 114's phonological acquisition.

100. [ʤejm[349]ps] *James* (March 8, 2012)

[tʰɛɹn[331]ʃ] *turns* (May 24, 2012)

And, the word *turns* is morphologically complex, as it is the third person singular present tense of the verb *to turn*. Thus, the third coda consonant /s/ may be seen as the phoneme serving as the morphological marker that is denoting the person and tense of the verb. Consequently, this may not truly be a simple case of a pause before the third coda consonant, but a case of a pause marking a morphological boundary, or occurring before another morpheme.

## 4.6. Intra-syllabic pauses after a word-initial consonant

Participant 114 also produced pauses within a syllable after a consonant at the beginning of a word. He had been producing word-initial consonants since the beginning of the study, including word-initial consonant clusters containing two consonants (e.g. October 4, 2012, he produced four words with word-initial consonant clusters containing two consonants). However, he did not start producing intra-syllabic pauses after word-initial consonants until the February 1, 2012 session (101). The pauses only ever occurred intra-syllabically when the word began with a consonant cluster. In other words, he did not produce a pause after a single word-initial onset consonant. Thus, the word-initial or onset intra-syllabic pauses do not mirror the word-final or coda intra-syllabic pauses.

101. [s[179]b[189]kʰə] *speaker* (February 1, 2012)

Pauses within syllables with a two-consonant word-initial consonant cluster demonstrated consistency in terms of the placement of the pauses. The pause was always placed after the first word-initial consonant (102).

102. [kʰ[221]kʰə[538]kʰ] *coconut*

Moreover, in almost all of those words with a word-initial intra-syllabic pause, the first consonant was the voiceless alveolar fricative /s/ and the second consonant was a stop consonant (103). This was the case for 20 of the 25 words produced with a word-initial intra-syllabic pause after the first onset consonant in a two-consonant consonant cluster.

103. [s[152]diw] *still*

There were three types of exceptions to this. The first was the production of a pause after the voiceless postalveolar fricative [ʃ] followed by a stop consonant in a word-initial two-consonant consonant cluster (104).

104. [ʃ[699]dɐ[356]k] *stack*

As both /s/ and /ʃ/ are voiceless alveolar fricatives and sibilants, and both the cases of [ʃ] before an intra-syllabic pause were in words whose target contained the phoneme /s/, the cases of [ʃ] could be classified as incorrect productions of /s/, and the pauses as resulting from the fact that the targets begin with /s/.

The other two exceptions could not be subsumed under *the /s/+stop consonant induces the production of a pause* “pattern”. One was the first word with an intra-syllabic pause after a word-initial consonant, where both the initial consonants were the voiceless velar stop /k/ (shown above in 102). And, the second was a word where the first consonant was the voiceless bilabial stop /p/ and the second consonant was the voiceless alveolar stop /t/ (105).

105. [$p^h$[230]$t^h$ɛn[564]$t^h$] *pretend*

Figure 7, below, illustrates the average duration of intra-syllabic pauses between the first and second consonants in onsets with two consonants. There are no average durations for October, November, and December, as Participant 114 only began producing an intra-syllabic pause in onsets in February of 2013. And, there is no average duration for the month of February because only one instance of a word contained a pause between the first and the second consonants in a two consonant onset. That pause was 221ms long in the word *coconut* (106).

106. [$k^h$[221]$k^h$ə[538]k] *coconut*

The average duration of the pauses decreases over the course of the last three months of the study. It decreases from 324.75ms in March to 188.23ms in April, and finally to 155.33ms in May. In the last three months of the study, the duration of the intra-syllabic pauses between consonant 1 and consonant 2 in onsets containing two consonants appears to follow a developmental trajectory; the duration of the pauses decreased as Participant 114 got older. However, the fact that he did not begin producing them until February of 2013, and was able to produce onsets with two consonants without a pause, like in the target structures, appears to be contradictory to the concept of a developmental trajectory. In so many words, he was able to produce two-consonant consonant cluster onsets in a target way (without a pause), and then, he began producing a pause between the two consonants.

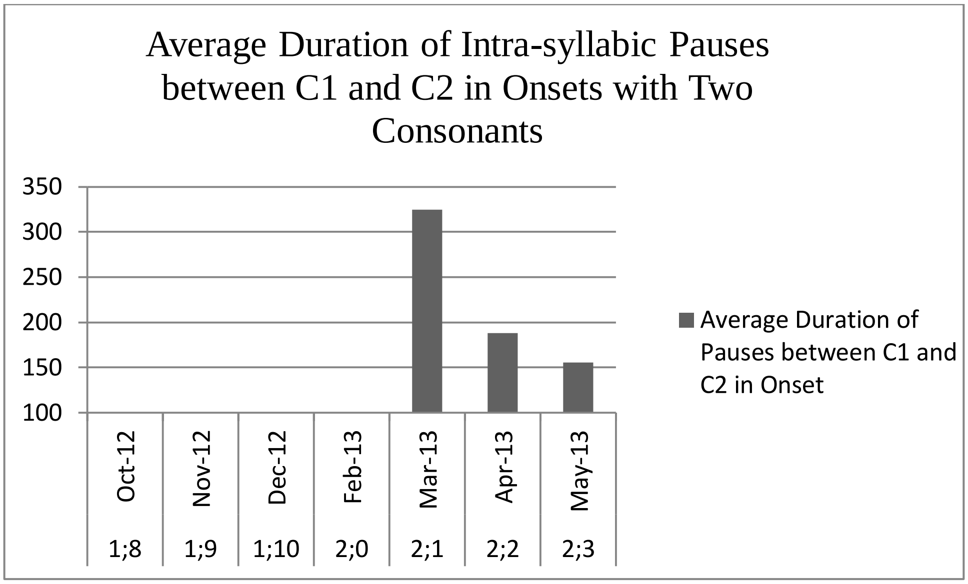


***Figure 7.*** ***Graph of Average Duration of Intra-syllabic Pauses between Consonant 1 (C1) and Consonant 2 (C2) in Onsets with Two Consonants by Month.***

As with the inter-syllabic pauses, Participant 114 did not produce intra-syllabic pauses in all words where the first consonant was the voiceless alveolar fricative /s/ and the second consonant was a stop consonant (107).

107. [sbejs] *space*

[stʌs] *stuff*

However, he did produce a pause after the first consonant in a word with two consonants word-initially in 68% (21 pauses out of 31) of all the instances where the two consonants were /s/ followed by a stop in seven of the eight of the months of the study (January 2013 was excluded). Furthermore, of the total number of instances where he produced an intra-syllabic pause after the first consonant in a two-consonant word-initial consonant cluster, 84% of them were words that began with /s/+ stop consonant. Moreover, the word-initial consonant cluster /ʃ/ followed by a stop was only produced four times over various sessions, and of those four times, Participant 114 produced a pause after the /ʃ/ in two of the words. And, if those two instances of an intra-syllabic pause after [ʃ] in a [ʃ]+stop word-initial consonant cluster are included in the instances of an intra-syllabic pause after /s/ in a /s/+stop word-initial consonant cluster, then /s/+stop would account for 92% of the intra-syllabic word-initial pauses produced by Participant

114. Thus, in the majority of instances where he produced a word-initial consonant cluster with a voiceless alveolar (including postalveolar) fricative followed by a stop, he produced a pause following the voiceless alveolar fricative.

Notably, there was one instance over the eight month period of a pause produced intra-syllabically after a single word-initial consonant. The pause followed a voiceless alveo-palatal affricate (108).

108. [tʃ[342]æ[121]p$^h$] *track*

Only three words were produced with three word-initial consonants, and the placement of the pause was not consistent in the two of those three words that contained an intra-syllabic pause. One word was produced with a pause after the first and the second word-initial consonants (109), and the other was produced with a pause after the second word-initial consonant (110).

109. [s[179]b[189]k$^h$ə] *speaker*

110. [ks[358]dim] *steam*

Thus, the consistency demonstrated in the words with two consonants word-initially did not extend to those words containing three word-initial consonants.

## 4.7. Summary

Attempting to view the pauses as one developmental process regardless of the position of the pause in the word does not yield a cohesive picture. When the two measures of pause usage are examined for disyllabic words with an inter-syllabic pause, both duration and frequency showed an overall decrease from the beginning of the study to the end of the study. What's more, both the duration and the frequency exhibited a decrease when the pauses produced above the age of two years were compared to those produced before the age of two years. But, the same is not true of intra-syllabic pauses before a word-final consonant. The duration of those pauses does differ between the beginning of the study and the end of the study, and before the age of 2;0 and after the age of 2;0. However, the frequency of production of these pauses does not follow the same pattern. There seems to be a U-shaped pattern. And, the frequency of intra-syllabic pauses before a single word-final consonant is actually higher at the end of the study than at the beginning of the study.

Therefore, the durations of the pauses regardless of position in the word (not including words with an intra-syllabic pause and two or three word-final consonants nor words with an intra-syllabic pause after a word-initial consonant) decreased over the course of the study. This decrease coincided with the aging and development of Participant 114. Thus, there is a possibility that the decrease in duration of the pauses reflects development towards a non-inclusion of pauses or typical timing. The decrease in frequency of production of inter-syllabic pauses over the course of the study may also indicate development towards a non-inclusion of pauses or typical production of words in terms of timing.

Despite being a quite interesting case study, the results presented here cannot be generalised to all children with ASD. This can only be said to be true of Participant 114. And, it is only a short snap shot of his development. The end of the study doesn't reflect the end to Participant 114's phonological development.

# 5. Discussion

Participant 114 was too young to determine whether most of the phonological patterns that he produced in his speech were delayed. However, as most of the other children with ASD did demonstrate some phonologically delayed patterns, this could be viewed as evidence in favour of the Fractionability of the Autism Triad. The phonologically delayed patterns could be considered to be one of the independent impairments that make up autism. Participant 114 did demonstrate an abnormal pattern of phonological development in terms of his unusual pauses. Unfortunately, these pauses are not specific to autism since they can also be found in the speech of children with Childhood Apraxia of Speech (CAS) (Shriberg et al., 2003; The American Speech-Language-Hearing Association 2007). Therefore, the pauses could also be regarded as an independent impairment, and thus, as evidence for the Fractionability of the Autism Triad. But, it should be noted that the existence of these pauses in conjunction with delayed phonological acquisition, and any other impairments associated with ASD could be considered a unique pattern of impairments. Nevertheless, none of these results can truly be generalised to all children with ASD due to the small sample size used in this study, and the fact that children with ASD are a heterogeneous group.

As previously mentioned, Participant 114's unusual prosody is not an abnormal speech characteristic that is unique just to him. Children with CAS are often characterised as demonstrating abnormal prosodic features such as longer than normal pauses between segments, syllables or words (also known as syllable segregation) (Shriberg et al., 2003; The American Speech-Language-Hearing Association 2007). CAS is a neurological childhood speech disorder where in the absence of neuromuscular deficiencies, the child's speech is characterised by a lack of precision and consistency of movements (Flipsen et al., 2009; Marquardt, Sussman, Snow, & Jacks, 2002; The American Speech-Language-Hearing Association 2007).

Some of the research into CAS has focused on the syllable and speech timing. Children with CAS have been found to have difficulties with the phonological structure of the syllable. They demonstrate sequencing problems which may be phoneme-to-phoneme or syllable-to-syllable (Marquardt et al., 2002). Additionally, they exhibit deficits in syllable structure control, specifically, the use of the processes of final consonant deletion, consonant cluster resolution, syllable repetition (Marquardt et al., 2002). Moreover, children with CAS do not seem to be aware of the syllable (Marquardt et al., 2002). They have displayed problems segmenting syllables, judging the position of intra-syllabic sounds, and parsing out consonants in consonant clusters within a syllable (Marquardt et al., 2002). Speech timing has been found to be impaired in children with CAS. Some children with CAS have deficits in the perception and production of rhythm (Shriberg et al., 2003).

Despite Participant 114 not having a diagnosis of CAS, his phonological deficits appear to be similar to those of children with CAS. Therefore, it seems prudent to examine the theories used to explain these characteristics in children with CAS in order to attempt to understand why he produces them too. Many of these theories revolve around the adult diagnosis of Apraxia of Speech (AOS), which instead of being developmental is acquired through brain damage.

The majority of speech-production models consider the system that produces speech to be comprised of distinct levels each with its own representation and specific processes (McNeil, Pratt, & Fossett, 2004).

It has been theorised that the deficits in AOS are due to impairments in the phonetic encoding level of the WEAVER model of language production (Levelt, Roelofs, & Meyer, 1999). The phonetic encoding level is where the abstract phonological representations are said to be transformed into motor plans or primatives (Ziegler, Staiger, & Aichert, 2010). Levelt (2001, as cited in Ziegler et al., 2010) proposed that over-learnt motor plans are stored in the premotor cortex. These motor plans are said to be those of frequent syllables (Crompton, 1982; Levelt, 1992). Ziegler et al. (2010) note that the reason that syllables may be considered to be the unit that is represented by articulatory plans is that only several hundred syllables are necessary to construct over 80% of the words that an individual produces each day. These frequent syllable motor plans are stored in a syllabary (Crompton, 1982; Levelt, 1992). The syllabary is formed during speech acquisition as motor plans for frequent syllables are acquired and stored (Levelt et al., 1999). During phonetic encoding, the syllabary may be accessed (Crompton, 1982; Levelt, 1992). Then, all the motor system has to do to produce a given syllable is take out the individual gestures that form the plan, and reveal the speech movements that are indicated by the individual gestures (Levelt et al., 1999). As the syllabary is said to be located in the premotor cortex (Levelt, 2001 as cited in Ziegler et al., 2010), and the lesion sites that are assumed to be associated with AOS have been found near the left inferior premotor cortex (Ziegler et al., 2010), it is predicted that speakers with AOS no longer have access to the syllabary and the motor plans for the frequent syllables (Varley & Whiteside, 2001). As such, it has been hypothesised that speakers with AOS are driven to construct syllables using the sub-syllabic encoding route of phonetic encoding (Varley & Whiteside, 2001), through the use of the motor plans for smaller units (Ziegler et al., 2010) that correspond to individual segments, the same mechanism used by typical speakers to produce low frequency syllables (Crompton, 1982; Levelt, 1992). For example, in order to produce the word *meat*, a person with AOS or a child with CAS, would have to access the motor plan for each of the segments of the syllable [mit] separately and in order. So the adult or the child would access the motor plan for [m], then the motor plan for [i], and the finally the motor plan for [t]. The necessity of accessing the motor plan of each segment of an utterance individually renders the process of encoding the utterance inefficient as it would require more on-line computation, and this would in turn cause the segments to have a longer duration and less articulation between the segments (Varley & Whiteside, 2001). The use of the sub-syllabic route in the production of all words all the time would result in an impairment in the timing of articulatory gestures and an impairment in the ability to meet the spatial targets of those gestures, which would in turn result in errors in speech production (Varley & Whiteside, 2001). This may also result in a greater degree of inconsistency in speech as the plans for the segments are not being retrieved as gestalt like plans; therefore, the necessary articulatory gestures cannot effectively be implemented in the same way every time (Varley & Whiteside, 2001). There will be some variation in production.

This theory may be able to explain the impairments yielding the symptoms of AOS, and possibly CAS as well; however, it is not truly able to explain the characteristics of Participant 114's speech. This theory does not seem to account for Participant 114's production of inter-syllabic pauses. Use of only the sub-syllabic route of encoding segments would cause his production of segments to have a longer duration. But, the separate encoding of segments in a syllable does not seem to lead to a pause between syllables, as it appears that each segment is being treated independently of the syllable. The retrieval of gestalt-like motor plans for a syllable seems just as likely to produce a pause between the syllables being produced as the independent encoding of each segment in a syllable. It could be argued that this theory is able to account for Participant 114's production of intra-syllabic pauses. That is, it is possible that the pauses within a syllable are due to the fact that each segment of a given syllable is being encoded separately, instead of the whole syllable being encoded as one set of motor plans, and thus, it takes more time to retrieve and encode the motor plans for each segment. This could lead to the production of pauses between segments within a syllable. Nonetheless, this would not predict where a pause would occur. That is, this theory would not account for the fact that the majority of intra-syllabic onset pauses with two word-initial consonants were produced after the first consonant, and the first consonant was either the voiceless alveolar fricative /s/ or the voiceless postalveolar fricative /ʃ/, and the second consonant was a stop consonant. Moreover, low frequency syllables are built through the sub-syllabic route by neuro-typical speakers and speakers with AOS. Despite findings that the duration of high-frequency syllables is shorter than equivalent low-frequency syllables (Levelt & Wheeldon, 1994), the use of low-frequency syllables in speech by speakers deemed neuro-typical does not result in a perceptible slowing of their production. But, the slowing of speech production is perceptible in speakers with AOS (McNeil et al., 2004). Thus, the slowing down of speech production must not be simply due to the necessity to build the syllables through the sub-syllabic route. It may be that the need to produce all utterances entirely through the sub-syllabic route results in a cognitive load that slows down the speech of individuals with AOS. If this is indeed the case, the use of the sub-syllabic route to encode all segments is still unable to account for Participant 114's unusual addition of inter-syllabic pauses and intra-syllabic pauses. Participant 114's pauses are quite perceptible. They occur both in single word and multi-word utterances. Single word utterances should not create a great cognitive load, and thus should not contain pauses, but they do.

Another theory that attempts to explain the symptoms of AOS, and by extension CAS, is that there exists a pre-motor planning processing buffer, and that its spatial capacity is decreased or impaired in individuals with AOS (Rogers & Storkel, 1999). A processing buffer is defined as a temporary storage space where the order of phonemes in speech can be specified (Rogers & Storkel, 1999). They have been proposed to exist at the phonological encoding level of speech production (Sevald & Dell, 1994). Rogers and Storkel (1999) suggest that there are most likely buffers at the speech motor programming level where the sequence of the motor commands is organised, and these motor commands would be responsible for the management of the force with which the articulators move, the timing of and direction of the movement of said articulators. Importantly, processing buffers have both temporal and spatial constraints (Rogers & Storkel, 1999). That is, there is a limit on the amount of information that can be stored in a given buffer, and there is a limit on the duration of time for which that information can be retained in said buffer. Due to the temporal segregation between syllables produced by speakers with AOS, it has been suggested that each syllable is produced separately (Kent & Rosenbeck, 1983; Kent & Rosenbeck, 1983 as cited in Rogers & Storkel, 1999). Rogers and Storkel (1999) hypothesise that this separate syllable production is the result of a reduced capacity in the processing buffer, namely to the spatial needs of only one syllable. Thus, individuals with AOS are forced to plan and programme speech one syllable at a time (Ziegler & Maassen, 2004).

As well as this theory may explain the characteristics of the speech of individuals with AOS, and even CAS, it does not adequately explain Participant 114's syllable segregation. Participant 114 does not always demonstrate syllable segregation in disyllabic words, and he does not always demonstrate two pauses in tri-syllabic words. That is, he is sometimes able to produce two or three syllables consecutively within the same word without a pause. This would suggest that at times he is able to encode more than one syllable in the processing buffer at a time. Moreover, over the course of the study, the number of instances of disyllabic words produced with an inter-syllabic pause decreased. This would mean that Participant 114's processing buffer would have had to gain spatial capacity over the course of the study. But, at the same time he did continue to sometimes produce inter-syllabic pauses in disyllabic words. Thus, Participant 114's syllable segregation may not be best explained by a reduced spatial capacity in the processing buffer. Additionally, Participant 114 also produced intra-syllabic pauses. Rogers and Storkel (1999) cite that there has been evidence that speakers with AOS may program syllable constituents, like onsets and rimes, independently. However, separate programming of the onset and the rime of a syllable does not account for the intra-syllabic pauses that Participant 114 produces. Participant 114's intra-syllabic pauses either occurred within the onset or within the rime, between the nucleus and the coda or within a coda consonant cluster. Thus, his pauses could not be solely due to separate programming of onsets and rimes. It is quite possible that Participant 114 has a reduced temporal capacity in his buffer; however, that would not explain why pauses sometimes occur between syllables, sometimes within syllables, and sometimes they do not occur at all.

It is possible to analyse Participant 114's use of pauses quite succinctly by making reference to the idea of word-minimality. A minimal word is the shortest well-formed prosodic word in a given language. The minimal word in English must be composed of at least two moras or a binary foot (Demuth, Culbertson, & Alter, 2006). Thus, the shortest well-formed prosodic word in English needs to be at the very least a bimoraic or "heavy" syllable (Demuth et al., 2006). For a syllable to be bimoaric in English, it can have a lax (monomoraic) vowel and a coda consonant, a tense (bimoraic) vowel or a diphthong (also a bimoraic vowel) (Demuth et al., 2006). If a syllable has a bimoraic vowel, any coda consonants present do not contribute to the mora or weight of the syllable (Demuth et al., 2006). In English, words composed of only one light or monomoraic syllable can only serve as closed class grammatical function words, such as determiners (Demuth et al., 2006). Any open class word that is composed of only one mora is considered to be subminimal or prosodically ill-formed (Demuth et al., 2006).

The syllable structure of early words produced by children show some variation (Demuth et al., 2006). That is, some children only produce coda consonants sometimes (Demuth et al., 2006). This would pose a problem for word-minimality if the children produced light or monomoraic syllables as single words without a coda consonant. However, Demuth and Fee (1995 as cited in Demuth et al., 2006) propose that in such cases where a child is not able to produce a binary foot, he or she will make modifications by lengthening the vowel or epenthesising a word-final vowel, creating a second light syllable. The child would do this in order to avoid violating word-minimality (Demuth & Fee, 1995 as cited in Demuth et al., 2006). This is supported by findings such as Demuth et al. (2006) discovering that the children in their study all had a predisposition to producing coda consonants earlier in their development in target words that contained a mono-moraic vowel, and thus, the coda consonant was licensed as part of a binary foot. They also found that the children began to produce coda consonants in disyllabic words two months later than monosyllabic words (Demuth et al., 2006). It is interesting to note that one of the children in Demuth et al. (2006) demonstrated a preference for open or CV syllables, so to keep her syllables open she would use epenthesis of a vowel to break up CC sequences.

It is possible that Participant 114 is overly committed to word-minimality. He seems to view the minimal word also as the maximal word. His inclusion of pauses between syllables of roughly the same length as the pauses he produces between words demonstrates a treatment of syllables that compose a multi-syllabic word as individual words. It appears that Participant 114 is equating the minimal word to the length of words in English.[4] For example, the word *speaker*, as produced by Participant 114 on November 16, 2012, [ʃi[303]bi[303]kʰə] is composed of three syllables with a pause between each of the syllables (see Figure 8). The first two syllables are bimoraic since they both contain a tense vowel. With the pauses between the syllables, Participant 114 could be seen as producing three separate words, composed of minimal words.

[4] This is assuming that all of the syllables that had pauses after them were bimoraic. This was not examined in the current study, but will be a further area of research for the future.

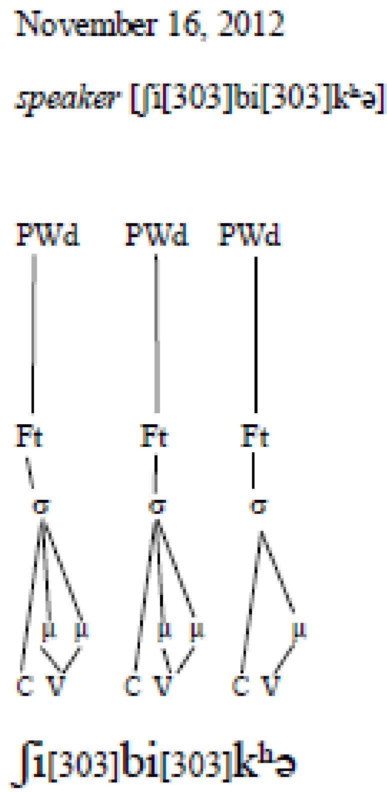


***Figure 8. Minimal Word Analysis of a Multi-syllabic Word with Pauses***

It becomes a little more challenging to understand how word-minimality can account for Participant 114's intra-syllabic pauses. However, in terms of the intra-syllabic pauses produced before word-final consonants, it has been shown that the grammars of young children tend to prefer CV or open syllables regardless of the target language (Goad & Brannen, 2003). This follows from the fact that codas are marked structures (Goad & Brannen, 2003). Goad and Brannen (2003) argue that when children first produce word-final consonants, they syllabify them as onsets of a following empty-headed syllable instead of as codas of the ultimate syllable of the word[5]. Thus, Participant 114's use of pauses could indicate that he is syllabifying word-final consonants as onsets, and thus, the pause is serving to indicate that he is treating the segments prior to the pause as a minimal word. Indeed, post-vocalic pauses (what I

[5] Goad and Brannen (2003) make a distinction between onset of an empty-headed syllable and onset of a nuclear syllable. This will not be addressed here. Instead, I will borrow the term "empty-headed syllable".

have termed word-final intra-syllabic pauses) serve as evidence that children syllabify word-final codas as onsets of empty-headed syllables (Goad & Brannen, 2003). Moreover, Goad and Brannen (2003) explain that post-vocalic pauses can actually be anticipated if the vowel is at the right edge of the word and the following consonant is actually the onset of another syllable or word. It should be mentioned that it could be that Participant 114 is syllabifying the word-final consonant as the onset of a following empty syllable in order to ensure that he doesn't produce words that are longer than a minimal word (Figure 9). This would mean that he doesn't have the knowledge that a coda consonant does not bear weight if the syllable contains a bimoraic vowel or a diphthong. It also bears noting that this cannot be used to explain pauses that occur between coda consonants or between the rime and the coda where the coda has more than one consonant.

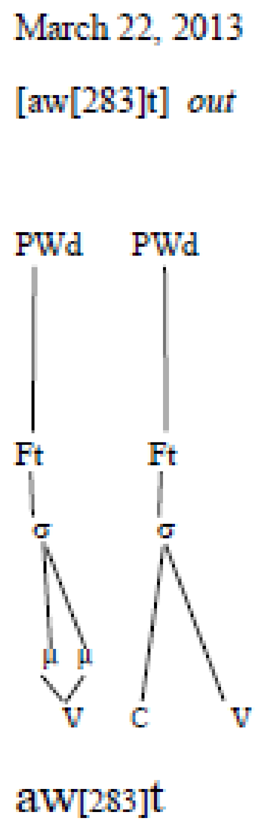


***Figure 9.*** ***Minimal Word Analysis of a Word with Intra-syllabic Pause before a Word-final Consonant***

It becomes once again even harder to understand how word-minimality can account for Participant 114's word-initial intra-syllabic pauses after /s/ or /ʃ/. However, this too can be explained by a re-syllabification, namely of the word-initial consonant. This stems from the fact that sC-Clusters (consonant clusters that begin with /s/) are privileged in that they don't require rising sonority profiles like other branching onsets (Goad, 2012). Moreover, the sC-cluster onsets don't respect the constraint that the consonants in an onset cluster cannot be produced using the same place of articulation and there is a wide range of place contrasts in the second consonant position in the cluster as opposed to the first as in other branching onsets (Goad, 2012). This has lead /s/ to be thought of as being outside of the onset to which the consonants following /s/ belong (Goad, 2012). Goad (2012) argues that the /s/ is actually the coda consonant of a preceding empty nucleus syllable. Thus, Participant 114 places pauses between the /s/, serving as a coda consonant, and the following consonants in order to produce words no longer than a minimal word (Figure 10).


***Figure 10.*** ***Minimal Word Analysis of a Word with an Intra-syllabic Pause after a Word-initial /s/ in a Consonant Cluster***

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# Appendices

# Appendix A.

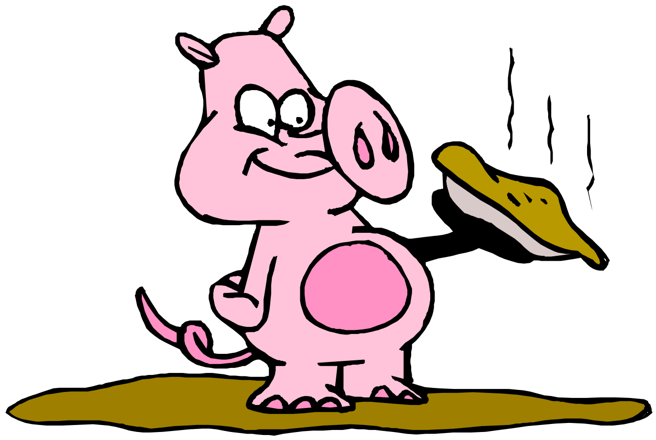
## List of Stimuli for Pilot Study

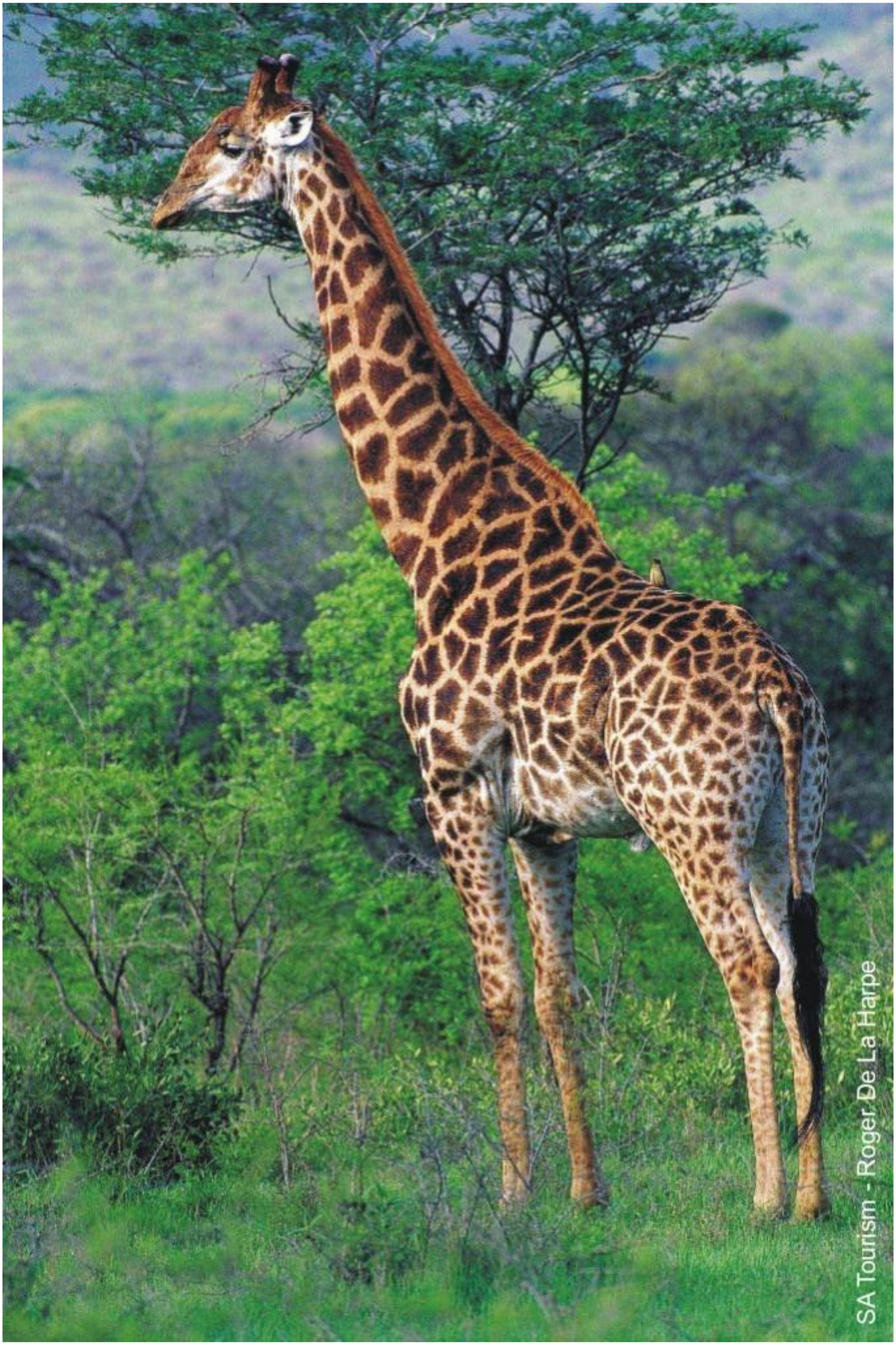
| Target sound | Word-initially | Word-medially | Word-finally |
|---|---|---|---|
| /m/ | Mud | Swimming | Gum |
| | Mother | Hammer | Comb |
| /n/ | Nail | Raining | Rain |
| | Nose | Money | Van |
| /ŋ/ | | Finger | Tongue |
| | | | Sleeping |
| /b/ | Back | Bubble | Robe |
| | Bus | Rabbit | Web |
| /d/ | Door | Reading | Bed |
| | Dog | Hiding | Mud |
| /g/ | Gum | Tiger | Frog |
| | Girl | | Pig |
| /p/ | Pig | Sleeping | Soap |
| | Pants | Happy | Cup |
| /t/ | Tear | Button | Foot |
| | Tail | Potato | Boot |
| /k/ | Comb | Pocket | Book |
| | Coat | Cracker | Rock |
| /f/ | Foot | Laughing | Leaf |
| | Fish | Elephant | Knife |
| /v/ | Vegetable | Driving | Wave |
| | Van | Waving | Stove |

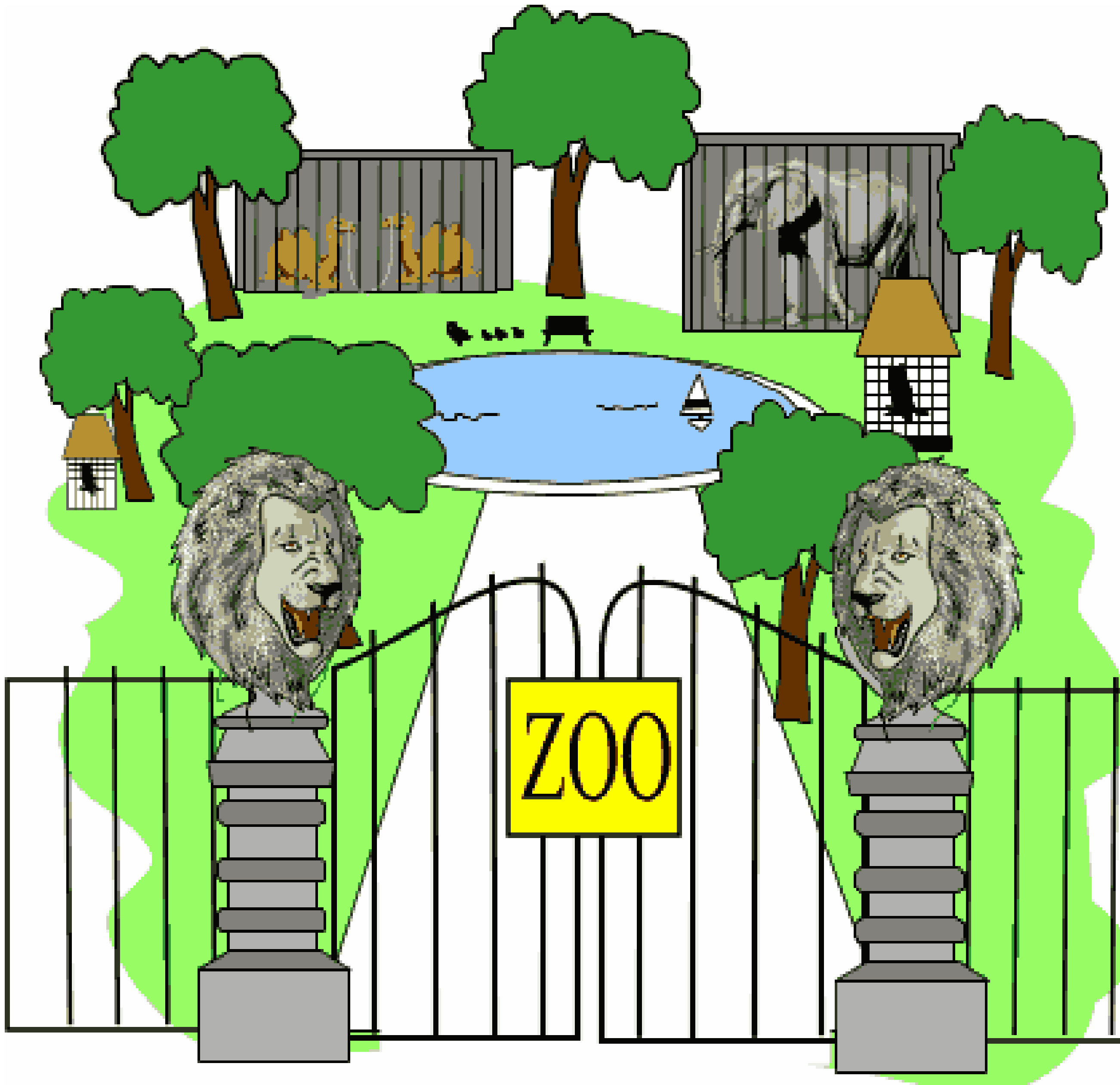
| | | | |
|---|---|---|---|
| /θ/ | Thumb | | Mouth |
| | Thief | | Teeth |
| /ð/ | Them | Mother | |
| | That | Feather | |
| /s/ | Soup | Baseball | Mouse |
| | Santa | Icy | Bus |
| /z/ | Zipper | Noisy | Cheese |
| | Zoo | Raisin | Nose |
| /ʃ/ | Shoe | Fishing | Brush |
| | Shirt | Crashing | Fish |
| /tʃ/ | Chicken | Picture | Peach |
| | Cheese | Kitchen | Pinch |
| /ʤ/ | Juice | Vegetable | Orange |
| | Jeep | | Cage |
| /l/ | Leaf | Colour | Girl |
| | Ladder | Yellow | Shovel |
| /r/ | Rain | Carrot | Door |
| | Ride | Giraffe | Chair |
| /w/ | Water | Snowing | Snow |
| | Waving | Flower | Blow |
| /j/ | Yellow | Crayon | |
| | Yard | | |
| /h/ | Hat | Behind | |
| | House | Treehouse | |

## Appendix B

## Stimuli used in Pilot Study




SA Tourism - Roger De La Harpe


ZOO