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CORONAL UNDERSPECIFICATION AND THE UNDERSPECIFICATION OF UNDERLYING FORMS IN CHILDREN WITH SPEECH SOUND DISORDERS

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Abstract: Little research has been conducted on the underlying forms of children with Speech Sound Disorder. This study has two key aims: (i) to explore whether the underlying forms of children with SSD are underspecified in comparison to typically-developing children and (ii) examine whether the hypothesis that [coronal] is the default place of articulation feature. Using the corpus data from PhonBank, the Syllable Repetition Task is used to study alternations from the target no word to the produced nonword, specifically alternations from labial consonants to other labial or coronal consonants. It is suggested that labial consonants contain more features than coronal ones and are therefore more specified. The present study predicts that when processing demands are high, labial consonants will be pronounced as coronal to relieve those pressures. Children with SSD are therefore predicted to have a higher number of labial to coronal alternations because they are assumed to have underspecified underlying forms comparatively to TD children. A distributional analyses and a logistic regression analyses support these claims. Indeed, children with SSD do produce more labial to coronal alternations than TD children. This provides evidence for the underspecification of underlying forms in children with SSD. Support is found for the proposal that [coronal] is the underspecified default place of articulation for consonant phonemes, and this effect is statistically significant. Further research in this field will help improve identification of SSD in children and help to minimise the negative effects on children with SSD and their families.

Keywords: underspecification, speech sound disorders, coronal underspecification, phonological processing, phonological working memory, phonological awareness, features

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1. Introduction

With SSD being reported as one of the most common communication disorder amongst children (Broomfield and Dodd, 2004), one might expect that a great deal of research has been conducted on this communication disorder. While this is generally true, it is only partially true when considering research on the underlying forms of children with SSD. Most research on the underlying forms of disordered populations has been conducted on children with SLI and dyslexia (Claessen, Kane and Leitão, 2013; Ramus et al. 2012). Phonological research on children with SLI and Dyslexia have suggested the underlying form may be underspecified. UT states that predictable features are omitted from the underlying form and only contrastive, unpredictable and distinctive features will be specified. An underlying form, often referred to in the literature as an underlying or phonological representation, is the "abstract mental representation of a linguistic unit" as defined by Kennedy (2017: 6). Faulty underlying forms develop from inaccurate perception of the input. This means they may contain less feature information than adult-like underlying forms.

Little research has been conducted on the underlying forms of children with Speech Sound Disorder (SSD). Bauman-Waengler and Garcia (2018: 2) defines SSD as referring to those who suffer from sound production difficulties and includes articulation disorders, phonological disorder and motor speech disorders. Specifically, articulation disorders concern sound production difficulties while phonological disorder refers to deficits in the underlying phonological system. Recent studies have found support for the findings that underlying forms are underspecified in developmental populations (Cummings, Wu and Ogiela, 2020; Roepke et al., 2020).

Researchers Broomfield and Dodd (2004: 311) in their study at Newcastle University found that the most common communication disorder diagnosis was for "speech difficulties (29.1%), followed by receptive language difficulties (20.4%) and expressive language difficulties (16.9%)". It is clear from these figures that speech difficulties are very prominent for many children during language acquisition. This underscores the importance of studying a range of speech difficulties, such as SSD. Furthermore, low quality and imprecise underlying forms may present in the inaccurate production of words and persist in literacy acquisition (Claessen, Kane and Leitão, 2013: 475; Swan and Goswami, 1997: 337).

1.1 Underspecification Theory

There are several approaches to UT, including the radical, contrastive and 'modified contrastive' approaches, which are outlined in detail in section 2. One model that utilises UT, the Featurally Underspecified Lexicon (FUL) proposed by Lahiri and Reetz (2010), assumes the underspecification of the [coronal] place of articulation of feature. It is proposed as the default place of articulation feature because of its lack of features in the underlying form.

1.2 The Special Status of Coronals in English

In UT, the coronal place of articulation is often proposed as the default place of articulation because it lacks place features in comparison to labial and dorsal consonants. In autosegmental analyses of place of articulation features, studies suggest that [coronal] lacks Place Nodes because of the variation it presents. Wheeldon and Waksler (2004: 402) exemplifies the variation that is elicited from coronal consonants with the phoneme /n/ in the English preposition "in", as in (1).

(1) [ɪ**n** dɹɔːz]
[ɪ**m** bɒksɪz]
[ɪ**ŋ** klɒzɪts]

– Wheeldon and Waksler (2004: 402)

Coronals are therefore proposed to lack place features, while labials are specified for the place feature [labial].

Inaccurate perception of the input and difficulties in phonological processing may lead to a higher number of labial consonants being realised as coronal in children with SSD. Underlying forms that contain more specified features (such as labial consonants) may be more difficult for children with SSD to process. The present study proposes that when processing demands are high, labials may be realized as coronal consonants.

1.3 Goals and Aims

The goal of the present study is to test whether the underlying forms in children with SSD are underspecified and follow patterns found in children with SLI and Dyslexia. The hypothesis that the coronal place of articulation is underspecified in comparison to labial is also tested.

This study finds support for both assumptions and is exemplified in example (2) where a labial target is realized as coronal in a child with SSD. The target word is 'bada'.

(2) Target: [**b**ɑdɑ]
Actual: [**d**ɑdɑ]

The alternation from b→d is shown in bold and can be referred to as a LC alternation. It is proposed that /b/ contains the [labial] place of articulation feature which makes it more specified than coronal consonants. Processing demands may be higher in a child with SSD, assuming deficits in speech perception and phonological processing (Pathi and Mondal, 2021: 10; Waring et al., 2017: 35 – 36; Cummings, Ogiela and Wu, 2020: 2). To relieve this processing pressure, target /b/ is realized as /d/ which is underspecified for the place of articulation feature [coronal]. Less feature information is stored in the underlying form, so processing is easier and quicker for the child.

This study uses corpus data from Eaton and Ratner (2016) available from PhonBank (TalkBank, n.d.) to compare 9 TD children with 9 children who have SSD. Using corpus data has the benefit of providing participants and transcribed data, but the disadvantage of limited control over the data and a small number of publicly available data that is available in this area of research.

In this paper I provide support that the [coronal] place of articulation feature is underspecified, and I show that the underlying forms of children with SSD are underspecified in comparison to typically-developing (hereafter, 'TD') children. It is interesting to study the feature specification of phonemes in children with SSD as researchers have paid more attention to communication disorders such as SLI.

In section 2, a literature review explores and critiques approaches to UT. The small amount of research conducted on the underlying forms of SSD are examined and the research questions and hypotheses are outlined. The methodology in section 3 provides the steps taken by the original authors for data collection and the analysis undertaken to test the claims made in this study. Results are presented in section 4 that support the research questions and hypotheses and statistical tests are run. Section 5 discusses the results in detail and contextualises those results in the literature. Some benefits and limitations of the present study are considered and some alternative analysis of the data are explored. Finally, section 6 concludes this study, finding that children with SSD are likely to have underspecified underlying forms compared to TD children and finding support for the proposal that the [coronal] place of articulation feature is underspecified.

2. Literature Review

“Speech Sound Disorder” (hereafter ‘SSD’) is defined by Bauman-Waengler and Garcia (2018: 2) as referring to all individuals who have sound production difficulties, encapsulating articulation disorders, phonological disorders and motor speech disorders. Articulation disorders refer specifically to difficulties in sound production. Children with articulation disorders will present sound distortions and have a high number of substitutions, omissions and additions (Bauman-Waengler and Garcia, 2018: 2). The American Speech-Language-Hearing Association (ASHA) acknowledge that Phonological Disorder (PD) is caused by deficits in the underlying representation of speech sounds and segments (Bauman-Waengler and Garcia, 2018: 2). Phonological Disorders (PD) involve difficulties in the underlying phonological system, and have more of a linguistic focus in comparison to articulation disorders. Research in PD has focused on investigating phonological processing in children with PD, as well as considering the underlying forms present in children with PD (Bauman-Waengler and Garcia, 2018: 2). The term “SSD” unites both of these disorders to refer to difficulties both in the phonological system, as well as production deficits.

Surprisingly, there has been “no previous incidence survey of children referred to a speech and language therapy service in the UK” until Broomfield and Dodd (2004: 303 – 305). The researchers in this study suggest that SSD is the most frequent case of communication disorder seen by speech language pathologists, highlighting how common it is among children (Wheeldon and Waksler, 2004: 304). It affects many children and their families, and can persist into late childhood. This puts children with SSD at risk of having difficulties with reading and spelling (Afshar et al., 2017: 118; Cabbage et al., 2018; Geronikou, Kimoglou and Rousou, 2021: 4). The importance of studying the phonological deficits experienced by children with SSD is underscored by the fact that even when SSD has been treated and the patient no longer requires therapy, there are often still some language areas that are still challenging (Bauman-Waengler and Garcia, 2018: 4). Symptoms of SSD should be identified and treated early on in order to prevent language difficulties at later stages in child language development. Treatment generally involves a range of therapy options that involves exercises such as repetition of phonological segments, phonological awareness training or whole-word approaches (Bauman-Waengler and Garcia, 2018: 9 – 10). Children's lives can be positively changed through early diagnosis and treatment, and the negative impacts of an SSD can be largely minimised or eliminated. Along with time, language experience and the help of speech language therapy (Cummings, Ogiela and Wu 2020: 2, Bauman-Waengler and Garcia, 2018: 5 – 6), underlying forms become more refined and adult-like (Claessen, Kane and Leitão, 2013: 476).

This investigation approaches the study of underlying forms in children with SSD using Underspecification Theory (hereafter, 'UT').

2.1 Approaches to UT

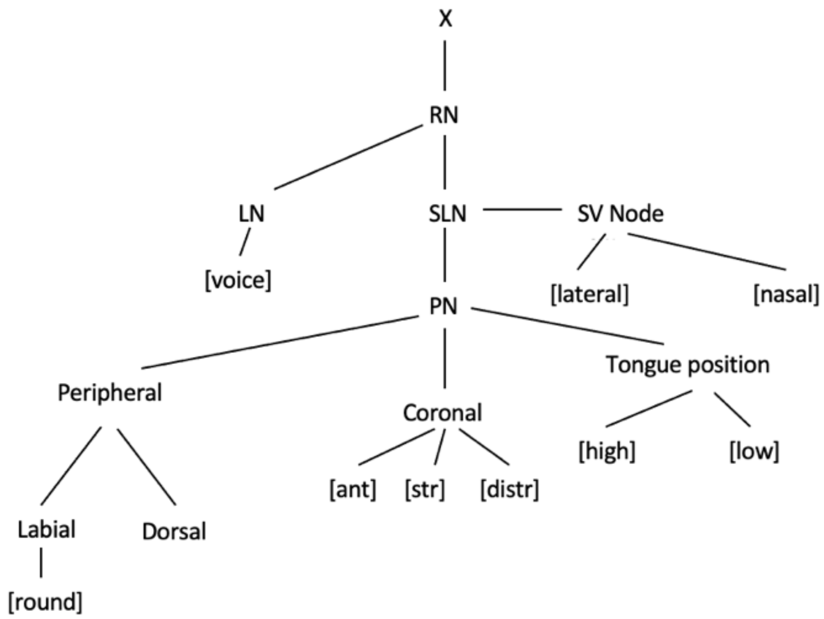
UT was first conceptualized in the eighties and different approaches have been taken. It adopts an autosegmental framework (Goldsmith, 1976), consisting of different segmental tiers. Cummings, Wu and Ogiela (2020: 2) note that researchers have proposed predictable features may be omitted from the underlying form, with only the unpredictable, distinctive and contrastive features being specified. More 'marked' (i.e., less common) features are unpredictable, and are specified in the underlying form. Mohanan (1989: 285) provides a summary of the various approaches to underspecification and notes that the majority of theories in UT agree with Chomsky and Halle's (1968) assertion that unpredictable feature information should not be specified in the underlying form. Paradis and Prunet (1991: 5 – 8) outlined the three main approaches, consisting of the radical, contrastive and modified contrastive approach.

2.1.1 Segmental Structure

Features are organized in terms of a hierarchal segmental structure, outlined in (2) from Paradis and Prunet (1991: 4). Throughout this structure, manner features are given. It consists of the segment named X, which encodes segmental length, followed by the Root Node (i.e., the phoneme). Two nodes follow from this: the Laryngeal Node (LN), which includes features produced with the larynx and the Supralaryngeal Node (SLN), which includes features produced above the larynx. One can see that the [voice] feature is the daughter of the

LN, but the LN also dominates glottalization and implosion (Paradis and Prunet, 1991: 5). The SLN dominates the Place Node, which dominates place features.

(3)



– Paradise and Prunet (1991: 24)

Lahiri and Reetz (2010: 46) also provide a similar segmental structure in the Featurally Underspecified Lexicon model that presents a feature hierarchy.

2.1.2 Radical underspecification

The radical approach (Kiparsky, 1982; Archangeli, 1988; Pulleyblank, 1983) proposes that only one feature is specified in the underlying form. A Universal Markedness Theory (hereafter, 'UMT') (Mohanan, 1989) is assumed in UT to provide the basic structure so that less marked features are omitted from the underlying form. Instead of having [±F], only one feature, (i.e., the unpredictable, marked feature), will be specified. Only one specified feature will contrast with the absence of another feature. The rule in (1) formulated by Paradis and Prunet (1991: 6) rejects any binarity of features and assigns predictable features a redundant status, where **α** can be ± feature.

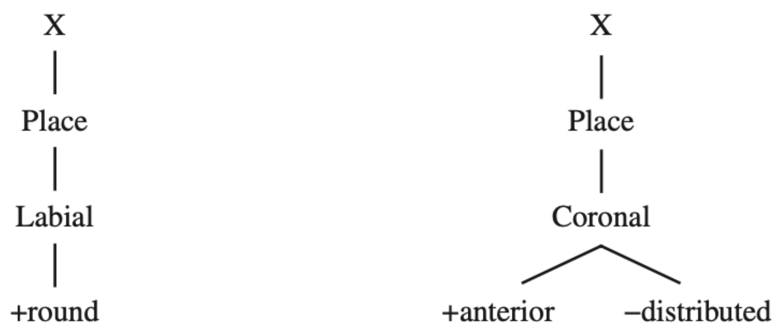
(4) $[0F] \rightarrow [\alpha F]$

If one considers voicing in stops to be unpredictable in a language, then the voiceless /k/ would take [0voi] while /g/ would take [+voi]. The phoneme /g/ has the unpredictable, more marked and distinctive feature of being voiced, and this is specified in the underlying form. On the other hand, /k/ is not specified for being [-voi] in the underlying form. Instead, this feature is omitted from the underlying form because it is not predictable, it is less marked and non-contrastive. Krämer (2012: 70) notes that non-contrastive features in radical underspecification have been termed as "inherent underspecification" by Archangeli, and "trivial underspecification" by Steriade.

This approach differs to Contrastive Underspecification because only one feature value can be specified, but as one will see in the following section, Contrastive Underspecification only allows features that are contrastive to be specified in the underlying form. Support for the radical approach is evident in Parker (1995) using evidence from Chamicuro. They argue that the radical approach better explains the preference for epenthetic vowel /i/, whereas a contrastive underspecification analysis can only explain this preference as being arbitrary. In contrast, though, Lin (1992) argues against the radical approach using evidence from Jiyuan Mandarin to show how the Minimization Principle contradicts itself.

Krämer (2012: 71) presents trivial underspecification in a hierarchal autosegmental framework, showing the labial and coronal structure. They use this example to highlight that a labial node lacks a coronal node, and [anterior] and [distributed] are daughters of the coronal node.

(5)



– Krämer (2012: 71)

2.1.3 Contrastive underspecification

Contrastive underspecification (Steriade, 1987; Clements, 1988) differs in that the specification of features in the underlying form is based on contrasting pairs. Where segments do contrast, they will specify for the specific contrasting feature. If there isn't any contrast, then there is no contrasting feature specified in the underlying form .

This is exemplified in (2), where the phonemes /k/, /g/ and /d/ exist in a language, but not /t/.

	-voi	+voi	
(6)	/k/	/g/	contrast
	~~/t/~~	/d/	no contrast

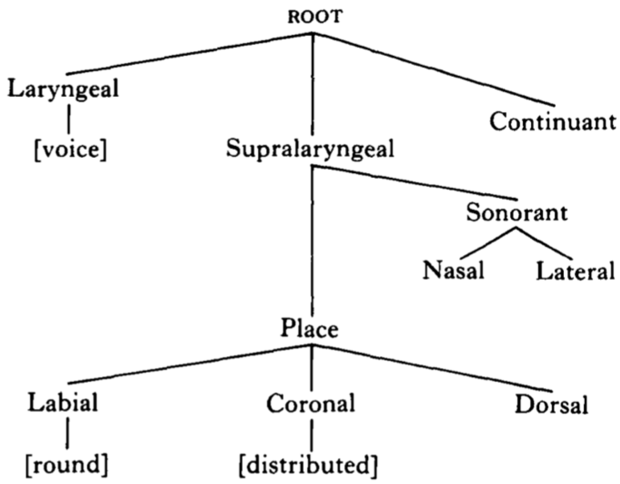
/k/ and /g/ are a contrasting pair, so they will specify for their contrasting features of [–voi] and [+voi]. /d/ does not contrast with its counterpart /t/ because /t/ does not exist in this language. Therefore, even though /d/ is voiced, this is not a distinctive feature and will not be specified in the underlying form. Instead, it takes on the feature [0voi].

The contrastive approach is also known as the restrictive approach, given the limitations it presents with respect to features. There is less opportunity for distinctive features to be specified in the underlying form than with the radical approach.

2.1.4 "Modified Contrastive" Underspecification

Paradis an Prunet (1991: 7) term this approach as "modified contrastive". It incorporates elements of both the radical and contrastive approaches. It assumes that features are underspecified under the UMT, as in radical underspecification, but if there is a minimal phonemic contrast between a pair of features then these features will be specified, as in contrastive underspecification. Proposed in Avery and Rice (1988), it specifies Organising Nodes, which refer to Supralaryngeal, Place and Sonorant, and Context Nodes, which are separated into Primary and Secondary Nodes, as exemplified in (4). Primary Nodes refer to the places of articulation (labial, coronal and dorsal) as well as laryngeal features. The Secondary Nodes are the daughters of those Primary Nodes.

(7)



– Avery and Rice (1989: 180)

The researchers adopt an autosegmental representational approach to the rule component, consisting of three main functions: spreading, fusion and delinking. Spreading involves the spread of a node to another node, fusion involves the fusing together of two primary content nodes, and delinking concerns the deletion of neutralised content nodes.

For any contrasting feature, a Primary Context Node will dominate it. So, /g/ and /d/ may specify as [+voi] and /k/ as [0voi], but all of these features will be dominated by the Laryngeal Node.

Sometimes a Secondary Content Node holds the distinctive feature; in these contexts, a 'Node Activation Condition' is utilised. This stipulates that the contrastive feature for the segments must be distinguished in the UF. The advantage of the model presented by Avery and Rice (1989) is that it offers a middle-ground between radical and contrastive approaches that make analysis more accessible.

This study adopts Avery and Rice's (1989) modified contrastive theory for analysing [labial] and [coronal] consonants in children with SSD, because of the added benefit it has of combining aspects of radical and contrastive.

2.2 [Coronal] underspecification

Avery and Rice (1998: 179) note that coronals have a special status as being the 'default' place of articulation feature. This is because they typically contain little feature information and are considered underspecified. This is a widely supported assumption in UT. Cummings, Wu and Ogiela (2020) considered the labial /b/ and coronal /d/ in 4 – 6 year olds, and found support for the suggestion that [coronal] underspecification is universal. Similarly in Cummings, Madden and Hefta (2017) support was found for [coronal] underspecification in English-speaking children using FUL.

The example in Wheeldon and Waksler (2004: 402) exemplifies the special status of coronal using the phoneme /n/, shown in (6).

(8) [ɪn dɹɔːz]
[ɪm bɒksɪz]
[ɪŋ klɒzɪts]

The allophones of /n/ are shown in bold. One can see that the coronal /n/ can become labial or dorsal depending on context. This example supports the notion that [coronal] consonants lack Place Nodes because of this variance. It may be possible that coronals are easier to store and hold in phonological working memory given that they contain little feature information.

Evidence for the special status of coronals is found by inspecting its transparency and frequency. One can also look to how coronals behave in consonant clusters and in assimilation processes, as explained in Paradis and Prunet (1991: 8 – 11).

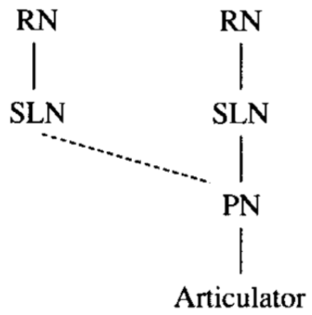
2.2.1 Assimilation

Coronals are the most likely consonant class to assimilate. Kiparsky (1985: 97 – 98) support for this in his study of Catalan nasal assimilation. His findings are highlighted in (7).

(9)	/n/	all consonant
	/m/	labiodentals
	/ɲ/, /ŋ	no assimilation

His findings can be explained in terms of Avery and Rice's (1989) 'spreading' of place features from one segment to the next. Paradis and Prunet (1991: 9) reinterpret Kiparsky's understanding, incorporating it into the articulator theory, as shown in (8). This exemplifies how one segment spreads (i.e., assimilates) to the next.

(10)



– Paradis and Prunet (1991: 9)

2.2.2 Transparency

Paradis and Prunet (1991: 10) note that coronals are highlighted when it comes to transparency effects. This is where segments enable features to spread across them. As [coronal] is underspecified and lacks place features, they behave differently to noncoronals. This is exemplified in West African languages, where vowel spreading occurs only across coronals, but not across noncoronals.

2.2.3 Frequency

According to Paradis and Prunet (1991: 10) coronals are often taken to be the most frequent consonants. They specify (a) inventory frequency – the frequency in the phonemic inventory of a language, (b) typological inventory frequency, the number of coronals in a 'universal phonemic inventory', like the IPA, and (c) occurrence frequency, the frequency of coronals with respect to a speech corpus. Coronals are argued to be more frequent in each one of these domains.

2.2.4 Consonant clusters

An analysis supports the claim that consonant clusters in English never contain more than one non-coronal (1991: 63).

Hume and Tserdanelis (2002) present challenges to the UMT through an analysis of Sri Lankan Portuguese Creole (hereafter, 'SLPC'), which may have implications for the special status of coronals. [Coronal] unmarkedness has been accounted for by several models in phonology. Many languages find that the [coronal] place of articulation feature behaves differently and is the universal default place of articulation feature because it is underspecified. Similarly, velar unmarkedness has also been accounted for by some scholars (Trigo, 1988; Rice, 1996). Hume and Tserdanelis (2002: 441 – 447) analyses the phonemic inventory and phonological processes of SLPC by looking at featural asymmetries. Contrary to the literature, researchers in this study find that [labial] is the unmarked place of articulation feature in this creole. This presents diverging evidence from phonological models that do not account for [labial] unmarkedness.

Development of the underlying form may be different in children with SSD. Accurate perception of the speech input enables children to form detailed and high-quality underlying forms. On the other hand, inaccurate perception of sounds causes difficulty in creating underlying forms that may be less fine-tuned and underspecified (Cummings, Ogiela and Wu, 2020: 4). This makes it difficult for children with SSD to differentiate sounds with similar features. Perception may not be as accurate, and this could lead to underspecified underlying forms. Children with SSD have perceptual deficits that may be the result of faulty underlying forms (Cummings, Ogiela and Wu 2020: 4). Indeed, underlying forms in children with SSD have been proposed to be underspecified because they do not contain fine feature information. A lack of specified feature information may result in production difficulties seen at the surface level.

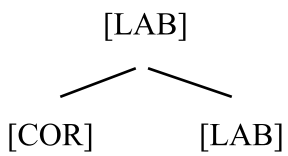
It is likely that the high frequency of speech distortions, substitutions, deletions and epenthesis that is characteristic of SSD may be the cause of deficits in the underlying phonological system, specifically in the underspecification of underlying forms.

Similarly, the same pattern of featural underspecification can be found in SLI (Claessen, Kane and Leitão, 2013; Claessen and Leitão, 2012; Joanisse, 2004; Maillart, Schelstraete and Hupet, 2004) and dyslexia (Ramus et al. 2012).

Studies have noted that poor performance on tasks such as non-word repetition and digit span recall tasks may suggest children with SSD may have trouble holding underlying representations in working memory (Farquharson, Hogan and Bernthal, 2018; Afshar et al., 2017).

Based on the assumption that coronals *are* easier to process than labials and dorsals because of their inherent underspecification, and given their lack of Place Nodes, we may analyse labial (and dorsal) consonants as being underlyingly coronal as in (7).

(11)



Focusing on labials and coronals, one might expect that because labials contain a higher number of features, when processing demands are heightened, (e.g., where a word in multisyllabic or morphologically complex), labials may be realised as coronals to relieve phonological processing pressures.

2.3 Research questions and hypotheses

Given the literature above, I form the following research questions and hypotheses, firstly considering underspecified underlying forms in children with SSD:

- **Research Question 1:** Do children with SSD have underspecified underlying forms in comparison to TD children?
- **Hypothesis 1:** Children with SSD will produce more LC alternations because [coronal] consonants contain less feature information, which relieves processing demands during phonological processing. This will suggest that children with SSD have underspecified underlying forms in comparison to TD children.

Secondly, I present the research questions and hypotheses with regards to specification of underlying forms in children more broadly:

- **Research Question 2:** Is the [coronal] place of articulation feature underspecified in comparison to [labial]?
- **Hypothesis 2:** Labial misarticulations are more likely to become [coronal] consonants because they contain less feature information and are therefore easier to process. This will suggest that [coronal] is underspecified in comparison to [labial] consonants.

3. Methodology

3.1 Participants

Only recently have studies in the phonology of communication disorders been able to be carried out using corpus data. There has been very little access to corpus data and a lack of tools for analysing that data (Rose and Stoel-Gammon, 2015: 1). PhonBank (TalkBank, n.d.), a part of the Child Language Data Exchange System (hereafter, 'CHILDES'), has recently become a useful host for providing publicly available corpus data for researchers. It provides the opportunity to analyse "phonological development in first and second languages for language learners with and without language disorder" (Rose, 2014). It works in conjunction with the software Phon, which allows researchers to access media and audio files as well as pre-transcribed data by the authors. Data from PhonBank can be imported into Phon for analysis. Often PhonBank will have files attached that already contain transcribed data and coded in Phon. The time and cost saved in transcribing and analysing data as well as recruiting participants for studies is hugely valuable and for this reason studies in corpus phonology are becoming increasingly popular.

In the Eaton and Ratner (2016) data, participants' anonymity were preserved using an ID. It consists of the file number followed by the pseudonymized initials of the participant. Their dataset consisted overall of 51 participants. I used data from 18 participants – as there were only 9 SSD participants from Eaton and Ratner (2016), I matched this with 9 TD children from the same dataset. The data was recorded in 2013 and the TD group was segregated via speech production skills: high, average and low. This was worked out via standardised testing. The participants were also matched for gender so that gender effects were minimised. As Eaton and Ratner (2016) segregated children via language ability, data from the high-level typically-developing children was contrasted with data from the SSD group. This was to keep the language ability of the TD group consistent so that the data could be studied independent from external factors like language-ability.

3.1.2 Recruitment

Various channels for recruitment were utilised by the researchers and participants were compensated for their time, as outlined in Table 1. Recruitment was based in the local area.

Table 1 – Overview of Stages of Recruitment from Eaton and Ratner (2016)

Recruitment aspect:	**Specific steps taken**
Recruitment channels *(2016: 681)*	University clinics
	Referral to a speech language pathologist
	Community-based mailing lists
	Word of mouth
	Personal referral
Compensation *(2016: 682)*	Child given a small toy
	Test scores sent to families of participant
	Interpretation of test scores by a speech language pathologist
	Monetary compensation
	Children with hearing difficulties

Exclusion criteria *(2016: 681 – 682)*	Children with motor issues
	Scoring within a specific range on three tests and passing two screenings

Participants were recruited in two main areas in the United States: Washington, D.C. and Kansas City in Missouri (Eaton and Ratner, 2016: 681), as these areas were local to the researchers' universities. The targeted participants were 4- and 5-year-old children, including 9 males and 9 females. Participants were a mix of TD children and children with SSD.

The exclusion criteria involved a number of standardised tests that were undertaken to categorise the participants in to 'high', 'average' and 'low' language ability. This divide was based on the authors' goals of the authors' study, which was concerned with the study of Executive Functions. When taking my data sample, I chose to contrast 9 'high' language ability TD children with 9 children with SSD to ensure no effects of language ability affected my results. The tests mentioned in Table 1 refer to "two standardised assessments of receptive language and one test of non-verbal intelligence" (Eaton and Ratner, 2016: 681). Participants were also required to successfully undertake hearing and oral-motor screenings to ensure no children had hearing difficulties or oral-motor problems. (Eaton and Ratner, 2016: 681). In terms of ethics, approval was sought from the family of the participant and informed consent was given from the family of each participant. This was presented in writing.

Table 2 presents a summary of the participants in terms of diagnosis, age and sex.

Table 2 – Summary of Participants by Diagnosis, Age and Sex

Child ID	**Diagnosis**	**Age**	**Sex**
1 – 9	TD	5-year-olds: 6	Males: 5

		4-year-olds: 3	Females: 4
10 – 18	SSD	5-year-olds: 7 4-year-olds: 2	Males: 7 Females: 8

3.2. Data

Narrowly-elicited data of a Syllable-Repetition Task (hereafter, "SRT") from Eaton and Ratner (2016) was accessed and treated as data. The SRT is a modification of the Non-Word Repetition, created by Shriberg et al. (2009: 1193 – 1994). It involves nonwords being built in such a way that involves voiced anterior consonants that are available in the phonetic inventories of children, both typically-developing and with SSD. It involves two labial consonants and two coronal consonants. Each place of articulation feature includes a stop and a nasal (i.e., the labials /b/ and /m/ and the coronals /d/ and /n/). The task starts with the syllable structures that are "easier" to process (CVCV) and end with more morphologically complex syllabic structures (CVCVCVCV). The consonants are evenly distributed in the nonwords so that they are balanced in terms of manner class. The syllable structures are simple in order to reduce any effect of final consonant deletion or cluster reduction. The structure of the nonwords also makes them emulate 'real' words.

Eaton and Ratner (2016) use Shriberg et al.'s (2009) stipulations for non-word building as a guide to form their own similar dataset. Their data involves more morphologically complex nonwords, varying in terms of stress. Non-Word Repetition Tasks and Lexical Decision Tasks have typically been used for studying phonological processing (and in particular, phonological working memory). These methods can also be used as a proxy for studying underlying forms. More recent methods include the Quality of Phonological Representations Task in Claessen et al. (2009), which involves children hearing real words and a variety of pseudowords (e.g., "spaghetti" and "spagheki"). The child then judges whether the production is correct or not by ticking or crossing the word via a computer. Cummings, Wu and Ogiela (2020) used the more advanced method of an Events-Related Potential (ERP) to investigate [coronal] underspecification in children with PD. The data was tested by looking at target production vs actual production of the nonword. Consonants were then compared to see whether any errors occurred, and if so, what those errors were. For example, the target-likeness of the nonword 'madaba' can be considered in example (1).

(12) Target: [ˈ**m**ɑˈ**d**ɑˈ**b**ɑ]

Response: [ˈ**n**ɑˈ**b**ɑˈ**d**ɑ]

The phonemes in bold show errors in repeating the nonword consonants. This is recorded as 2 instances of LAB→COR (m→n and b→d) and 1 instance of COR→LAB (d→b).

Each syllable repetition task was structured so that the participant heard nonwords, with the smallest words heard first and the most morphologically complex words heard last. If a participant did not respond then they simply moved on to the next non-word – there were no repetitions of stimuli as this could have effected the data. The point of the task is to form underlying forms for words that have not been heard before, so a repetition of an individual stimulus could lead to better results on the SRT, which would not have been fair.

Corpus data was used as data collection with children was not possible due to the COVID-19 pandemic. The SRT is chosen for this study because it is practical, easy to administer and does not require complicated equipment. The design of the SRT in Eaton and Ratner (2016) specifically elicits both [coronal] and [labial] consonants, which makes it ideal for studying coronal underspecification and underspecification more generally in children with SSD. A similar study was conducted by Roepke et al. (2020) who used the SRT to study children of the same age range with SSD, comorbid developmental language disorder (CDLD) and typically-developing children, but in relation to phonological processing.

Similar non-word repetition tasks have been used to study phonological processing in disordered populations (Farquharson, Hogan and Bernthal, 2018; Roepke et al., 2020; Ebbels et al., 2012). The data in this study was collected by presenting the auditory stimulus to children and recording their responses using a Shure SM51 microphone, which was connected to a Marantz PMD600 digital recorder. Responses were then transcribed in Phon by the authors and made available via PhonBank (Eaton and Ratner, 2016: 682).

3.3. Data analysis

One token is defined as one phonemic alternation in any direction (e.g., LC or LL). Although vowels did occur in the dataset, they were not coded seen as they did not form part of the research questions or hypotheses. The stimuli contains no [dorsal] consonants because [dorsal] consonants do not form part of the research questions and hypotheses. This is because the nonwords do not elicit dorsals and only 1 dorsal is produced in the dataset. In a total of 18 transcripts, there were 26 nonwords elicited, meaning a total of 86 phonemes were elicited per SRT. A total of 1548 phonemes were elicited across 18 interviews. There were 4 levels of nonwords based on syllabic length (CVCV to CVCVCVCVCV). Table 3 summarises this information.

Phonetic transcription was pre-transcribed in Phon by the authors, and included transcriptions for stress. These stress transcriptions were ignored seen as it is not the goal of this study to examine stress patterns in SSD.

Table 3 – Overview of Tokens in Eaton and Ratner's (2016) dataset

Number of transcripts	18
Number of nonwords per transcript	26
Number of phonemes per transcript	86
Number of nonwords with different syllabic length	4

Interview 13 contained no response for 4 nonwords *N*=17 phonemes. These nonwords were deleted from the data. The data was coded for number of syllables and number of times LC and LL alternations took place in each nonword, as well as coding for diagnosis (TD v SSD). Phon was used to compare target pronunciations of the nonword vs the child's actual production and code for number of syllables. Alternations were only coded as genuine if the alternation occurred at the same place in a word. For example, in (9) m→n, which equates to a LC alternation, because the alternation occurs at the same place in the word, i.e., word-finally.

(13) [dəbɑ**m**ə]

[dəbɑ**n**ə]

The data ignored epenthesized consonants, deletions and CL and CC alternations seen as these elements did not form part of the research question and hypotheses.

3.4 Statistical Tests

The data will be analysed using a distributional analysis and statistical tests. The distributional analysis will consider the frequency of LL and LC alternation overall in the dataset, as well as the frequency of LC alternations in the TD v SSD group.

It is hypothesised that there will be a higher number of LC alternations overall, and that the SSD group will have a higher number of LC alternation than the TD group.

Chi-square tests and t-tests are conducted to test whether the effect is statistically significant and whether the null hypothesis should be accepted or rejected.

4. Results

The present study's aim is to test the hypothesis that the [coronal] place of articulation feature is underspecified in comparison to [labial], and examine whether children with SSD have underspecified underlying forms in comparison to TD children. The SRT has been used to test both these hypotheses by considering focusing on the frequency of LC alternations in the dataset. It is predicted that there will be a high frequency of labial consonants that are realized as coronal consonants to relieve processing pressures, as labial consonants are more specified than coronal ones.

The data was coded for number of times LC alternations occurred and number of times LL alternations occurred. The data was then visually presented using R Studio.

Statistics were conducted on nominal categorical data with the dependent variable of pronunciation and independent variable of diagnosis.

A total of 18 interview transcripts were extracted from the corpus, with a total of 214 tokens overall being extracted. Of this, there were 81 LL alternations and 133 LC alternations.

Table 5 summarises the number of and frequency of LC and LL alternations in the dataset, separated for diagnosis. The SSD group have a higher frequency of LL alternations than LC alternations, while the TD group have a higher frequency of LC alternations than LL ones. Focusing solely on LC alternations, the SSD group have a slightly higher frequency of LC alternations than the TD group.

TABLE 4: Raw numbers and frequencies of LC and LL alternations in TD children and children with SSD.

Diagnosis	LC (N)	%	LL (N)	%	Total
TD	61	46	32	39	92
SSD	72	54	50	61	122

Considering the overall distribution of alternations, in a total of 18 transcripts, 214 tokens overall were extracted. Of this, there were 81 LL alternations, and 133 LC alternations. The raw numbers for LC and LL alternations are presented in Table 4, as well as their relative frequencies divided between TD children and children with SSD.

There are more instances of LC alternations (62%) than LL ones (38%), as shown in Figure 1. The x-axis shows the direction of alternation, with the y-axis showing the relative frequency of the alternation. This supports the hypothesis that there will overall be a higher frequency of LC alternations than LL ones.

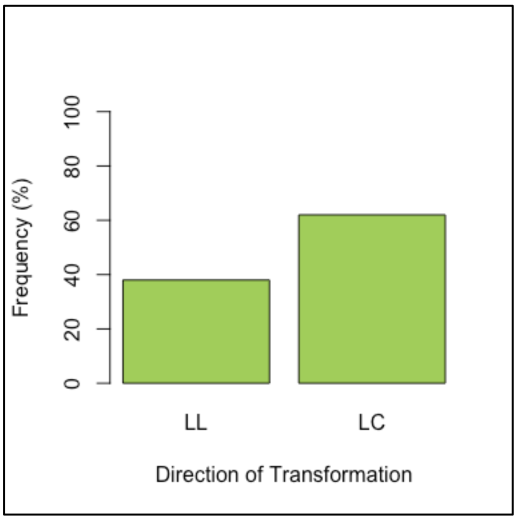


Figure 1 – Overall Distribution of LAB→LAB and LAB→COR Alternations

4.1 Distributional Analysis

Figure 2 illustrates the result for the distribution analysis of the relative frequency of LAB→COR alternations. LAB→COR alternations occur more frequently in the SSD group (54%) than the TD group (46%), although the difference is small. The x-axis shows diagnosis, with the y-axis showing the frequency of LAB→COR. This supports the hypothesis that the SSD group will have a higher frequency of LC alternations than the TD group.

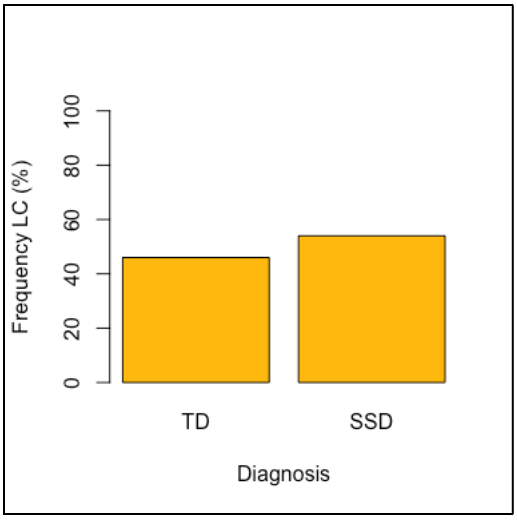


Figure 2 – Distribution of Relative Frequency of LAB→COR in TD and SSD Populations

A uniform distribution shows that overall there are more LC alternations than LL alternations, supporting both hypotheses. The SSD group shows more LC and LL alternations than the TD group, which suggests they substitute more during the SRT than their TD peers. The most amount of alternations are LC ones in the SSD group, which supports hypothesis 1.

Of all alternations from a labial in the SSD group, LC alternations occurred 61% of the time, while LL alternations occurred 54% of the time. In the TD group, LC alternations occurred 46% of the time while LL alternations had a frequency of 39%. This is exemplified in Figure 3.

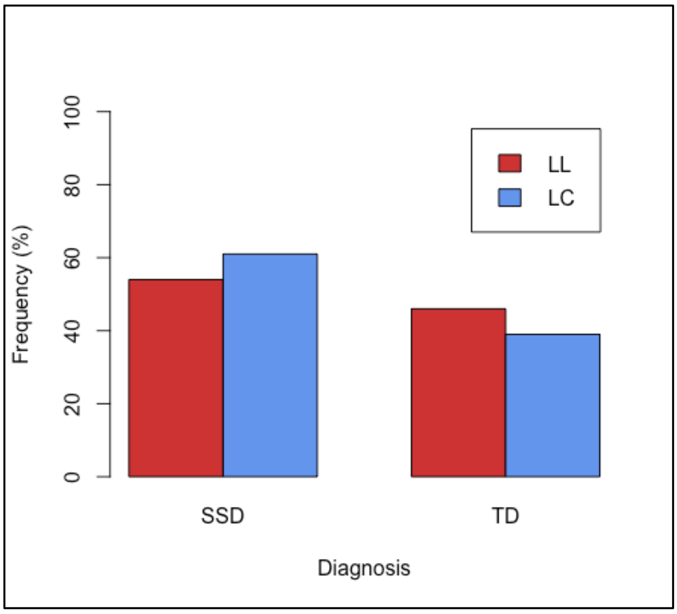


Figure 3 – Uniform Distribution of Relative Frequency of LAB→COR and LAB→LAB in TD and SSD Groups

4.2 Inferential statistics

A logistic regression model predicts the number of times labials are realized as coronals, based on diagnosis. The preference for LC alternations over LL alternations is shown to be statistically significant (p = 0.048 = <0.05), so the null hypothesis that the frequency of LC and LL alternations will be similar is rejected. The effect for diagnosis is shown to not be statistically significant, so the null hypothesis is maintained that the TD group and the SSD group are similar in their rate of LC alternations.

TABLE 5: Logistic regression model predicting the number of times labials are realized as coronals based on diagnosis

Coefficients				
	Estimate Std.	Error	z value	Pr(>|z|)
(Intercept)	0.3646	0.1841	1.981	0.0476 *
DiagnosisTD	0.2805	0.2855	0.982	0.3259

*Notes: * p < .05 ** p < .01 *** p < .001*

There is a significant effect for the number of LC alternations which supports hypothesis 2 that the [coronal] place of articulation feature is underspecified. There is also support for the hypothesis that children with SSD produce more LC alternations than children with TD, but this effect of diagnosis is not significant.

5. Discussion

This study found that there was more LC than LL alternations. The SSD group produced more LC alternations than the TD group, though this effect is not significant. The underspecification of underlying forms in TD children and children with SSD has been examined, specifically considering the alternation of LLs and LCs. This provides evidence for the special status of [coronal] as the 'default' underspecified place of articulation. It also provides support for the presence of underspecified phonemes in children with SSD. The NRT has typically been used to study phonological processing and phonological specification (references). The SRT modifies this task to minimise the effect of stress and consider syllable length/morphological complexity. The results also support the notion that there are processing deficits in children with SSD, because LC alternations may occur due to heavy processing demands due to the number of features that are part of the labial underlying form, thus giving a [coronal] response.

Firstly, considering the results that test hypothesis 1, this is supported. LC alternations occur more than LL alternations, but this effect is not significant. There was a very small difference of 4%. Although the results support the hypothesis that children with SSD have underspecified underlying forms in comparison to TD children, it is more likely that TD children and children with SSD have similar underlying forms based on this dataset. This result is consistent with literature such as Cummings, Ogiela and Wu (2020) who find that children with SSD do have underspecified underlying forms. However, the difference in results in this study is very small.

Considering the results testing hypothesis 2, this is also supported. There are more LC alternations than LL ones overall in the dataset, and this is effect is significant. This supports claims made by seminal researchers like Avery and Rice (1989) that the [coronal] place of articulation feature is underspecified. More specified place of articulation features like [labial] and [dorsal] may be difficult for children to process, and thus these features are pronounced as underlyingly coronal. The results support this assumption and is consistent with literature on the universally default status of coronals.

5.1 Contextualisation of results in the literature

Cummings, Ogiela and Wu (2020) used the FUL model to investigate whether underlying forms were more frequently underspecified in children with PD vs TD children. In this study, assumptions from the FUL model that [coronal] is the underspecified place of articulation feature are adopted. The present study is similar because it considered phonemic underspecification in children with SSD. However, it differs in that the present study focused on misarticulations of phonemes, which are hypothesised to be due to the number of features present in labial and coronal consonants. Both studies consider labial and coronal consonants, and a similar age range, as well as the effect of diagnosis on the underspecification of underlying forms in children. The stimuli are similar in that they compare minimal pairs of 1 syllable: one labial and one coronal, while we compare a number of stimuli with varying syllable length, differing in terms of coronal-labial combinations

Both studies touch on the importance of phonological processing: this study notes that difficulties in accessing, storing and holding underlying forms in working memory could be related to the feature specification of underlying forms. Underlying forms that contain more specified features, such as labial consonants, may be more difficult to process for children with SSD and result in more coronal consonants being produced. As noted in section 2, we may analyse [labial] as being underlyingly [coronal].

Indeed, Cummings, Ogiela and Wu (2020: 2) take a similar position noting that if very detailed features needed to be accessed in phonological processing, this would likely be ‘inefficient for rapid speech processing’ (Cummings, Ogiela and Wu, 2020: 2). This supports the use of UT in analysis more generally, and highlights the importance of using UT analysing the underlying forms of children with SSD.

Overall, the findings in Cummings, Ogiela and Wu (2020) are similar. [Coronal] consonants are underspecified in comparison to [labial] and [coronal] ones, and children with PD, (a type of SSD), showed more evidence of underspecified phonemes than TD children. Our findings therefore support Cummings, Ogiela and Wu (2020).

A few years earlier, Cummings, Madden and Hefta (2017) conducted a similar study but studying TD adults, and with a wider set of stimuli. They studied coronal /d/, labial /b/ and /p/ as well as the dorsal /g/. While finding support for the underspecification of some underlying forms, they note a difficulty that arises from the Usage-Based Account of language (UBA). UBA highlights that English contains 14 coronal consonants and only 4 labial ones. [Coronal] therefore has a high neighbourhood density in comparison to labial which could affect their results. Their study is different in that they study adults, but similar in that labial and consonants were the main focus of the study in terms of underspecification.

Following their study in 2020, Cummings, Wu and Ogiela (2021) continued their work in underspecification, this time considering approximants, specifically the liquid /ɹ/ and glide /w/. They find support for the predictions made in FUL that the [consonantal] feature is underspecified. Although children with SSD are not considered as the main part of their study, they note that the motivation for examining the underspecification of approximants was based on the observation that children with SSD often substitution [w] for /ɹ/. (2021: 4). The studies differ given that the present study considers the effect of diagnosis at length, while Cummings, Wu and Ogiela (2021) primarily focus on the underspecification of approximants more generally.

Another difference is the consideration of approximants in Cummings, Wu and Ogiela (2021), while the present study considers [labial] consonants as [coronal]. The methods are also different: they prefer a ERP oddball paradigm approach using an EEG, while we use the SRT. The researchers test this in adults, while we test it in children.

Overall, both studies contribute to the understanding of underspecified underlying forms.

Roepke et al. (2020) used the SRT to uncover deficits in the underlying forms of children with SSD and Developmental Language Disorder (DLD) in comparison to TD children. Three groups of children ages 4 – 5 years old were studied. They found that children with SSD and SSD + DLD showed evidence of faulty underlying forms in comparison to TD children. This study is very similar in terms of the method used, age of children and goals of the study. The diagnosis is slightly different in that DLD is also considered. Roepke et al. (2020) mainly diverge from our study in that they explain the underlying phonological deficits in terms of phonological processing, considering the effects of stress and vowel changes. Our study explains these deficits in terms of the underspecification of features in the underlying form which in turn effects processing speed because of the number of features that are stored in working memory. This study supports the findings of Roepke et al. (2020) in relation to SSD only in terms of the underlying phonological deficit in SSD. We, however, offer a UT analysis in explaining this deficit.

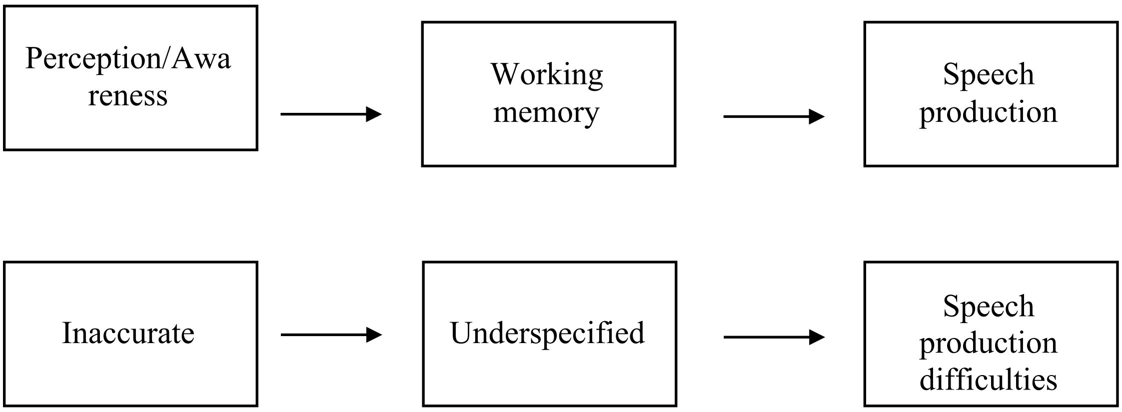
An earlier study by Wheeldon and Waksler (2004) considers speech variation in relation to speech perception in adults. They take a radical underspecification and contrast coronals with the more specified labials and velars. With regards to the method, they use a lexical decision task to measure reaction time and accuracy. The study differs in that adults are studied and explaining the variability in speech is the main focus. The radical approach is adopted for analysis and velars are included in the investigation. Their study is similar in terms of using UT for analysis, but their analysis is based on variability while the present study's aim is to explain speech production difficulties in SSD using UT. They find that there is more variability in coronals because they coronals are proposed to lack Place Nodes.

5.2 Underlying Forms with regards to Working Memory and Underspecification

Studies have noted that poor performance on tasks such as non-word repetition and digit span recall tasks may suggest children with SSD may have trouble holding underlying representations in working memory (Farquharson, Hogan and Bernthal, 2018; Afshar et al., 2017. Adams and Gathercole (1995) grouped pre-schoolers with PD into "high" and "low" phonological working memory, finding that there is a correspondence between low phonological working memory and speech production errors.

This phonological processing deficit may be the result of faulty representations (Afshar et al., 2017: 121). The present study proposes that the 'faulty representations' Afshar et al. (2017: 121) are referring to are underspecified underlying forms that arise from inaccurate perception of the input. Highly detailed and specified underlying forms are necessary for identifying words, accurately perceiving speech and accurate production of one's own speech (Cummings, Ogiela and Wu, 2020: 2). An underspecified underlying form together with a delay or deficit in storing and accessing underlying forms in working memory may make speech perception and production difficult for children with PD.

The model below represents the relation between phonological processing and underspecification. The three main parts of phonological processing are represented: perception/awareness, phonological working memory and the motor programmes that make speech possible. If perception of the input is inaccurate, this can lead to the underspecification of underlying forms based on the child failing to pick up important acoustic information from the input. This manifests itself in the form of speech production errors; it is possible that an unusually high rate of substitutions, combined with other speech difficulties, could be symptomatic of SSD.



5.3 Evaluation of study

NRT have often been used to assess underlying forms and phonological processing, as the task involves holding underlying forms in working memory and creating a novel string, while ordering these underlying forms and then actually implementing a motor plan to articulate the nonwords (Coady and Evans, 2008).

5.3.1 Benefits

Benefits of this study include the fact that dataset was balanced: there were 9 TD children and 9 children with SSD. Of the 9 TD children, 5 were male and 4 were female. Of the children with SSD, 7 were male and 8 were female. This provides a dataset that is also balanced for gender to minimise any effect gender might have. The data was also balanced for the number of phonemes elicited per transcript (N=86). Much of the literature on underspecified underlying forms in children with SSD is very recent whilst also being grounded in the seminal work of UT that was conceptualised in the eighties. This means that the literature is very relevant. The findings of this study supports claims made in recent works like Cummings, Ogiela and Wu (2020) that underlying forms in children with PD are underspecified and similar claims made in Roepke et al. (2020).

The adoption of the SRT made it possible to present nonwords that eliminated any effects of consonant clusters and controlled for syllable length, using 2 labials and 2 coronal consonants. This meant it was easier to look for patterns of LC alternation. Traditionally, NRTs involve holding underlying forms in working memory, then creating a novel string and executing the repetition via activation of the motor programme (Coady and Evans, 2008). This makes it an ideal proxy method for studying the UFs of children with SSD.

This study examined underlying forms in children with SSD with respect to UT. The research in this area has not been covered in depth before. Literature considering underspecification in developmental populations is already small, with this specific area being even more sparse. This investigation therefore offers new insights concerning the underlying forms in children with SSD. The data was coded for number of times LL and LC alternations take place. This way of studying UFs has not been done before, so offers a new way of exploring this phenomenon. A wide range of recruitment channels were utilised by Eaton and Ratner (2016) to gather participants for the study, which made the data more reliable.

Using corpus data for studies in phonology is something that has only been explored more in recent years (Rose, 2014; Rose and Stoel-Gammon, 2015). There are many advantages to using corpus data. Data is already transcribed in Phon and Phon is a useful tool for comparing target vs actual pronunciation of nonwords. The findings are consistent with literature that children with SSD more frequently have underlying forms that are underspecified. This causes problems in speech production and can cause problems in reading and spelling (Afshar et al., 2017: 118; Cabbage et al., 2018; Geronikou, Kimoglou and Rousou, 2021: 4). Only PhonBank was accessed so the data was consistent and coherent. The finding was that TD children were more accurate at repeating nonwords than the children with SSD, so diagnosis does seem relevant to the feature specification of underlying forms.

5.3.2 Limitations

There was also a number of limitations. The data was not balanced in terms of age: there were thirteen 5-year-olds and five 4-year-olds. The number of nonwords varied in terms of syllable length. There were 8 CVCV, 6 CVCVCV, 8 CVCVCVCV and 4 CVCVCVCVCV nonwords. In a future study, there would be the same number of nonwords per syllable length (e.g., 4 of each syllable length). The results of the t-test showed that there was no significant result for number of LC alternations by diagnosis.

As corpus data was accessed and treated as data, there was less control over the data. PhonBank is great for providing publicly data that is already transcribed, however there is only so much of this available. It was difficult to find any kind of non-word repetition task involving children with SSD. If data had been collected, an NRT combined with an LDT would have been conducted so that reaction time and accuracy could be examined.

The 2 labials /b/ and /m/ and 2 coronals /b/ and /d/ were the primary focus of this study. The inclusion of other labials like /v/ and /f/ and others coronals like /s/ and /z/ could have made the data more reliable by studying more phonemes. The inclusion of dorsals may also have provided interesting results. However, as corpus data was used this was not possible. A benefit is that individual differences were minimised via screening and standardised testing, but one recognises that this doesn't totally rule out the possibility of individual differences in participants.

In interview number 13, there was no response for 4 nonwords, equating to no elicitation of 17 phonemes. The lack of responses were discarded from the dataset. In total, there are 46 coronals and 40 labials elicited by the SRT. Although fairly balanced, there are more coronals elicited which could have an effect.

In 1965 Noam Chomsky distinguished between competence and performance. This study has taken a competence approach to understanding the UFs in children with SSD. Indeed, it is possible that the difficulties children with SSD may be one concerning performance. It could be that the articulatory difficulties that arise at the surface level may be production difficulties. However, this study takes a competence approach given that there is a converging body literature surrounding SSD that suggests that it is more likely the UF is underspecified. Support for this is found by other scholars (Cummings, Ogiela and Wu, 2020; Cummings, Wu and Ogiela, 2021).

5.4 Directions for Future Research

As evidenced when contextualising the findings of this study in the literature, further research is needed to understand the underlying phonological deficits in children with SSD. Coronal consonants are proposed to lack Place Nodes. If this is true, then this means that coronals are variable, and can become labial or dorsal consonants (as noted in Wheeldon and Waksler, 2004). This could be a hypothesis for a future study. (But would totally go against the results of your study). An LDT combined with the SRT or NRT could uncover more patterns giving us more data, which would allow one to consider the effects of reaction time and accuracy. The effect of voicing could be studied to see whether that affects frequency of LC alternations.

Further research on phonological context could also be undertaken to see whether alternations are more likely to take place word initially, medially or finally. Further research would benefit from exploring whether underspecification is something that is present from birth or develops during child language development. Minimal pair reading tasks looking at phonemic contrasts may also be a helpful method for considering underspecification.

6. Conclusion

This study considered whether coronals are underspecified in comparison to labials, and whether children with SSD have underspecified underlying forms in comparison to TD children. It was hypothesised that coronals are underspecified in comparison to labials and that children with SSD would have a higher rate of LC alternations than TD children, acting as evidence for the underspecification of underlying forms.

The findings of this study support both these research questions and hypotheses via corpus data and through a phonological analysis of labials and coronals. It is the case that children with SSD have underlying forms that seem to be underspecified in comparison to TD children. The SRT was used as proxy to study the underlying forms of 18 children by comparing the target pronunciation of nonwords with their actual pronunciation.

The approach was taken based on literature on children in SLI, which found that the underlying forms in children with SLI were underspecified (Claessen, Kane and Leitão, 2013; Claessen and Leitão, 2012; Joanisse, 2004; Maillart, Schelstraete and Hupet, 2004). It seemed reasonable to predict that the underspecification of underlying forms in children with SLI could be applied to children with SSD. A small body of research has explored the underlying forms in children with SSD and supported this prediction (Roepke et al., 2020; Cummings, Madden and Hefta, 2017). This study also supports that prediction. Although the effect is not as strong as expected, there is still an effect that can be observed between the underlying forms of children with SSD and their speech production. UT offers a logical explanation for this relationship. This is consistent with the literature in this field.

There were limitations with the methodology given the restrictions of corpus data, including the amount and conditions set in the data. However, the present study endorses the use of corpus data in studies of phonology given the valuable advantage of providing participants, media and audio files and pre-transcribed data. It is suggested that children with SSD may present a higher number of substitutions (specifically, substitutions to coronal consonants) due to the underspecified underlying forms that arise in less mature phonological system than that of TD children.

The methodology used was appropriate for this study, however a combination of methods to study the phonological system will provide more reliable insights. We suggest using a NRT with an LDT, or other tasks like the Quality of Phonological Representations task (Claessen et al., 2009) and ERPs (Cummings, Wu and Ogiela, 2020)

We have considered the various approaches to UT and endorsed Avery and Rice's (1989) recommendations for UT analysis. We analysed some of the data, but did not analyse this in terms of rules. Criticisms of both radical and contrastive approaches were examined. We also considered how more research is needed regarding children with SSD, particularly regarding their underlying forms.

This research will benefit speech language pathologists in their treatment of children with SSD. It can be used to help look for patterns in the speech difficulties of children with SSD, and in turn be used to offer advice to parents and families about how to identify SSD.

As Bauman-Waengler and Garica (2018: 1) note, the American Speech Language-Hearing Assocciaton (ASHA) states that “over 90% of clinicians reported that they work with children with [SSD]s” (ASHA, 2014). With such a high number of case rates, the importance of conducting research on the underlying phonological system in children with SSD is clear. Studies on the underlying forms of children with SLI and dyslexia have showed similar patterns presented in this study that features are sometimes omitted from the underlying form. Future studies may wish to consider the effect of word length on this – a high number of labial consonants in one environment may increase phonological processing pressures, which lead to a high number of LC alternations.

With a larger body of research in this area, we can together mitigate the severity of SSD and help to make children’s lives more positive. Our research can be used to help identify signs of SSD from an early age and inform speech therapy.

Further research would benefit from exploring the effects of voicing and phonological context on underlying forms in children with SSD. Additionally, a methodology that combines a NRT (or the SRT) with a LDT would enable researchers to study the effects of reaction time and accuracy. A comparison of reaction time in TD children and children with SSD could tell us more about how quickly different types of features are accessed, and whether specified underlying forms are processed quicker or slower.

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Appendix: List of nonwords elicited in the Syllable Repetition Task.

Number	Nonword	Syllable Length
1	bama	2
2	bada	
3	mada	
4	neba	
5	dama	
6	deba	
7	nama	
8	naba	
9	bamana	3
10	debama	
11	nabede	
12	madaba	
13	dabama	
14	nedame	
15	bamadana	4
16	benamada	
17	manabada	
18	nedemabe	
19	danabama	
20	mebedane	
21	denamabe	
22	nadamaba	
23	benamedabe	5
24	mabanamada	

25	mabenademe	
26	nadabamana	