Early Phonological Systematization in Children with Williams Syndrome: A Longitudinal Study

Early Phonological Systematization in Children with Williams Syndrome: A Longitudinal Study

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Abstract

This longitudinal study looks at the systematic phonological development of children with Williams syndrome during the first three years of life. Williams syndrome is a genetic condition that impairs both cognitive and language abilities in those affected. It is commonly researched by linguists and speech pathologists alike because its phenotype provides a unique example of the interaction between cognitive impairment and language development. In this case study, four children's first words were examined through the transcription of 30-minute-long play sessions to gain a better understanding of how children with Williams syndrome acquire phonological patterns. These transcripts were then analyzed using a customized battery of routines created and calculated in the Phon acoustic analysis software. It was found that some of these children did appear to be using patterned structures or 'templates' (Vihman, 2016) to produce their initial words. However, idiosyncrasies of language acquisition also were present in the data, as it was also found that not all participants appeared to be using defined templatic structures when vocalizing early word forms. By discussing how these children were or were not evidencing phonological systematization, these case studies can be added to the current literature to further understand not only how phonology is acquired, but how linguistic skills emerge in children with Williams syndrome.

Introduction

In recent literature, the concept of phonological reorganization has emerged to explain the threshold period between the production of the first few words that a child utters and his eventual robust phonological performance.[1] Phonological systematization is the manifestation of the speaker's ability to generalize from known forms to novel productions of words, reflecting the child's emerging linguistic competence. While the first several words are typically similar to the targets expected in adult production, they lack evidence of any organizational patterns in a child's phonology; these words instead parallel babbling patterns that a child may favor in his vocalizations (Vihman, 2016). In a transitional phase that commonly occurs before organized phonological systems are fully developed, templates, or retrievable structures a child may use to formulate words, are evidenced. Over time, children gain a phonological system that allows for novel speech production through these word formation patterns.

In this study, words that children with Williams syndrome utter during the aforementioned period will be phonologically analyzed in an effort to determine if there are any salient production patterns that emerge for these children. Through the use of in-depth phonetic and syllabic analysis, the progression of word formation between 18 and 36 months will be closely examined for four children with Williams syndrome. The relation between the data provided by these subjects and the accepted theories regarding phonological systematization in cognitively typical children will be discussed. This study is significant, with regards to the current literature, because it provides individual analyses of phonological reorganization, but within the linguistic limitations of children with Williams syndrome. In doing so, it provides a

[1] It is difficult, when referring to the entire population, to appropriately gender pronouns to be as inclusive as possible while maintaining clarity. For the purposes of this thesis, 'he/him/his' pronouns will be used when referring to entire populations and their phonological acquisition, but should not be taken to represent only male-identifying individuals.

multidimensional analysis by allowing for the comparison of the subjects with Williams syndrome to typically developing children in previous studies. Thus, it contributes to the current literature regarding templates and reorganization.

Because a population that has delayed cognitive and language abilities is under investigation, the interaction between the children's abilities and current phonological theory provides an interesting grounding to this research. When speaking of phonological reorganization, Vihman (2016) notes that, "the evidence base for most languages remains small, ranging from individual diary studies to rare longitudinal studies of as many as 30 children. Thus templates undeniably play a role in phonological development, but their extent of use or generality remains unclear, their timing for the children who show them is unpredictable, and their period of sway is typically brief" (n.p.). It is therefore crucial to add to this field of research in hopes of better understanding how children, especially those with atypical language abilities or a delayed onset of speech, move from 'whole word phonology' to a more organized system.

Review of the Literature

I. Phonological Acquisition in Typically Developing Children

In order to understand the speech development of children with Williams syndrome, it is first crucial to define the stages of phonological acquisition in typically developing children. One must note that language acquisition is highly variable from one child to the next, and so the following patterns are meant to be understood solely as general descriptors for how speech develops. Phonology is the processing of the sound system of a language (Ladefoged,1975). Because this paper primarily inquires about phonological systematization, and therefore the acquisition of such, only the phonological aspects of language acquisition will be discussed in this thesis.

At birth, the first vocalizations made are cries, coos, burps, coughs, grunts and other sounds that are involuntary or reflexive (Velleman, 2016). By two to four months, a child will have more voluntary utterances, such as laughter and coos, as they interact with their caretakers. Expansion of vocalizations is witnessed between four and six months, during which time a child begins uttering sounds that approximate speech (De Villiers, 1978). These sounds are commonly referred to as closants, which are incomplete consonant-like sounds, and vocants, which are vowel-like sounds. Additionally, clicks, lip smacks, squeals, shrieks and friction noises are widely attested at this stage (Velleman, 2016).

Children will also begin to adopt non-linguistic skills that are considered crucial for the eventual robust linguistic system that will be acquired. While gestures such as sharing eye contact or involuntary pointing can be witnessed in children as early as 3 months old, the intentionality of these actions relates directly to the communicative nature of speech. Eye-gaze towards a referent suggests this 'communicative intent' and is commonly witnessed around 8-9 months in typically developing children (D'Odorico & Levorato, 1990, as cited in Vihman, 1996). Additionally, open-hand reaching and intentional pointing also foreshadow the beginnings of referential speech. These examples of joint attention, in which the child and caretaker are both focusing on an object, are important to mention because they are frequently thought of as required precursors to speech.

After this period, babbling becomes the most prevalent form of vocalizing that a child experiments with. A child produces canonical babbling in which syllable timing much more closely resembles that of speech (Velleman, 2016). Within this stage, two different types of babble can occur. Reduplicated babble includes strands of replicated syllables ([babababa]), whereas variegated babble has greater variation in the syllable strings ([didupapapi]) (Stoel-Gammon, 1992).

After and even throughout the time a child is familiarizing himself with the syllable timing of speech through the use of babble, jargon emerges. These forms may be confused for words by an adult speaker, as they closely resemble modes of adult speech; jargon is speech-like in that intonation patterns, eye contact and syllable timing are consistent with adult conversation patterns (Menn, 1976). However, jargon speech does not closely resemble the sound-meaning associations within the native language and is not consistent in form. ‘Protowords’, which are consistent and related to true words, then become prevalent in the child’s vocalizations. These ‘quasi-words’ (Stoel-Gammon & Cooper, 1984) are vocal forms that have a consistent form and meaning, regardless of whether it was invented by the child or imposed by a caregiver (Menn, 1976). Jargon, late-stage babbling, and protowords can all be difficult to distinguish from one another because they commonly co-occur in a child’s speech development.

The first referential words a child produces typically follow or co-occur with the protoword phase and are different than protowords in multiple ways. Protowords are specific to the child and therefore require a closeness of speaker and referent (Vihman, 1996). Words, in contrast, are symbolic on a larger referential scale. As will be discussed in the methods section of this paper, the criteria for defining what constitutes a word are variable within the literature and will therefore be clearly conventionalized for the purposes of this study (See Appendix C.) With regards to phonotactic structure, ‘true’ words are typically mono- or disyllabic in the first stages of English word production and usually have at most one consonant present (Vihman, 1996). First words are also fairly accurate when compared to their adult target forms; this is most likely due to an ‘articulatory filter’ (Vihman, 1996) which matches an adult word form to a child’s familiar babble forms to elicit an early word. This strong association between a child’s phonetic sequences in babble and his first word forms is highly likely because the child is only attempting words which fit his phonological schemes (Clark, 2003). These ‘Vocal Motor Schemes’ affect production by filtering what the child perceives and what they produce (Velleman, 2016). As a child begins to produce more words, phonological systematization then occurs, allowing the child to express a larger variety of forms, sounds, and constructions. This phonological ‘reorganization’ will be discussed in further detail in the following sections of this paper.

II. Phonemic Development in Typically Developing Children

With regards to the individual sounds produced and the order in which they are acquired, generalizations are a bit more difficult to make. Phonemes are the smallest segments of sound that exist in contrast within words (Ladefoged, 1975). These ‘building blocks of speech’ develop over time based on a child’s ability to perceive the sounds, control their oratory muscles and ultimately execute the correct production (Ladefoged, 1975). Phoneme acquisition is specific to the language being learned, because different languages have different inventories of speech sounds (Ladefoged, 1975). For the purposes of this paper, only American English phonemes will be analyzed, and, more specifically, only consonants will be tracked in both word-initial and word-final positions.

In typically developing American English speakers, most of the articulatory development happens in the first two years, although some more difficult sounds can be acquired as late as age eight (Sander, 1972). Many studies, such as Templin’s project in 1957, have tried to assign ages of mastery to the phonemes of English. Templin analyzed the speech of 60 children between the ages of 3 and 8 to determine a relative pattern of phoneme development, yet this study yielded questionable results because by 36 months, about 60% of typically developing children were producing accurate [t] and [s] consonants in their speech (Templin, 1957). As seen in Appendix A, [s] can be an especially difficult phone for children, sometimes taking the first seven years for a child to master. It is therefore questionable that Templin's study yielded such a high percentage of accuracy at 36 months. In a different study conducted by Stoel-Gammon (1987) that analyzed the speech of 33 typically developing 2-year olds who spoke American English, it was found that stops (b, d, g, t, k), nasals, fricatives (f, s) and glides (w, h) were attested by at least 50% of the subjects in the initial position. Of these phones, [b] and [d] were present in 90% of the children's speech (Stoel-Gammon, 1987). In word-final position, fewer phones were produced, but [t] was the most consistent in the data.

Because of the varying results in the current literature, creating a definitive ordering of articulatory development poses several issues. According to Sander (1972), quantifying consonant mastery will yield highly unsatisfying results and therefore ranges of acquisition for articulatory classes should instead be studied. This corresponds to concepts presented in Velleman (2016). Infants primarily use bilabial consonants in the first year, then usually acquire nasals, followed by [w], [h], and select fricatives (Velleman, 2016). Other phones, such as laterals and affricates, tend to appear later in a child's phonological development. To illustrate a general sequencing of development, Appendix A shows the average periods of acquisition for each of the American English consonants.

III. Phonological Systematization

The phonology of typically developing children has been widely studied by speech scientists and linguists, alike. Jakobson first postulated in 1941 that two periods of production exist for children: babbling and meaningful speech (as cited in Stoel-Gammon & Cooper, 1984). While Jakobson argued that babble production is not acquired in a patterned manner, this has been refuted in more recent literature. Additionally, he claimed that phonemes and phonemic contrast were the driving forces behind meaningful speech production, but this too has been questioned in several studies. Firth (1948) and Francescato (1968) both state in their work that sounds are acquired only after words are learned; the basis for development at this stage is 'syntagmatic' (as cited in Vihman, 1996). Ferguson & Farwell (1975) also suggested that words, rather than phonemes, are the organizing units of development. As Vihman and Croft note (2007), this model is more logical because a child is able to eventually identify, say, [kæt] and [kɛt] as variations of the same target word 'cat'. If phonological development were segment-based, a child would not be able to identify that these two variations had the same sound-meaning association and eventually adopt the correct target form (Vihman & Croft, 2007).

Another point of contention arising from Jakobson's work was his claim that children acquire their phonological systems passively. The following three arguments are commonly given as evidence of children having an active role in their phonological development:

> (1) Children often create, or invent, their own words, not based on any adult model (Carter, 1979; Halliday,1975); (2) they actively select or reject adult words to be included in their early vocabulary on the basis of phonological characteristics of the adult words (Ferguson & Farwell, 1975; Menn, 1976); and (3) they create favorite word patterns or articulatory routines which are used in the pronunciation of target words with similar

phonological structures (Ferguson, Peizer & Weeks, 1973; Menn, 1976; Waterson, 1971). (Stoel-Gammon & Cooper, 1984, p. 248).

As children pass the babbling stage of early speech and begin to utter words, they also begin to develop phonology, or the system of sounds for their respective languages. Although there are common tendencies and patterns in the progression of a child's speech, it is important to note that individual variation is very prevalent in this stage of speech development, as it is in many other aspects and stages of child development. Ferguson and Farwell (1975) first suggested that linguists be wary of creating universal rules for phonological development. Their approach suggests that the phonetic basis of a child's language provides the foundation for his phonology, that early words are seen as whole entities, rather than combinations of segments, and that a child will create generalizations from the given input over time (Ferguson & Farwell, 1975).

As a child's vocabulary reaches 25-100 words, systematization begins to occur. Familiar word shapes that are comfortably produced appear to be favored in a child's speech as he begins to selectively 'choose' words that accord with his preferred routines (Velleman, 2016). Sometimes, but not always, these favored patterns are applied to adult target words with different structures. At this stage, the routines being used to change an adult form to a child's output form are called 'templates' (Velleman, 2016). The following three 'clues' are generally used to identify a child's templates:

(a) Consistency of patterning in a substantial number of the child forms for words produced in one or more recording sessions or over a period of some weeks or months;

(b) The occurrence of unusual phonological correspondences between adult and child forms (i.e., rules or processes or 'repairs' to target word violations of child constraints), under the influence of a dominating pattern or template;

(c) Frequently, a sharp increase in words attempted that either fit or can be fitted into the pattern.

(Vihman & Croft, 2007, p. 693-4).

These concepts have become widely accepted and expanded upon in the recent literature. In a case study that looked at one typically developing child, Molly, evidence of this progression was seen on an individual scale through the use of acoustic analysis over 5 months (Vihman & Velleman, 1989). Stages of importance in her development were described as: 1) pre-systematic utterances containing no patterns, 2) experimentation with target word formation, 3) regression of advanced forms seen in early development, and 4) the restructuring of previously known words to match these templatic forms (Vihman & Velleman, 1989). Initially, children tend to produce whole words. These words are highly variable and lack any true systematicity (Vihman & Velleman, 2000). As children begin to create templates that they produce words through, regression also becomes a relevant part of word production. Apparent regression, as seen in Snow and Stoel-Gammon's (1994) study of three children sampled at 18 and 24 months, is the apparent loss of advanced forms seen in earlier sessions as templatic structures become more salient in a child's speech; these forms then reappear in later sessions. For example, in Vihman and Velleman's (1989) case study involving Molly, a young typically developing toddler, Molly's mother noted that the target words, 'button', banana', 'balloon', and 'bunny' were all being newly produced as [bʌn:ə] or [ban: ə], when these words each had a unique form in Molly's earlier speech. Apparent regression can be expressed as the bottom point of a U-shaped curve in phonological development. This phenomenon was also noted by Ferguson and Farwell (1975) as a typical and important stage in phonological reorganization because it demonstrates generalization of templatic patterns being applied to many outputs. Thus, although accuracy may seem to have decreased, it actually represents an advance in the child's emerging phonological system. The use of production patterns, commonly called 'templates' or 'word recipes' in the literature, is attested in many other similar studies across a variety of languages (Vihman, 2016). Although these systematic forms are not universal, they do provide at least some children with the beginnings of a phonological system (Velleman & Vihman, 2000). The emerging use of these forms is referred to as 'reorganization' in the literature and is thought to mark the beginning of a child's phonological system.

When investigating the use of templates in a child's speech, two processes commonly referred to as 'adaptation' and 'selection,' may be at work. A child may only attempt words that are selected based on the adult target word form because these words are accessible within the child's current phonological system (Vihman, 2015). 'Avoidance' and 'exploitation of favorite sounds' are cited as the two strategies children tend to take when selecting words (Menn, 2013). Once a child is able to move beyond solely selecting words based on their structure and attempt more complex word forms, he may also show signs of adaptation. Adult words are adapted to fit a child's templates when their target word forms may be beyond the phonological capabilities of the child. The most commonly cited example of this within the literature is Priestly's observational study of his own son, who used <CVjVC> as a template for many disyllabic words containing word-final consonants, resulting in forms such as [fajam] for 'farmer' and [tajak] for 'tiger' (Priestly, 1977, as cited in Vihman, 2015). Both adaptation and selection must be taken into account when studying a child's phonological systematization because they are widely attested steps within the process of reorganization.

'Controlled expansion' is another learning strategy in the emergence of a phonological system that involves the "gradual relaxation of production constraints [and] expansion in the range of adult targets attempted" (Vihman, 2016, p. 151). This gradual increase in the number of simple forms used by a child differs from experimentation that many children exhibit when faced with more complex adult forms. Instead of exhibiting a narrowing of production patterns through the use of 'selected' forms, children with controlled expansion demonstrate a wider variety of simpler target words (Walley, 1993).

IV. Williams Syndrome Phenotype

Williams syndrome is a genetic condition that is caused by the deletion of about 26 genes on the longer portion of the seventh chromosome (Mervis & Becerra, 2007). Previously, it was thought that Williams syndrome affected 1 in every 20,000 births, but a more recent Norwegian study conducted by Strømme, Bjørnstad, and Ramstad (2002) suggests that 1 in 7,500 are affected (as cited in Brock, 2007). Low muscle tone and elf-like features are commonly cited as recognizable characteristics of the Williams syndrome phenotype (Hsu & Karmiloff-Smith, 2008). Several health complications also arise in those who are affected by Williams syndrome; these include supravalvular aortic stenosis (narrowing of the arteries), hernias, and wrinkles due to altered elastin proteins in the skin tissue (Masataka, 2001). More recent research has attested "unilateral or bilateral mild to moderate high-frequency hearing loss" in young children, which may or may not be apparent to the child's parent or guardian (Mervis & Velleman, 2011, p. 98). Due to the significantly heightened blood calcium levels at birth, Williams syndrome was previously referred to as ‘Infantile Hypercalcemia’, although it is unclear whether this is a persistent issue for all those affected by the condition (Jarrold, Baddeley & Hewes, 1998). In some previous studies, potential misdiagnosis based on hypercalcemia posed issues in determining whether subjects were actually affected by Williams syndrome, and therefore made conclusive results about their speech difficult to accept. However, most of those studies have been replicated or refuted in more recent literature.

Additionally, people with Williams syndrome have a variety of cognitive, intellectual, and learning disabilities. IQ levels for children with Williams syndrome suggest delayed mental ability, as they are about two standard deviations below the typically developing child’s score (Mervis & Becerra, 2007). However, it should also be noted that no one score accurately portrays the overall intellectual profile of a person. In fact, about 85% of children with WS show significant differences between their “Verbal and/or Nonverbal Reasoning Cluster SSs [standard scores] and their Spatial cluster SS,” which suggests a discrepancy between reasoning and spatial abilities (Mervis & Velleman, 2011, p. 99). Visuospatial skills are extremely poor in Williams syndrome, as several studies involving visuospatial cognitive testing have demonstrated (Brock, 2007). Other impairments, such as quantitative and reasoning skills, are also cited in the literature (Masataka, 2001).

Behaviorally, children with Williams syndrome are quite friendly and social beings. Some studies have even described them as ‘hypersociable’, especially in comparison to other individuals with learning disabilities (Brock, 2007). They show little social anxiety and are quite outgoing in interpersonal reactions (Mervis & Velleman, 2011). Leyfer, Woodruff-Borden, Klein-Tasman, Fricke, and Mervis (2006) note that in other respects, children with Williams syndrome are quite anxious; over 50% of a sample of 119 4-16 year olds met the DSM-IV criteria for Specific Phobia and 14% of 7-10 year olds met the criteria for Generalized Anxiety Disorder (as cited in Mervis & Velleman, 2011). It has also been noted that many children with Williams syndrome have Attention Deficit Hyperactivity Disorder (Brock, 2007). Even with non-social anxieties and difficulties with prolonged attention, one would possibly assume that those affected by Williams syndrome would have intact language skills because of their highly interactive demeanors. This was previously presumed to be the case, but more recent studies show the intricacies of the Williams syndrome language profile.

V. Williams Syndrome and Language

With regards to speech and oral abilities, it was previously thought that, despite severe cognitive impairments, language abilities in those affected by Williams syndrome remained fairly intact (von Armin and Engel, as cited in Mervis & Velleman, 2011). However, as Brock (2007) notes, 'the empirical evidence to support many of the claims made about Williams syndrome is less than straightforward' (p. 119). This is consistent with a study of 16 children with Williams syndrome conducted by Jarrold, Baddeley, and Hewes (1998) in which it was found that verbal abilities develop at a faster rate than non-verbal skills and therefore they may appear to be more advanced. However, the onset of speech is delayed, which creates an interesting paradox: even with a delayed onset, these children catch up to the expected language abilities for their mental respective mental ages. Perhaps, then, the best way to characterize the language of those affected by Williams syndrome is that it is at a level that is no better than expected for a person's nonverbal mental age (Brock, 2007).

As previously mentioned, the onset of babbling is 'extremely' delayed and the trajectory of typical precursors to language (referential pointing, eye contact) does not follow the usual progression (Hsu and Karmiloff-Smith, 2008). For example, pointing starts after the naming process begins (Mervis, Morris, Bertrand & Robinson, 1999), deviating from the typical trajectory. In fact, in typically developing children, spurts in both vocabulary and 'fast-mapping or sorting' (Ferguson, Menn & Stoel-Gammon, 1992) are typically simultaneously seen around 18 months. But, in a study conducted by Nazzi, Gopnik, and Karmiloff-Smith (2005), this extensive categorization was not witnessed in the 8 subjects with Williams syndrome until after the vocabulary had already grown rapidly (around 33-82 months). In another study conducted by Laing, Butterworth, Ansari, Gsödl, Longhi, and Panagiotaki (2002), joint attention, which usually occurs pre-linguistically, was lacking in the 13 verbal children with Williams syndrome tested. These studies provide further evidence for the claims that even with later language skills that are relatively good, and later adequate social skills, many of the precursors to language are impaired or delayed (Laing et al., 2002). Although it is now commonly accepted that language skills are not fully intact, it is still unclear why it is the case that both the developmental trajectory deviates from the norm and that language skills are not fully intact.

More recent literature also suggests that children with Williams syndrome have strengths and weaknesses within the aspects that make up human language. For example, vocabulary and phonological skills are considered to be relatively strong, grammatical skills are correlated to a child's cognitive skills and are therefore at a lower level than those of a typically developing child, and pragmatic abilities are rather weak (Mervis & Velleman, 2011). Although the overall onset of the development of speech is rather delayed, later speech tends to follow the above trends. With regards to phonological systematization and Williams syndrome, there is a lot left to be learned. Very few, if any, longitudinal studies have explored whether English speaking children with Williams syndrome use templatic structures in their phonological reorganization processes.

Methodology

I. Participants

This study follows the development of four children with Williams syndrome through the use of 30-minute play-session videos recorded at 18, 24, and 36 months, respectively, for each child. These children are part of a larger study conducted by Carolyn B. Mervis at the University of Louisville and Shelley L. Velleman at the University of Vermont; consent for sub-studies is included in University of Louisville consent forms. An IRB submission and exemption were submitted and approved for both the mother project and this case study.

Within this larger study, these four children were the only participants whose collected data included at least one word produced at all three ages in question. Thus, for the purposes of looking at phonological development, these subjects were the only members of the larger study deemed appropriate for all three of the chosen ages. It should be noted that these children with Williams syndrome are quite precocious in comparison to the other subjects of the larger study, because they are producing words at as early as 18 months. The following table includes further information about each child.

Table 1. Participant Information

Child ID	Sex	Exact age at 18 month session	Exact age at 24 month session	Exact age at 36 month session
781 WS	M	19 months, 18 days	21 months, 26 days	36 months, 26 days
3236 WS	F	18 months, 22 days	24 months, 22 days	36 months, 7 days
3262 WS	M	19 months, 9 days	25 months	38 months, 17 days
2668 WS	F	18 months, 1 day	25 months, 28 days	36 months, 2 days

Of the four subjects, two are male and two are female. It is important to note that the exact chronological ages of these children deviate slightly from the given ages in question. This was partially due to availability for recording the play sessions. Of course at such a young age of development, a few months can greatly affect the overall language levels of a child, and therefore these differences will be discussed more in further sections of this thesis.

II. Procedures

Each play session was recorded in Kentucky with a research assistant from the University of Louisville, not a parent or guardian. For each session, the research assistant played with the child within the lab playroom, while encouraging the child to speak as much as possible. The video footage of these sessions was recorded and burned to de-identified CDs, which were then sent to Dr. Velleman’s lab for transcription.

Each of the sessions was transcribed separately by two research assistants in Dr. Velleman’s lab, using the International Phonetic Alphabet (IPA), and these transcripts were compared to ensure accuracy. In the preliminary transcripts, the IPA of the utterance, the time at which the utterance occurred in the session and any relevant notes were recorded. Transcribers used a broad transcription style. A final transcript based upon consensus between the two transcribers was then completed. If at least 80% agreement on both consonants and vowels was not found between the first two preliminary transcripts, then a third was made by another research assistant with which to be compared, or the consensus transcript was reviewed and corrected by Dr. Velleman, with agreement between the consensus transcript and her transcript calculated again. Of the eight transcripts that were ultimately evaluated by research assistants and Dr. Velleman, the average agreement for consonants was 93.9%, and the average agreement for vowels was 92.1%. The average consonant agreement for final transcripts based solely upon consensus between two research assistants was 93.1%, while the average vowel agreement for these transcripts was 95.4%.

On these final transcriptions, words and babble were labeled accordingly. Because this study aims to explore the development of phonological processes in relation to word production, only words from each transcript were of interest. For the purposes of this study, vocalizations were considered to be words if they had at least some of the following characteristics: a) sounded similar to the target word, b) used in an appropriate context (e.g., the child appropriately labels an object he is holding), c) used consistently after being recognized once in the appropriate context (e.g., the child uses the vocalization [do] when holding a doll multiple times in a transcript), and d) recognized by the adult in the playroom as a word. Criteria for word status by Vihman and McCune (1994), given in Appendix B, were used to help create these conventions and were used as guidelines when vocalizations were particularly difficult to identify as words or babble. If the target word for a child’s utterance was difficult to determine, the video recording of the session was rewatched in order to identify the adult target word.

Final transcripts were then analyzed using Phon, a phonetic analysis database software that is available to the public online. Phon was designed and implemented by Gregory Hedlund, Yvan Rose, Jason Gedge, Rod Byrne, Todd Wareham, Philip O'Brien, Keith Maddocks, and Allison Penney. The PhonBank database is primarily curated by Dr. Yvan Rose at Memorial University in Newfoundland, Canada. PhonBank is part of the Child Language Data Exchange System (CHILDES), which allows for samples and data regarding child speech and language development to be shared amongst researchers internationally (MacWhinney, N.D.). CHILDES is operated by Dr. Brian MacWhinney at Carnegie Mellon University. PhonBank is funded by grant RO1-HD051698 from NIH-NICHHD to Brian MacWhinney and Yvan Rose.

Within the Phon software, customized analysis programs can be developed or requested for individual use when looking at specific populations. The vocalization routines implemented in this research study were constructed by Dr. Yvan Rose and Gregory Hedlund. In these analyses, words and babble were differentiated, in order to yield results that only took word structure into account. For each transcript, the number of words, phonetic type-token ratio, number of unique initial consonants, and percentage of words containing a CV sequence were calculated, amongst other features. For a full list of vocalization routine calculations, see Appendix C. Once the Phon analyses were completed, one participant's Phon analysis summary was checked with an analysis which had been calculated by hand in order to ensure that the Phon software was measuring repertoires, type-token ratios, and syllable shapes correctly.

Certain conventions were also developed in order to form more standardized parameters upon which to base the analysis. For example, if a glottal stop was being used word-finally, it was only considered an actual consonant if it was being used in situations where the target word had a final consonant. If a glottal stop was used consistently in the word-final position for a target word that had a final consonant, then this glottal stop was considered to be a consonant. Glottal stops and [h] were not considered as actual 'true' consonants when calculating the percentage of words containing a CV sequence, nor the percentage of syllables containing a CV sequence, in keeping with conventions within the field. Yet, they were often treated as actual consonants when discussing a child's phonetic repertoires, word forms or templates, because many early patterns demonstrated a prevalence of [h] word-initially. Additionally, if multiple vowels occurred in sequence within a vocalization, two vowels were treated as a monosyllabic diphthong, unless transcription diacritics were used to identify the vowels as separate syllables. Otherwise, if three vowels, such as [ueo] were present, the first two were treated as a diphthong and the third was counted as an additional [V] syllable. Rhotic vowels were considered to be vowels within the analyses. These two conventions were used when creating vowel repertoires using the Phon software.

III. Key Analysis Concepts

Before the results are explained in detail, some important terminology that is used in the analyses must be defined. While these terms are commonly used in phonotactic analyses, it is important to define them in the context of this study. For example, the 'phonetic type-token ratio' refers to the relationship between the total number of word-based vocalizations produced (tokens) and the total number of different phonetic shapes (types) produced in word targets, including both structure (e.g. CV) and segments (e.g. C or V). To calculate this score, the total number of types is divided by the total number of tokens. If a child has a type-token ratio of 1.00, this means that every word-based vocalization produced was representing a novel phonetic shape.

In words with multiple syllables, a few processes may be discussed. In this context, it is crucial to note that 'processes' is used to refer to the outcome of the child's production patterns, rather than the motivations for these productions. Reduplication refers to the process of repeating one syllable within a word, such as 'mama' or 'boo-boo' (Velleman 1998). Reduplication can be partial, in that only part of the word is repeated, or total, meaning that the entire word is repeated. Consonant and vowel harmony are also important features of children's speech that will be discussed. Consonant harmony is used to describe instances when one consonant in a word is repeated whether it is or is not predicted by the target word form. For example, if the child is attempting to say 'doggie' but instead says [dʌdi], this is consonant harmony (Menn,1978). In other cases, the child may substitute [d] for /g/ everywhere, regardless of the presence of /d/ elsewhere in the word. In that event, the process is fronting. However, 'mama' uttered as [mʌmə] is also consonant harmony, even though it is predicted in the target word form. Vowel harmony occurs when the same vowel is repeated, very similarly to consonant harmony.

Finally, when looking at the resulting data, a few common notation devices are used. When discussing syllable shapes, consonants are referred to as 'C' and vowels as 'V'. Phonetic transcriptions in brackets ([ ]) refer to what was actually uttered by the child. Templatic structures are referred to using angle brackets (< >). Because of the broad transcription style used when transcribing the play sessions, very few diacritics will be noted.

Results

The results for this study will first be presented by analyzing each participant's samples and data separately. A summary of the Phon calculations for each session, as well as phone development charts will be discussed for each child. A table showing a child's given templates and the words that were selected or adapted by this template is included for each child at each age where evidence of templatic structures is present. Then, a further reading of specific examples drawn from the transcripts will be performed to determine relevant patterns and practices in each child's speech. After the results for each child have been detailed separately, a systematic summary of all the participants' data will be provided.

I. 781 WS

Table 2. 781 WS Developmental Summary

Age	Number of Words (tokens)	Phonetic Type-Token Ratio	% of Words that Include at Least 1 CV Sequence	% of Syllables that Include at Least 1 CV Sequence	% Multisyllabic Words
18 MOS	4	1.00	100.0%	100.0%	25.0%
24 MOS	63	0.78	84.1%	80.2%	38.1%
36 MOS	252	0.66	65.9%	63.9%	34.5%

Table 2 shows a summary of the relevant patterns in the development of 781 WS's speech. It is important to note that there seems to be an inverse relationship between the number of words uttered and the percentages of the variables in question. This is partially due to the very small number of words produced at earlier stages. For example, the percent of words that are multisyllabic appears to be remaining fairly steady over time. However, if one looks at the actual number of words that are multisyllabic, one sees an increase from 1 to 24 to 87 words.

At 36 months, the phonetic type-token ratio suggests that two out of three tokens (in a dataset of 252 words), represented a different form. It was also seen in the word listing that a much higher proportion of function words were used in the latest session. These words are shorter and make up a closed class of words; it is thus expected that these words also affected the type-token ratio. Therefore, when analyzing this chart, it is crucial to take the total number of words per session into account.

Table 3. 781 WS Word-Initial Phone Development

781 WS	Word-Initial Consonants
18 Months	ʔ p **b** m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	ʔ **p b m n h w k g d t** ŋ f **j** ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	ʔ **p b m n h w k g d t** ŋ **f j ʧ ʃ ʒ** ɹ **l s z v** ð θ ʤ

Note: Grey letters represent English consonants that were not present in the repertoire.

Table 3 exhibits the phones found in word-initial position for 781 WS over the course of the first 36 months. 781 WS exhibits a fairly steady increase in articulatory development during the three sessions. This child demonstrates a classic progression of phones as he ages, in comparison to the approximated trajectory in Appendix A.

Table 4. 781 WS Word-Final Phone Development

781 WS	Word-Final Consonants
18 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	**ʔ** p b m n h w **k** g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	**ʔ** p b **m n** h w **k** g **d t ŋ f** j **ʧ ʃ** ʒ ɹ **l s z** v ð θ ʤ

Table 4 shows the consonantal phones found in word-final position in each of the three sessions. While no word-final consonants were produced in the first session, 14 were present in this child's repertoire in the third session. It is interesting to note that his word-final phones are a bit more sporadic in terms of the order in which they are acquired. In fact, some rather difficult sounds, such as [l], and [s] are attested in this child's speech in final position.

Table 5. 781 WS Phonological Templates at 18 Months

Template: <bV(CV)>	Adult Form	Child Form: Selected	Adult Form	Child Form: Adapted
	'Ball' /bɑl/	[boʊ]		
	'Ball' /bɑl/	[baʊ]		
	'Ball' /bɑl/	[bʌ]		
	'Beep beep' /bipbip/	[bɛdɛ]		

Table 5 shows the relevant templates used at 18 months for 781 WS. It should be noted that only words that fit this template were 'selected' and produced.

Table 6. 781 WS Phonological Templates at 24 Months

Template: <CVCV>	Adult Form	Child Form: Selected	Adult Form	Child Form: Adapted
	'Cookie' /ˈkʊki/	[gɑgu], [gægu]	'Banana' /bəˈnænə/	[nænə]
			'Monkey' /ˈmʌŋki/	[mɑni], [mɑpə]
			'Pizza' /pitsə/	[bibʌ]
Template: Velar Word-initially	'Cookie' /ˈkʊki/	[gɑgu], [gægu]	'Duck' /dʌk/	[gʌk], [gʌʔ]
	'Cow' /kaʊ/	[kaʊ]	'Soccer' /ˈsɑkɚ/	[gagʊ]

	‘Cat’ /kæt/	[kæ], [gæʔ]	‘Tree’ /tɹi/	[ki]
			‘Truck’ /tɹʌk/	[kʊʔ]

Table 6 shows the templates in 781 WS’s speech from the 24-month sample, with some example words. He both ‘selects’ and ‘adapts’ words for both of his template forms. For words like ‘monkey’ and ‘pizza’, the produced forms are ‘adapted’ because of the consonant cluster reduction in the medial position. When looking at this table, it is interesting to note the processes used to achieve the templatic structures for each of the target words. Weak syllable deletion is seen in the adapted form of ‘banana’ and consonant cluster reduction is attested for both ‘monkey’ and ‘pizza’, all of which are examples of the <CVCV> structure. In the words that are adapted to have velars word-initially, consonant harmony, coalescence and metathesis are strategies used to alter the target word forms. Thus, the child is using a variety of processes to achieve his templatic goals.

Table 7. 781 WS Phonological Templates at 36 Months

Template: <CVCV>	Adult Target	Child Form: Selected	Adult Target	Child Form: Adapted
	‘Doggie’ /dɑgi/	[dɑgi]	‘Donut’ /ˈdoʊˌnʌt/	[dʌnʊ]
	*‘Happy’ /hæpi/	*[hæpi]	‘Food’ /fu:d/	[fu:də]
	‘Mommy’ /mɑmi/	[mɑmi], [mʌmi]	‘People’ /pi:pəl/	[bipoʊ], [pipoʊ]
	*‘Hello’ /hɛˈloʊ/	*[hɛˈloʊ]	‘Purple’ /ˈpɚpəl/	[ˈpʊpoʊ]
			‘Pizza’ /pitsə/	[pizə]
			‘Tomato’ /təˈmeɪˌɾoʊ/	[ˈteɪ:do], [təedoʊ]

			‘Strawberry’ /stɹɑbɝi/	[stwɑbɛ]
Template: <(C)CVC(C)>	‘Beads’ /bi:dz/	[bits]	‘About’ /əbaʊt/	[baʊt]
	‘Black’ /blæk/	[blæk]		
	‘Truck’ /tɹʌk/	[tʌk]		
	‘Piece’ /pis/	[pits], [pi:s]		
	‘This’ /ðɪs/	[dɪz]		
	‘Green’ /gɹin/	[gwin]		

781 WS expands upon the <CVCV> template structure seen in 24 months during his 36 month session, as is seen in the examples in Table 7. He also uses <CVC> structures both with, and without, consonant clusters in the word-initial and word-final positions. Note that words beginning with [h] are starred because [h] is not always considered a true consonant, as reflected in the Phon analyses. However, when forms with [h] fit a child’s templates, these words are included in the phonological template charts. Once again, several processes are used in the adapted forms for both of 781’s templates. Final consonant deletion, weak syllable deletion, consonant cluster reduction, and epenthesis are all strategies that describe how the target forms were altered, and the templates explain why these alterations occur.

At 18 months, 781 WS utters four tokens within the half hour play session. Of these four words, three are monosyllabic <CV> words in which the initial consonant is a [b]. The fourth word has one <bV> syllable and one <dV> syllable. The targets for these utterances are words beginning with ‘b’, suggesting that 781 WS is only attempting words that contain a phone he is familiar with from babble. While his vowel production varies, the initial consonant in the <CV> sequences remains predominantly the same, as is revealed in Table 5.

In contrast to his 18-month session, 781 WS greatly expands his production abilities at 24 months. He no longer solely uses a <bV> structure for the majority of his syllables, but instead produces a wide range of structures and phones. Velars are especially prevalent in his productions, even in scenarios where they are not expected by the target word. Examples of this include [gagʊ] for 'soccer', [ki] for 'tree', and [gʌk], [gʌʔ], and [gɪk] for 'duck'. This provides evidence of a favored production pattern in which word-initial velars are present. Additionally, many of his words adopt a <CVCV> structure that is not present in the target forms. Words such as 'zebra', which is produced as [mibə], and 'alligator', which is produced as [ɛgɑgə], show signs of 781 WS applying a template to target words. These data suggest that this child is beginning to move beyond 'selection' and is now adapting forms to fit his familiar templates. Although [ɛgɑgə] does not perfectly match the <CVCV> pattern that appears to be prevalent in 781 WS's speech because of the initial vowel that is present in the produced form, vowel onsets are common in early stages of word production and therefore this example can be considered to be adhering to the child's routines. These words also show examples of several processes, including vowelization, syllable deletion, consonant cluster reduction, and consonant harmony, being used to achieve this template. In fact, in these data, there are no consonant clusters attested.

At 36 months, his production abilities exponentially expand. 781 WS now utters 252 words in the thirty-minute play session that evidence various syllabic structures and many different phones. For example, 781 WS now produces many more <CVC> structures, many of which have consonant clusters in either the initial or final position. He does not reduce all words to <CVCV> structure, but rather attempts to produce the entire word; examples of this include [tɛləfonz] for 'telephone', [gwæmpəs] for 'grandpa's', and [æmbəgəs] for 'hamburger'. While these utterances are not completely accurate with regards to the expected targets, they do suggest an increased usage of new forms, as consonant clusters and trisyllabic words are attested here.

Additionally, with more difficult words, such as ‘firetruck,’ which contains both a rhotic diphthong and a consonant cluster containing a rhotic, 781 WS does not produce any one consistent form, but instead alters the structure each time. ‘Firetruck’ is produced as [fʌkək], [fʌtwʌk], [ʧfɑɪəfə], [fɑɪfək], and [fɑɪəfək]. These forms all contain various phonological elements that are required to produce ‘firetruck’ as the target predicts. Perhaps this wordplay, when analyzed more closely, does in fact have some templatic elements to it. Of the five productions, four are bisyllabic vocalizations that have [f] in the word-initial position and [k] word-finally. This especially difficult target word is adapted, or modified, in an attempt to fit into the child’s patterns. Even with a different variation produced in each utterance, the overall consonant cluster reduction and lack of rhotics within the ‘f-onset/k-coda’ routine suggests signs of experimentation in his adaptation to the template.

Overall, it appears that 781 WS evidences a steady progression in his phonological development and shows signs of templatic structures. At 18 months he only attempts words within his <bV> structure. These words are selected based on the adult target form because they are readily accessible based on the child’s phonological system (Vihman, 2015). Then, as he ages, 781 WS begins to expand his templates, using more <CVCV> structures at 24 months and even <(C)CVC(C)> structures at 36 months. While his vocabulary expands, more of his productions show signs of being adapted to meet some of his more familiar structures, as seen in Table 7. As Vihman notes, these adaptations are hard to explain using typical phonological substitutions (2015). Phonological processes describe how specific templates are achieved, but templates highlight the motivations behind the use of those processes.

II. 3236 WS

Table 8. 3236 WS Developmental Summary

Age	Number of Words (tokens)	Phonetic Type-Token Ratio	% of Words that Include at Least 1 CV Sequence	% of Syllables that Include at Least 1 CV Sequence	% of Multisyllabic Words
18 MOS	61	0.46	62.3%	61.2%	9.8%
24 MOS	33	0.67	57.6%	54.4%	54.5%
36 MOS	415	0.56	66.0%	59.8%	33.5%

Table 8 shows certain features of production that are relevant to the development of 3236 WS during the first three years. It is interesting to note that this child uttered fewer words at 24 months than he did at 18 months. This could be due to non-linguistic factors within the play session environment (e.g., level of fatigue, interlocutor) and will not be considered to be a developmental issue. Once again, percentages should be analyzed in the context of the number of words produced. This child is rather precocious in comparison to many other children with Williams syndrome based on the data from his 36-month session, which will be discussed later in this section.

Table 9. 3236 WS Word-Initial Phone Development

3236 WS	Word-Initial Consonants
18 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ

Table 9 represents the development of consonants in word-initial position for 3236 WS. It is interesting to note that while the increase in phones is slight between the 18- and 24- month sessions, it does almost double between 24 and 36 months. Not all of the consonants present at 18 months are accounted for at 24 months, such as [n], [g], and [d], but this could simply be because the child did not attempt words with these phones in them. It is assumed that these phones are still present at 24 months, just not attested in the transcript.

Table 10. 3236 WS Word-Final Phone Development

3236 WS	Word-Final Consonants
18 Months	(ʔ) p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	(ʔ) p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ

Table 10 shows the word-final consonants that are attested in the three sessions for 3236 WS. The glottal stops in parentheses represent glottal stops that do not correspond to actual target consonants. Although 3236 WS does have glottal stops in the final position, these are not considered to be acting as true consonants because they are not attested in the target forms. More simply, if the target word structure ended with a vowel, rather than a consonant, and a glottal stop was present in the child's production, these glottal stops were not counted as actual consonants. This was done to follow current conventions within the literature, and because glottal stops are quite difficult to transcribe reliably in final position, especially. Additionally, 3236 WS uses glottal stops too infrequently in the word-final position to consider <CVʔ> as a possible template. Once again, it is crucial to note the rapid development that is evidenced in this child between the 24- and 36- month sessions.

Table 11. 3236 WS Phonological Templates at 18 Months

Template: <CV>	Adult Form	Child Form: Selected	Adult Form	Child Form: Adapted
[hV]	*‘Hi’ /haɪ/	[haɪ], [heɪ], [hɑ]		
[mV]	‘Moo’ /mu:/	[mu]		
	‘More’ /mɔɚ/	[mo]		
[jV]	‘Yeah’ /jæ/	[jæ], [jæʔ], [jɛʔ], [jɑ]		
Template: <CVCV>	‘Baby’ /ˈbeɪbi/	[geɪbi]		
	‘Daddy’ /ˈdædi/	[dɑdɪ]		

Table 11 shows the phonological templates attested in 3236 WS’s sample at 18 months. It is interesting to note that words are being ‘selected’, but not ‘adapted’. Additionally, within the <CV> structure, certain word initial consonants are favored, as is seen in Column 1.

Table 12. 3236 WS Phonological Templates at 24 Months

Template: <CVCV>	Adult Form	Child Form: Selected	Adult Form	Child Form: Adapted
	‘Baby’ /ˈbeɪbi/	[beɪbi], [bebe]		
	‘Bye-bye’ /ˈbaɪbaɪ/	[bʌbaɪ]		
	*‘Hello’ /hɛloʊ/	[həwo], [haɪjoʊ]		
	‘Mama’ /mɑmə/	[mɑmə]		
	‘Papa’ /pɑpə/	[pɑpə]		
	‘Yellow’ /ˈjɛloʊ/	[jɛwoʊ]		

Table 12 shows the words that fit the <CVCV> template that 3236 WS uses at 24 months. These words demonstrate an expansion upon the number of <CVCV> words used, when compared to this child's 18-month session. Again, all examples of this template are 'selected', not 'adapted'.

Table 13. 3236 WS Phonological Templates at 36 Months

Template: <CVCV(CC)>	Adult Form	Child Form: Selected	Adult Form	Child Form: Adapted
			'Elephant' /ˈɛləfənt/	[ˈɛfɪnt]
			'Butterfly' /ˈbʌɾɚˌflaɪ/	[ˈbʌˌfwaɪ]
			'Kitty cat' /ˈkɪɾi kæt/	[ˈkɪˌkæ]
			'Another' /əˈnʌðɚ/	[əðɚ]
Template: <CVC>	'Take' /teɪk/	[tek]	'Again' /əˈgɛn/	[gɛn]
	'Cake' /keɪk/	[keɪk]	'Gonna' /ˈgɑnə/	[gən]
	'Big' /bɪg/	[bɪg]	'Just' /ʤʌst/	[ʤʌs]
	'Chug' /ʧʌg/	[ʧʌg]	'Block' /blɑk/	[bɑk]
	'Sick' /sɪk/	[sɪk]		
	'Knock' /nɑk/	[nɑk]		
	'Good' /gʊd/	[gʊd]		
	'Like' /laɪk/	[laɪk]		
	'Knife' /naɪf/	[naɪf], [maɪf]		
	'Not' /nɑt/	[nɑt]		
	'Some' /sʌm/	[sʌm]		
	'Stuff' /stʌf/	[stʌf]		

Table 13 shows the two salient phonological templates evidenced in 3236 WS's 36-month sample. Weak syllable deletion, specifically of the middle syllable, is seen in all adapted forms within the <CVCV(CC)> template. In all but one case, the output is CVCV; in fact, final consonant deletion is sometimes used to achieve that simpler form. For the <CVC> structure, there is only one case of a consonant cluster ('stuff') attested in the transcript, which shows some variation from the frequent use of consonant clusters in 781 WS's data. The phonological processes used to adapt the target word forms within this template are consonant cluster reduction and vowel deletion.

At 18 months, this child seems to be using a few templates to produce the majority of her words. Many variations of the word 'more' are produced using a <mV> structure. A reliance on <CV> structures also is attested for words like 'yeah', where the structure is <jV>, and 'hi', for which the structure is <hV>. It seems that 3236 WS is only attempting to produce words that fall in this basic <CV> structure for much of the sample. Later in the session, she begins to produce variations of words with <CVCV> syllabification. Although not all of these words adopt the expected target form in terms of phonetics, they are words that are expected to have a <CVCV> structure. Examples of these are 'baby' as [gVbV] and 'daddy' as [dVdV]. Thus, she is selecting words with one or two simple open syllables, as shown in Table 11.

3236 WS does not evidence drastic development between 18 and 24 months. She continues to use the basic <CV> syllabification pattern but does attempt a more diverse list of target words that adapt to this structure. For example, she says 'ball' as well as 'phone' without the final consonant. 'Cup' is the only 'phonological idiom', or early word, that is not consistent with other aspects of the child's phonological patterns (Velleman 2016), in that it is consistently produced with the true word-final consonant, although “yeah” is sometimes produced with a glottal stop. Her use of <CVCV> patterned words also increases as she tries more words that have this structure or a similar one in the target forms. For this template, she is primarily selecting words, not adapting them. Notably, ‘yellow’ and ‘mama’ are produced in addition to the previously attested ‘baby’ and ‘daddy’. A few more complex words are produced, such as ‘broccoli’ as [bɑkowi], in which the rhotic cluster is simplified and the lateral liquid is replaced with a [w], resulting in a <CVCVCV> form.

The increase in phonological ability between 24 and 36 months is explosive for 3236 WS. Not only does this child utter over 300 tokens more than the previous sessions, but there are also several more complex phonological elements in her speech. Perhaps the most noticeable difference is the presence of sentences and phrases, such as ‘I like squirrels’, ‘I gonna knock’, ‘he’s feel good’, ‘find a green’ and even ‘let’s go make a building’. These strands of words suggest a big leap between her first two sessions and these data. While the initial <CV> template attested at 18 months is still present, its influence is much weaker. This child is now not only attempting but even producing words containing consonant clusters, final consonants, and multiple syllables. Examples of this are [skwɝːl] for ‘squirrel’, [ˈtɹaɪjɛngəl] for ‘triangle’, and [ˈbʌˌfwaɪ] for ‘butterfly’. As one can see, these forms are quite close to the target words. Although these rather advanced forms are present and accurate in her speech, 3236 WS also has many templatic forms. For example, many of her iambic disyllabic words beginning with a vowel have a consonant inserted word-initially; the word ‘again’ is produced in variation as [nɪˈgɛn], [dɪˈgɛn] and [təˈgɛn]. This pattern can be represented as: <CVCVC>.

As is shown in Table 13, <CVC> structures also become much more prevalent in this child’s speech by 36 months. Of the 415 words produced in the session, 74 were of a <CVC>

structure. This means that this pattern is attested in almost 18% of her words. It also seems that within this template, 3236 WS no longer has favorite word-initial consonants that she uses, but rather a wide array of consonants that she is comfortable using. Even more complex phones, such as [ʧ], [s], and [l] are found in the initial position.

Within the <CVCV(CC)> template, the adapted forms all undergo the phonological process of weak syllable deletion, omission of the middle unstressed syllable. Single-word trochaic targets, such as ‘elephant’ or ‘butterfly’, are altered to fit the <CVCV(CC)> templatic structure, producing [ˈɛfɪnt] or [ˈbʌˌfwaɪ], respectively. However, 3236 WS also says multiword vocalizations in which the middle weak syllable is deleted. For example, ‘kitty cat’ becomes [ˈkɪˌkæ], as revealed in Table 13. This type of adaptation is commonly attested in words and phrases in the literature, even in adult casual speech. Macken (1979) notes that many two-word utterances can become one shorter two syllable vocalization in which only one syllable of each word is present. The <CVCV(CC)> template is prevalent within 3236 WS’s speech throughout the 36-month session, but this phonological strategy is especially interesting to look at as a method for achieving this templatic structure.

This child definitely appears to be using templatic structures throughout her phonological development. What begins as <CV> structures with a fixed initial consonant, such as [hV] and [jV], progresses to more complex <CVCV> structures. Between 24 and 36 months a threshold of development seems to be crossed, as now 3236 WS is attempting many more structures and using a variety of potentially templatic forms. Word-initial consonant insertion, middle-syllable deletion and the previously discussed patterns are all prevalent throughout the session.

III. 3262 WS

Table 14. 3262 WS Developmental Summary

Age	Number of Words (tokens)	Type-Token Ratio	% of Words that Include at Least 1 CV Sequence	% of Syllables that Include at Least 1 CV Sequence	% of Multisyllabic Words
18 MOS	2	0.50	0.0%	0.0%	0.0%
24 MOS	6	1.00	50.0%	50.0%	33.3%
36 MOS	119	0.55	78.2%	70.8%	25.2%

Table 14 shows the relevant information related to phonological development for 3262 WS. This child shows perhaps the most consistent increase in use of <CV> sequencing over time, but this is partially due to the fact that he utters very few words in the first two sessions.

Table 15. 3262 WS Word-Initial Phone Development

3262 WS	Word-Initial Consonants
18 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	ʔ **p** b m n h w **k** g d t ŋ f **j** ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	ʔ **p** **b** **m** **n** **h** w **k** **g** d t ŋ **f** **j** ʧ ʃ ʒ ɹ l s z **v** ð θ ʤ

3262 WS demonstrates a steady progression of phone acquisition, as revealed in Table 15. The first session did not have evidence of any word-initial consonants. The most development is seen between the 24- and 36- month sessions, where 7 phones are added in the word-initial position. Many of these are nasals and stops, as is expected based on previous studies, such as Stoel-Gammon (1985).

Table 16. 3262 WS Word-Final Phone Development

3262 WS	Word-Final Consonants
18 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	(ʔ) p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ

Table 16 depicts the word-final consonants present during each of the three play sessions. There are no final consonants in the first session, but he gradually adds more. However, there are still not many instances of most of these phones. In the 36-month sample, [p] and [s] were the most prevalent phones in final position due to frequent target words such as ‘poop’, ‘pop’, and ‘please’. Note that the glottal stop was not treated as an actual consonant in the 36 months session in this analysis, because the target words that corresponded to the uttered words did not have consonants in this position. Additionally, of the 119 tokens produced, less than 4% had glottal stops in the word-final position.

Table 17. 3262 WS Phonological Templates at 36 Months

Template: <CV>	Adult Form	Child Form: Selected	Adult Form	Child Form: Adapted
	‘Cow’ /kaʊ/	[kaʊ]	‘Ball’ /bɑl/	[ba]
	‘No’ /no/	[no]	‘Pop’ /pɑp/	[pʌ], [pɑ]
	‘Yeah’ /jæ/	[jæ], [jɛ]	‘Please’ /pli:z/	[pi]
			‘Truck’ /tɹʌk/	[kʌ]

Template: <CVC>	‘Big’ /bɪg/	[bɪk]	‘Please’ /pli:z/	[pis]
	‘Book’ /bʊk/	[bʊk]		
	*‘Hat’ /hæt/	[hæt]		
	‘Make’ /meɪk/	[mek]		
	‘Poop’/pu:p/	[pu:p]		
	‘Pop’ /pɑp/	[pʌp]		
	‘Shoes’ /ʃuz/	[sus]		

Table 17 shows the templates seen in 3262 WS’s 36-month session. Because the first two samples for this child did not have strong evidence for phonological templates, tables for these two sessions will not be included. Even in this session, most words are ‘selected’ by the templatic structures, with the exception of a few examples of final-consonant deletion and one example of consonant cluster reduction, as seen in the ‘adapted’ columns. Of the adapted forms, most demonstrate use of consonant cluster reduction or consonant deletion word-finally, while one also results from migration of the final /k/ to initial position. The same consonants ([p, k]) that are deleted or moved to achieve the <CV> template in some word tokens in Table 17 are actually produced in the examples of the <CVC> template in other word tokens.

At 18 months, 3262 WS shows evidence of the earliest form of sound-meaning association. The target word ‘woof’ is being uttered as [ʌ]. Not only is this production a very simplified version of the expected target form, but it also is in reference to a word that might not truly be considered a word in all contexts. This ‘word’ is actually a vocal representation of an animal sound, which does not meet all the criteria outlined in the methodology for the definition of a word. However, it does meet the majority of the criteria outlined by Vihman and McCune (1994) in Appendix B. For the purposes of this study, 3262 WS was included to demonstrate the highly variable spectrum of development in these early stages of speech. Because only two 'words' are attested in this session, there is not enough data to determine whether or not this child is using templates in his speech. Even though the structure of both words, which have the same target, are monosyllabic <V> vocalizations, generalizations about his speech cannot truly be made. Instead, this session serves as a baseline for comparison, not only for this child, but also for some of the other subjects who evidence more advanced phonological skills at 18 months.

Six word tokens are produced at 24 months and each of these tokens has a different form, giving a type-token ratio of 1.0. This is quite different from the other children in this study, who typically have lower type-token ratios because many of their vocalizations are attempts at the same target word. 3262 WS does not appear to be using templatic forms, but rather is simply attempting to produce the adult forms, which are all quite different from each other. 'Pictures' [pɪtsə], 'thank' [ɪŋkə], 'out' [aʊt], and 'egg' [ɛg] are some of these target forms; while one could postulate that word-final consonants are being favored, the child's productions do not always end with a closed syllable. For example, [ɪŋkə] for 'thank' has the nasal-velar consonant cluster that is predicted in the target form, but also has an appended vowel at the end of the vocalization.

It is also interesting to note that some of these six words, such as 'out' and 'egg,' are produced accurately, with regards to the adult target form. While the other subjects in this study have a larger number of words produced at 24 months with varied success, this child's word forms appear to be closer to their targets. This is consistent with the claim by Ferguson and Farwell (1975), Vihman and Velleman (1989), and others that the first few words are more accurate but not yet systematic. It is still not appropriate to designate any of the words as 'selected' or 'adapted'; they appear to be idiosyncratic and structurally unanalyzed.

At 36 months, many more words are attested and several phonetic forms are repeated multiple times in the session, giving a phonetic type-token ratio of 0.55. ‘No’, ‘cow’, ‘shoes’, ‘pop’ and ‘poop’, ‘on’, and ‘ball’ are all examples of such favored words. As one can see, most of these words are monosyllabic words with an initial consonant. Because of this common target word form, over 78.0% of words in the session include a <CV> sequence. Additionally, 40.3% of words end with a consonant, which follows the trend seen in the limited data observed at 24 months. Overall the majority of this child’s word forms are adapted or selected to the monosyllabic <CV> or <CVC> structure. His ‘selected’ or ‘adapted’ forms for this age are shown in Table 17.

The consonant and vowel repertoires for these words are also much more robust, with 12 individual consonant phones and 17 individual vowel sounds present in the words uttered. In fact, this child uses lots of variation in vowel and consonant sounds when attempting the same adult target form. For example, ‘bubble/bubbles’ are vocalized as [bʌbus], [pʌpʌ], [bʌbʊ], and [bʌbəs]. ‘Poop’ is realized as [ʌʃupup], [əʃupup], [ʌpup], [ijʌpup], and [pup]. In these two examples, back vowels are interchanged within the same word, bilabial consonant voicing is altered across vocalizations of the same target, and additional syllables are added. This wordplay is an indication of phonological reorganization; as 3262 WS ages, he begins to experiment with word forms. This experimentation relates back to Vihman and Velleman’s (1989) study in which it was postulated that the subject, Molly, followed four steps in her phonological reorganization; 3262 WS’s wordplay is consistent with stage 2: experimentation with target word formation.

There are a few possible explanations for this word-play and also the simple nature of the forms produced. As was previously noted, the other participants were demonstrating more advanced syllabification and phonological patterns at 36 months. In contrast, 3262 WS uses primarily monosyllabic <CV> or <CVC> forms. This is a reflection of this child's pace of acquisition, which is somewhat more delayed than that of the other participants with Williams syndrome. He had very few words at both 18 and 24 months, so he is still reliant on very simple templatic structures at 36 months. It is not possible to determine whether this child is exhibiting any apparent regression in this play session because of the sparsity of data witnessed at earlier stages.

IV. 2668 WS

Table 18. 2668 WS Developmental Summary

Age	Number of Words (tokens)	Type-Token Ratio	% of Words that Include at Least 1 CV Sequence	% of Syllables that Include at Least 1 CV Sequence	% of Multisyllabic Words
18 MOS	10	0.60	0.0%	0.0%	20.0%
24 MOS	15	0.73	66.7%	62.5%	53.3%
36 MOS	85	0.61	35.3%	36.5%	16.5%

Table 18 shows the developmental summary for 2668 WS across the three sessions. It is especially interesting to note that in her 36-month session very few words were multisyllabic. While some of the other participants had a low percentage of multisyllabic words at 36 months, primarily due to the presence of function words, 2668 WS exhibits a low percentage due to her simple target words that frequent the transcript, such as 'hi', 'no', and 'yeah'. Note that the percentages of words and syllables including a <CV> sequence are 0% at 18 months because [h] is not considered a true consonant for this analysis.

Table 19. 2668 WS Word-Initial Phone Development

2668 WS	Word-Initial Consonants
18 Months	ʔ p b m n **h** w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	ʔ **p b m** n h **w** k **g d** t ŋ **f** j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
36 Months	ʔ **p b m n h w k g d t** ŋ f **j** ʧ ʃ ʒ ɹ **l s** z v ð θ ʤ

There is a steady progression in the number of phones used word-initially by this child over the course of the three sessions, as seen in Table 19. In the first session, as was previously seen in the developmental summary in Table 10, only [h] was produced. In the next two sessions, more stops and nasals are present, as is expected based on typical phone acquisition trajectories.

Table 20. 2668 WS Word-Final Phone Development

2668 WS	Word-Final Consonants
18 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l s z v ð θ ʤ
24 Months	ʔ p b m n h w k g d t ŋ f j ʧ ʃ ʒ ɹ l **s** z v ð θ ʤ
36 Months	**ʔ** p b **m n** h w **k** g d **t** ŋ f j ʧ ʃ ʒ ɹ l **s z** v ð θ ʤ

Table 20 represents the number of phones attested in word-final position for each of the samples; not many are seen throughout the three sessions. In fact, besides one token in the 24-month session and 10 tokens in the 36-month session, all other productions were lacking a final consonant.

2668 WS exhibited very little variation in her initial 18 month play session. Of the 10 words uttered, seven were monosyllabic word variations of ‘hi’. These seven productions all had an <hV> syllable structure with varying vowel sounds following the consonant. The other three words did not have consonant sounds in them, as the target words did not contain supraglottal consonants (e.g., ‘uh-oh’), but were either mono- or disyllabic vowel vocalizations. This common <CV> syllable structure, in which one consonant is favored, is similar to what we see in the data provided by both 3236 WS and 781 WS’s 18 month play session transcripts.

The data provided at 24 months suggests some expansion within this child’s phonological system. Not only does she attempt more adult target words, including ‘fish’, ‘meow’, ‘pizza’, ‘quack’ and ‘thank you’, but she also uses a greater variety of consonants and vowels. For the aforementioned target words, 2668 WS produces tokens that are fairly similar to the target forms. She says ‘meow’ as [miaʊ], ‘uh-oh’ as [ʌʔo], and ‘pizza’ as [piz.ɑː]. Like 3262 WS, this child’s word forms appear to be closer to their targets. This is again consistent with the claim that the first few words are more accurate but not necessarily ‘selected’ or ‘adapted’; they are idiosyncratic and structurally unanalyzed. Only one word, ‘quack’, shows signs of being ‘adapted’ to a <CV> structure, but this could simply be an idiosyncratic occurrence. For this reason, a phonological template table is not included for this sample.

In contrast to her first session, 2668 WS produces many multisyllabic words at 24 months; 53.3% of the tokens were multisyllabic in this sample. It is important to note, though, that many of these multisyllabic words contain a <V> syllable in the final position, such as [miaʊ], and are therefore not complex in form. Additionally, more phones are attested in the word-initial position, especially stops and nasals. While this child does have one instance of word-final [s], there are no other instances of word-final consonants at 24 months.

At 36 months, 2668 WS utters 85 words. In comparison to the other samples that were produced at 36 months, this child has less multisyllabic harmony, with only four instances of consonant harmony and three instances of vowel harmony attested. Additionally, many of the utterances have the same target word: ‘yes’ or ‘yeah’. There are variations of these two target forms being realized in the child’s production, as ‘yes’ is uttered as [jɛs], [jːɛs], and [jʌs], whereas ‘yeah’ is evidenced as [jæ], [jɛ], [jɑ], and [jʌ]. Over 34% of the total tokens are one of these variations. In contrast to 3262 WS, who is using wordplay and experimentation with more difficult words, this child is experimenting with different vowel sounds in words that have a more simple syllabic structure. In fact, the majority (83.5%) of the words observed in this sample are monosyllabic, with only 14 having multisyllabic structures and the average number of syllables per word being 1.22.

2668 WS does show progress over time, but it is unclear whether this progress is related to templates within her phonological systematization. Across all three of her sessions, only one word is ‘adapted’. This sole token, found in the 24-month session, may suggest ‘controlled expansion’, but not phonological template usage. In the 36 month session, she either only selects words that have a <CV> structure or executes the target word form quite successfully (e.g. 'oink' [ɔɪŋk]; 'house' [haʊs]). While this could point to a <CV> template in her phonological system that she is selecting for, the sparsity of data makes this conclusion difficult to make. Based on these data, phonological template charts were not made for 2668 WS, because it is unclear whether or not they are having an impact on her development.

V. Summary of Participants

Tables 21-27 compile all four children’s results and summarize the findings at each age in question. For example, the ‘18 MOS’ row of table 21 represents the mean, range, and standard deviation of all four subjects’ number of words during the 18-month session. Standard deviations were calculated to two decimal values to stay consistent with the results produced using the Phon analyses.

Table 21. Number of Words (tokens) Summary for all Participants

Age	Mean	Range	Standard Deviation
18 MOS	19.25	2-61	28.04
24 MOS	29.25	6-63	25.14
36 MOS	217.75	85-415	149.90

Table 22. Phonetic Type-Token Ratio Summary for all Participants

Age	Mean	Range	Standard Deviation
18 MOS	0.64	0.46-1.00	0.25
24 MOS	0.79	0.67-1.00	0.14
36 MOS	0.60	0.55-0.66	0.05

Table 23. % of Words Including a CV Sequence Summary for all Participants

Age	Mean	Range	Standard Deviation
18 MOS	40.58%	0-100	49.32
24 MOS	64.59%	50.00-84.10	14.68
36 MOS	61.25%	35.30-78.20	18.30

Table 24. % Syllables Including CV Sequence Summary for all Participants

Age	Mean	Range	Standard Deviation
18 MOS	40.30%	0-100	45.16
24 MOS	61.77%	50.00-80.20	13.33
36 MOS	57.75%	36.50-70.80	14.87

Table 25. % Multisyllabic Words for all Participants

Age	Mean	Range	Standard Deviation
18 MOS	13.71%	0-25.0	11.11
24 MOS	44.80%	33.30-54.50	10.70
36 MOS	27.43%	16.50-34.50	8.39

Table 26. Word Initial and Word Final Consonant Summaries for all Participants

Age	Word-Initial Consonants Mean	Word-Initial Consonants Range	Word-Initial Consonants SD	Word-Final Consonants Mean	Word-Final Consonants Range	Word-Final Consonants SD
18 MOS	2.0	0-6	2.71	0.0	0-0	0
24 MOS	7.3	3-11	3.30	1.5	1-2	0.58
36 MOS	15.5	10-20	4.80	10.5	7-15	4.12

Table 26 shows the average of all four children's numbers of word-initial and word-final consonants at each age, as well as the range and standard deviation for these averages, respectively. It is important to note that when calculating these averages, [h] was included as a consonant. Additionally, if it was determined that [ʔ] was not an actual consonant, based on the adult target word form, then it was not included as an actual consonant in these calculations. In instances where glottal stops were behaving as actual consonants, they were included in the total phone count for the child at the appropriate age.

Table 27. Common Template Forms by Child Age

<CV>	<CVCV>	<CVC>
781 WS - 18 MOS 3236 WS - 18 MOS 3262 WS - 36 MOS (2668 WS - 36 MOS)	781 WS - 24, 36 MOS 3236 WS - 18, 24 MOS	781 WS - 36 MOS 3236 WS - 36 MOS 3262 WS - 36 MOS

Table 27 shows the templates that were used by more than one child and the ages at which each was evidenced in the data. This chart makes it quite apparent that 3236 WS and 781 WS produce templatic structures earlier and more frequently than the other two participants. The developmental course that 3236 WS follows is quite similar to that of 781 WS; both subjects begin with simple <CV> structures and then expand to more complex templates, such as middle unstressed syllable deletion and <CVC> forms with consonant clusters in word-initial and word-final position (expressed as: <(C)CVC(C)>). Although the two children have slightly different preferred phones and structures, it can be concluded that phonological patterning is occurring for both children. In contrast to these children, 3262 WS and 2668 WS provide less data that point towards the usage of templates. In fact, 3262 WS does not provide evidence of emerging templates until his 36-month session, during which selected and adapted forms for both <CV> and <CVC> forms are present, as seen in Table 17. The data from 2668 WS's sessions does not indicate the use of templates at all, because of a lack of 'adapted' words. For this reason, 2668 WS is shown in parentheses in Table 27, because she does use <CV> forms consistently, but it is unclear whether these are templatic or not.

Discussion

When analyzing the speech of the children with Williams syndrome in this study, patterns begin to emerge within each child's speech with regards to phonological systematization. Although the onset of speech in these children is rather delayed in comparison to that of typically developing children, there is evidence of templatic structures being used to produce the early vocalizations observed in the play sessions of this study. 781 WS and 3236 WS provide the clearest indications of phonological reorganization through the use of templates with their gradual progression from <CV> structures, in which specific consonants are favored, to more complex forms. As seen in children who are typically developing, a variety of processes may be used to achieve a single templatic goal. While the samples provided for the other subjects suggest the possibility of templatic forms, the data are not completely conclusive.

Previous studies that have looked at templates in phonological systematization do not provide a large body of data regarding how children with Williams syndrome 'reorganize'. However, the general trends seen in typically developing children can be compared to the data collected in this study. Vihman (2016) notes that, 'the first templatic pattern of many children is simply <CV>' (n.p). This claim is supported by the participants in this study, as 781 WS and 3236 WS use <CV> templates as early as 18 months, while 3262 WS uses this form at 36 months, and 2668 WS shows potential emergence of this structure in her final session. Perhaps this is related to why the canonical syllable is a <CV>, and why canonical babble in the <CV> form is a typical precursor to syllabified speech. The data seen in these atypically developing participants suggests that these templatic forms are part of a larger ontological process related to overall language acquisition.

In contrast to previous studies by Menn (1976), Stoel-Gammon and Cooper (1984), and Vihman (2016), consonant harmony was not a salient feature of these children's templates. Whereas <C_1VC_1V> structures were frequently evidenced cross-linguistically in these previous studies, they were not strongly attested in the four participants with Williams syndrome. Perhaps some of the productions that 3236 WS uses at 24 months, as shown in Table 12, could be considered signs of the emergence of this template. There are four examples of consonant harmony in this sample: 'baby', 'bye-bye', 'mama', and 'papa'. Yet, all these examples are 'selected' based on their target word form, and the <CVCV> template also applies to two other words that do not have harmony (in the adult form or by the child). Consonant harmony is also seen as one of the phonological processes that 781 WS uses to achieve the adapted forms for structures containing velars word-initially. This points to the importance of consonant harmony as a strategy used to alter adult target words to fit a child's templates. This possibly suggests that even if consonant harmony is not a templatic form in a child's phonological reorganization, it may still affect the output forms a child produces.

It is also crucial to note that the subjects in these other studies begin their phonological systematization much earlier than the children with Williams syndrome in this study, as is expected. For example, the participants in Stoel-Gammon and Cooper's (1984) longitudinal study were on average 11 months old when the study began and 17 months old when the study ended. By the end of this 6-month study, at least 50 different adult targets words (types) were produced by each child. This greatly contrasts with the children in this study who had an average of 19.25 meaningful vocalizations (tokens) at 18 months, many of which were attempts at the same target word.

Typically developing children in other cases also exhibit signs of stable production patterns much earlier than the participants with Williams syndrome. In Vihman and Velleman's (1989) diary study of Molly, a typically developing female, it was found that by 15 months, she had consistent production patterns that were applied to many adult target words. This greatly contrasts with how children such as 3262 WS and 2668 WS have developed, as they do not even have stable patterns by 36 months.

While the development of phones is also delayed for these children with Williams syndrome, they do follow the typical trends seen in phonetic acquisition overall. The results provide evidence of the individual variation in phonological development, but also point to the 'universal phonetic tendencies' mentioned by Ferguson and Farwell (1975). Each child has his own preferred patterns of production, especially in the later sessions. However, as is clearly visible in the phonemic development charts, consonants generally are acquired in order from simplest to more complex consonants (i.e. from left to right across each row). In addition, the children's early phonotactic forms were similar to trends seen in typically developing children, such as the frequent use of <CV> syllables in the first words. This suggests that there are somewhat 'universal phonetic tendencies' due to the anatomy of the human vocal tract and motor control. However, the children also follow their own unique trajectories of development, based on their "individual strategies and preferences and an idiosyncratic lexicon" (Ferguson & Farwell, 1975, p. 437).

There are a few important limitations in the methodology of this study. For each child, one 30-minute play session was used at each of the three ages of interest. While this method allows for consistent data collection, it may not always be representative of the overall speech capabilities of a child at any given age. For example, non-linguistic factors such as social and emotional influences could alter the number of utterances a child produces. When a child is put in a new environment, such as that of the playroom, and with an unknown adult, his production may be drastically different from when he is in the assumedly more comfortable environment of his home. It is especially important to note that the presence of research assistants, rather than parents, could have altered the environment, even though children with Williams syndrome are rather outgoing around strangers. In order to keep external variables consistent for all subjects involved, data collection through moderated play sessions, such as those in this study, is a commonly accepted method. Such factors could possibly have impacted 3262 WS more than the other participants, explaining why he had so few words in both his 18- and 24- month sessions. However, his word usage was much lower than that of the other three participants in all three sessions. Thus, it seems more likely that he was simply more delayed than they.

As was mentioned in the methodology of this study, the exact chronological ages for each child deviated slightly from the targeted 18-, 24-, and 36-month benchmarks. The difference of a few weeks or months at this stage in development could greatly affect a child's linguistic competence. Yet, as we see with 3262 WS, who is about 38-months old in his third session and is just beginning to show the emergence of templates, or 781 WS, who is 21-months old in his second session but producing a multitude of structures, chronological age is not always the best predictor of development for children with Williams syndrome. Therefore, the differences in age due to availability of the child for data collection are not considered a major limitation to the conclusions drawn.

The classification of glottal stops as consonants only when the target word also had a final consonant also poses a few issues. The rationale behind this decision lies mainly in the unpredictable nature of this phone and the current conventions within the field. Glottal stops tend to have relatively poor transcription reliability based on how variable their presence is in different research assistant's transcriptions. Glottal stops are also one of the first phones that most children develop, even within earlier stages when speech is less voluntary. While the methods used in this study reflect the current conventions within the field, it is not yet clear exactly how this phone should be handled when analyzing transcripts. For example, other consonants that are not predicted by a target form are still treated as such when found in the child's output. Vowels that do not correspond to vowels in the adult target form are still relevant to the analysis. If glottal stop had been treated as a consonant in all environments, then some of the participants, such as 3236 WS, would have had evidence of closed-syllable templates (<CVC>) at an earlier age. These issues are important to recognize, but ultimately the accepted methods were used in order to compare this data as efficiently as possible to the current literature.

It is also crucial to note that the sample size for a study of this nature would ideally be much larger, in terms of the number of subjects and the number of sessions. Within the greater pool of data in Dr. Mervis and Dr. Velleman's research, these four subjects were the only children with Williams syndrome in the study to date who had words at 18, 24, and 36 months, respectively. Thus, these four participants are actually precocious within the context of Williams syndrome because of the presence of words at 18 months. Some children with Williams syndrome may behave more like 3262 WS, who was the most delayed of the four subjects, while others may not even have words until 36 months.

It is not uncommon for studies related to phonological systematization to have very few subjects; in fact, many studies have taken a 'diary' approach and simply tracked the development of 1-2 children over time (Vihman, 2016). Yet, when observing solely four subjects, it is hard to draw larger conclusions or make generalizations to an entire population. Three sessions over the course of three years may also have yielded unrepresentative results. As Vihman (2016) notes, the time of onset and length of reorganization remains fairly unknown. In children with a delayed onset of speech, such as those in this study, it is even more unpredictable to determine exactly when templatic structures are most prevalent. To ameliorate this in the future, perhaps shorter intervals between sessions could be adopted.

These data instead serve as a set of case studies looking at the individual trajectories that these four children have followed. This study adds to the body of literature regarding templates in phonological systematization by applying this theory to a more specific population. It supports the validity of templatic analysis by demonstrating that, for this population as well as for children who are typically developing, while processes may be used to describe children's error patterns, templates highlight the underlying causes of those processes. As Vihman and Velleman (1989) note, "emerging phonological systems must be studied in greater detail if we are to understand how the child gets 'from here to there'; from whole words to segments" (p. 150). So too, it should be added, must the phonological systems of children with Williams syndrome and other neurodevelopmental disorders be studied in order to better understand not only their pathway to speech, but its relation to the pathway taken by typically developing children. In looking at an atypically developing population, we see that templates do appear to be prevalent, suggesting that this phenomenon is relevant to all forms of phonological acquisition, however delayed.

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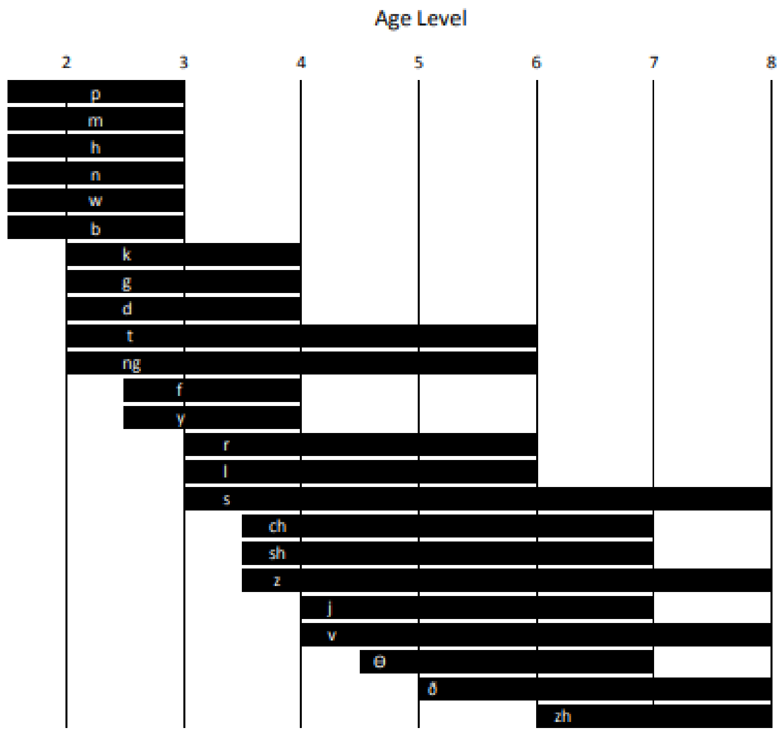
Appendix A.



The above chart shows a relative trend of phoneme development in typically developing children, taken from Sander 1972.

Appendix B.

Word Identification Criteria (Vihman and McCune, 1994, p. 149-50)

I. Criteria Based on Context

1. Determinative context: Does at least one use occur in a context which strongly suggests that word and no other?

Applies only to words with specific meanings easily identifiable in context, including most concrete nouns and many relational words. Does not apply to an imitative response to a purely verbal stimulus.

2. Maternal identification: Does the mother identify at least one instance of the form as a token of the hypothesized word?

Identification need not be explicitly intended as such; it could involve the mother acknowledging a particular word by continuing the conversation or by rejecting the child's word choice as an error.

3. Multiple use: Does the child use the word more than once?
4. Multiple episodes: Is there more than one episode of use?

Multiple uses are identified only in determinative contexts, and with similar phonological shapes across different uses.

II. Criteria Based on Vocalization Shape

1. Complex match: Does the child form match more than two segments of the adult form?

Credited if three segments match, or two non-nasal segments plus nasality match a model which includes a nasal, or vowel length or an off-glide match the complex nucleus of the model, in addition to the basic two-segment match. Also applies if a second consonant matches in manner of articulation but not in place, or vice versa.

2. Exact match: Is there at least one instance that even an untrained ear would recognize as an instance of a word?

Credited if the child form neither clearly omits, adds, nor substitutes segments in relation to the model (again disregarding voicing). Reflects the probable judgment of a non-specialist that a particular word is intended.

3. Prosodic match:

(a) To model: Is there a tuneful match with the adult target?
(b) Across tokens: Is there a characteristic tune which fits the word-meaning and occurs across all suspected tokens?

Credited when the child uses a special vocal effect (growl, squeak) repeatedly, in pragmatically plausible contexts, for the same probable word (lion, mouse).

III. Relation to Other Vocalizations

1. Imitated tokens: Is at least one instance imitated?

Credited if imitation is produced with apparent understanding.

2. Invariant: Do all instances of the word exhibit the same phonological shape?

Phonetic identity evaluated b the principles applied for phonetic match in general and for ‘exact’ in particular.

3. No inappropriate uses: Do all uses occur in contexts which plausibly suggest the same word?

Scored if candidate form is not used in conflicting contexts (no homonymy) or outside of any plausible context.

Appendix C.

# of words / session
type / token ratio
# of unique initial consonants
# of unique final consonants
# of unique vowels
% of words that include a CV sequence
% of words that include at least one CC sequence
# of syllables / word
% of syllables that include a CV sequence
% of syllables that end with a C
# of words with at least two syllables
% of words with at least two syllables and some consonant harmony
% of words with at least two syllables and some vowel harmony
# of CVC words
% of CVC words with consonant harmony

This image shows the full list of items that were analyzed for each transcript in the Phon program written by Yvan Rose and Gregory Hedlund.