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**Department of Clinical Therapies**

**Final Year Project**

**Module: SL6036**

**“An investigation of non-word discrimination and phonological representation in a sample of children with speech sound disorders”**

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## Abstract

### **An investigation of non-word discrimination and phonological representation in a sample of children with Speech Sound Disorders (SSDs).**

**Background:** Resolution of SSDs without therapy occurs for some children. Identification of those *unlikely* to resolve spontaneously would facilitate effective targeting of intervention resources. A test of non-word discrimination (NWD) may be effective in gaining a measure of phonological representation while controlling for confounding speech-production variables (Reuterkiöld-Wagner, Sahlen & Nyman; 2005).

**Objectives:** To find out: 1) what proportion, in a sample of children with SSDs, show deficits in NWD; 2) whether scores on NWD correlate with measures of phonological representation (Real-word Discrimination; RWD); and 3) whether scores on NWD are a useful predictor of which children with SSDs will resolve, with/without therapy.

**Method:** 13 participants with SSDs: 8 boys, 5 girls; aged 3; 02-4;08 (M = 3;10). Participants were recruited through another study on the efficacy of a parent-administered home programme. Participants completed tests of NWD and RWD at study outset. The phonology sub-test of the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd et al, 2006) was administered at initial assessment, and again 8 weeks later.

**Results:** Data from 2 children were excluded due to non-completion of the test of NWD. Only 2 children had good NWD scores; both made significant improvement in PCC by Assessment Time 2, despite not receiving therapy. The only other child making significant improvement received therapy. There was no significant correlation between scores of NWD and RWD; however children with good NWD had highest scores in RWD.

**Conclusions:** Findings from this small sample suggest the utility of NWD as a predictor of spontaneous resolution for children with SSDs continues to warrant investigation. Further investigation is needed of the relationship between good NWD and phonological representations of real words.

**Keywords:** Speech Sound Disorders (SSDs), Non-word Discrimination (NWD), phonological representation, Real-word Discrimination (RWD).

## **Introduction**

### Background

Children with speech sound disorders represent 40% of the typical client base for Speech and Language Therapists (Broomfield and Dodd 2004). Research shows that some of these children will go on to have difficulties in social interaction and education, and that these problems may persist to limit employment opportunities (McCormack, McLeod, McAllister and Harrison 2009; Leitao and Fletcher 2004). In particular difficulties within the speech processing system have been associated with problems in reading, spelling and writing development (Pring and Snowling 1986; Scarborough 1990). However spontaneous resolution does occur for some children (Sadock and Sadock 2011). This poses a challenge in the context of limited resources to identify and prioritise those children requiring therapeutic input. Shriberg (2003) argues that 'accurate differential diagnosis of a patient's disorder, including information on both original and maintaining causes, is necessary to determine the optimum form and content of treatment' (p.502).

It is generally agreed that children with speech sound disorders are a heterogeneous group and that different subgroups respond to different treatment approaches (Dodd and McCormack 1995). The research literature has identified several possible underlying deficits associated with speech sound disorders, as summarised by Dodd (2005): 1) Children with deficits in oro-motor skills (i.e. developmental and speech disordered errors reflect limited oro-motor control which may reflect a more general motor immaturity; Hewlett, Gibbon, & Cohen-McKenzie 1998); 2) Children with deficits in input skills (i.e. children may fail to learn to perceive the phonetic differences between sounds leading to pronunciation and language difficulties; Tallal and Percy 1973); and 3) Children with deficits in cognitive-linguistic ability (i.e. children may have limitations in cognitive processes that may affect their ability to process speech information, including phonological working memory (Adams and Gathercole 2000), and lexical representation (Elbro 1993). While much of the research to date has investigated these underlying deficits within a framework of speech production tasks there is a dearth of research using a speech perception approach to the investigation of the development of phonological representations and their impact in the development and

persistence of speech sound disorders for certain children (Rvachew and Brosseau-Lapré 2012a).

Dodd (1995) proposes a classification of subgroups of speech disorders including: 1) Articulation disorder: an impaired ability to pronounce specific phonemes; 2) Phonological delay: all the error patterns derived to describe a child's speech occur during normal language development but are typical of younger children; 3) Consistent phonological disorder: consistent use of some non-developmental error patterns; 4) Inconsistent phonological disorder: children's phonological systems show at least 40% variability, with multiple error forms for the same lexical item. Rvachew and Brosseau-Lapré (2012a) suggest that while it is possible to reliably classify children's error profiles at a given point in time using this framework; it has not been established that the resulting classifications reflect stable subtypes with respect to underlying psycho-linguistic processing deficits. Research by Williams and Chiat (1993) compared children with developmental versus deviant error patterns on four speech production tasks: picture naming, word repetition, non-word repetition and sentence repetition. They concluded that children with consistent deviant error patterns presented with a qualitatively similar profile to children with developmental phonological errors but with a more severe impairment. A longitudinal study by Rvachew, Chiang and Evans (2007) of 58 children with speech sound disorders with assessment at 57 months and again at 70 months found that severity of the speech sound disorder decreased with age for most children; and that error types changed with age and varied with severity, with younger and more severely impaired children producing more syllable structure errors and more atypical errors than older and less severely impaired children. This suggests that inconsistent and unusual matches to adult targets may exist on a developmental continuum of phonological development and may only persist for a subset of children requiring professional speech and language therapy assessment and intervention. In this way the development of phonological representations may be considered integral to the overall speech development of the child. Identification of subsets of children for whom a speech sound disorder is likely to persist relies on establishing underlying causal deficits for the presenting speech problem.

## Motivation for the current study

The motivation for the current study arises from a consideration of the question that there may be a subset of children with speech sound disorders who have difficulties with both input and output speech processing. For such children their resulting impairments may be slower to resolve than those of children with output deficits alone. If this should be the case, therapists could prioritise these types of children for early treatment to address the dual deficit. Support for this position comes from recent research by Wright (2013). In a prospective cohort study of 85 children aged 3-5 years waitlisted for assessment of speech sound difficulties, at initial assessment 4 were diagnosed with articulation disorder, 34 with phonological delay, 28 with consistent phonological disorder and 8 with inconsistent phonological disorder; the remaining 11 children were found to have age appropriate speech development. At follow-up assessment 2 years later, the majority of the children originally meeting diagnostic criteria had seen a marked decrease in the severity of their speech sound disorder with associated movement between classification groups: 3 children retained a diagnosis of phonological delay, only one child retained the diagnosis of consistent phonological disorder and none presented with inconsistent phonological disorder. The majority of the children had age appropriate speech at assessment time 2. Similar patterns were evident whether or not children received therapy. The only predictive factor associated with the outcomes in Wright's study was children's performance on a test of auditory discrimination (i.e. non-word discrimination): all of those children with good auditory discrimination of speech at assessment time 1 had their speech problems resolved at assessment time 2, regardless of the severity of the presenting problem at time 1, or whether or not they received therapy. This suggests that the impact of speech perception and processing ability in the development of phonological representations within speech sound disorders warrants further investigation.

The following literature review presents an overview of theories of typical speech and language development while considering the development of phonological representations within these theoretical frameworks. Speech sound disorders (SSDs) are then discussed with particular reference to the consideration of potential underlying deficits. Particular methods

for ascertaining difficulties in speech sound perception that may contribute to deficient phonological representations are explored. Consideration is given to the importance of tailoring intervention provision to underlying deficits, with particular emphasis on input-based intervention for speech perception and phonological processing deficits; before the research questions pertaining to the current study are presented.

## **Literature Review**

### Speech development

A full account of theories relevant to speech and language acquisition is beyond the scope of this study; however a brief consideration is presented here in the context of approaches to phonological development. Ambridge and Lieven (2011) posit that in general terms theories of speech and language development within the research literature may be represented along a dichotomy of approaches: 1) the nativist, generativist approach and 2) the constructivist, emergentist, socio-pragmatic, functionalist, usage-based approach. Within the nativist-generativist approach innate adult-like underlying linguistic knowledge present from birth emerges through a process of maturation whereby developmental constraints (e.g. due to the child's stage of cognitive or craniofacial development) are gradually overcome (e.g. Pinker 1979).

According to more recent advances in nativist theory such as the emergence of optimality theory, underlying representations (inputs) of words are modified via a system of constraints to produce a surface representation, or output, that maintains as much as possible faithfulness in form to the input, and adheres to nativist assumptions of unmarked properties of language being produced (e.g. Barlow and Gierut 1999). A study by Edwards and Beckman (2008) examined two- and three-year-old children's productions of obstruents in Cantonese, English, Greek, and Japanese, and found substantial differences in the acquisition of what are fundamentally the same sounds across languages. This showed that both language specific constraints (frequency of occurrence in the language) and language universal constraints (relating to ease of production and perception) were needed to



account for the patterns across languages. This then underlines the importance of input from the ambient language in the development of the child's phonological system

Both variations of the nativist position rely on adult-like lexical/phonological representations. Within the original nativist theory of Universal Grammar (Chomsky, 1965) environmental language input only acts as a trigger to set the particular parameters of the innate system to account for the ambient language. Similarly optimality theory assumes perfect perception of adult surface forms (Boersma and Hayes 2001). Such positions do not allow that individual differences in phonological development might arise from differences in the nature of the language input or differences in the child's access to that input due to environmental or child-related variables, including problems with auditory or phonological processing or attentional mechanisms (Rvachew and Brosseau-Lapr e 2012a). Such differences are accounted for within cognitive-linguistic models and usage-based theories of language development. According to this theoretical perspective the most important influence on a child's language development is the language input provided by adults in the environment (Hoff and Naigles 2002). Speech production skills are held to be dependent on the development of detailed acoustic-phonetic representations for words (e.g. Hoff and Naigles 2002). Thus perception both shapes and is shaped by the acquisition of language-specific phonological categories. It is then a natural extension to consider the potential impact of deficits in speech discrimination skills in the development of speech sound disorders.

#### Speech sound disorders and underlying deficits.

Common developmental phenomena support the notion of cognitive-linguistic deficits such as auditory perception/ discrimination in speech sound disorders, particularly with regard to an interaction between phonological input processing and motor speech output. Smith (1973) reports a common occurrence in the development of phonology where a child can pronounce a word's sound sequence correctly when the target is another word (e.g. *puddle* produced as [pʌg l], but *puzzle* produced as [pʌd l]). Children may also commonly imitate

words correctly that they produce in error in spontaneous speech (Dodd 1995), indicating that it is not a motor deficit that affects speech accuracy. The mismatch between auditory processing and speech production in the above examples indicates the complexity of phonological knowledge and its role in speech production.

The psycholinguistic approach to speech problems in children proposed by Stackhouse and Wells (1997) sees speech problems as being derived from a breakdown at one or more levels of input, stored linguistic knowledge, or output. The use of the psycholinguistic term 'phonological processing problem' reflects specific underlying cognitive deficits that may give rise to speech and or literacy difficulties. The terms speech processing and phonological processing are used interchangeably in the literature to refer to problems processing spoken information in the absence of any hearing impairment (i.e. the deficit lies somewhere between the functioning auditory system and the lexicon). The impact of speech processing problems may include the child having difficulty discriminating between similar sounding words, or having a limited memory for spoken words. Stackhouse and Wells (1997) propose that this is likely to lead to inaccurate or imprecise phonological representations of words and that this is necessarily reflected in phonological errors in the speech output derived from these representations. This position is echoed by Cabbage (2015) in a review of the research literature on the role of speech perception problems in speech sound disorders. This review indicates that speech perception problems are common and persistent among individuals with speech sound disorders: Edwards, Fox and Rogers (2002), Schuster (1998), Rvachew and Jamieson (1989) and Locke (1980) among other researchers, found that some children with speech sound disorders demonstrated difficulties in speech perception within phoneme discrimination tasks in research settings; while Kenney, Barac-Cikoja, Finnegan, Jeffries, and Ludlow (2006) found that a small group of adults with persistent speech sound disorders (i.e. individual and familial history of speech sound disorder with at least one articulation error persisting to adulthood in the absence of any other developmental delay) had speech perception deficits relative to adults with no history of speech sound disorders. This raises the question of whether those children presenting with speech perception

deficits underlying their speech sound disorder are more likely to have their speech difficulties persist.

### Investigating the influence of input processing on speech output

Munson, Edwards and Beckman (2005a) propose four subtypes of phonological knowledge:

1) Perceptual knowledge: knowledge of the perceptual-acoustic properties of phonemes and categorical perception of meaningful contrasts between phonemes of the ambient language;

2) Articulatory knowledge: knowledge of the articulatory characteristics of speech sounds to facilitate accurate production; 3) Knowledge of higher-level phonological categories:

knowledge of how sound categories are used to code meaning in language; and 4) Social indexical knowledge: knowledge of how linguistic variation is used to convey and perceive membership in different social groups (e.g. social class, race, gender, and regional dialect).

Further investigation into the relative dependence and independence of these subtypes of phonological knowledge by Munson, Edwards and Beckman (2005b) utilised a non-word repetition task across 40 children with phonological disorders and a control group of 40 typically developing children and found that across the whole sample children with poor speech perception ability were less accurate than children with good speech perception ability on repetition accuracy; and that for those children with phonological disorders speech perception ability was predictive of word repetition accuracy. This study also replicated Edwards, Beckman and Munson's (2004) finding that sequences of phonemes that are evident in few or no real words are repeated less accurately than those that are evident in many real words. Munson et al (2005b) also replicated previous findings that measures of vocabulary size predict difference in repetition accuracy between high and low-frequency sequences beyond what is predicted by age. Thus speech input variables appear to influence speech output abilities in both typically developing children and children with speech sound disorders.

In terms of typical speech development Sussman (1993) established developmental differences in auditory processing of speech stimuli across child vs. adult subjects. Results

from an auditory discrimination task revealed that children's sensory capabilities for the detection of formant transition differences were developmentally poorer than those of adults. Further investigation by Nijland (2009) indicated differential deficits in higher-order perceptual processing of speech input for children with phonological disorders when compared with those children with specific motor speech output deficits associated with Developmental Verbal Dyspraxia (DVD). In a multiple regression analysis of variables (receptive vocabulary, phonological awareness, articulation and speech perception) Rvachew (2006) found that speech perception skills at prekindergarten age predicted articulation development at kindergarten age. The reverse relation was not evident. However a reciprocal relationship was indicated between speech perception and phonological awareness across stages. An earlier study by Rvachew, Ohberg, Grawburg & Heyding (2003) similarly found that children with expressive phonological delays demonstrated significantly poorer phonemic perception and phonological awareness skills than their typically developing peers. Thus phonological knowledge and phonological processing warrant further investigation as underlying deficits within speech sound disorders.

#### Non-word discrimination as a measure of phonological processing

Gathercole (2006) asserts that the abilities to repeat non-words and to learn the phonological forms of new words are closely linked since both rely on phonological storage and are constrained by auditory, phonological, and speech–motor output processes. Correlations between non-word repetition and expressive phonology in children with language impairment have been shown (Bowey, 1996; Sahlen, Reuterskiold-Wagner, Nettelblatt, and Radeborg 1999). Gathercole and Baddeley (1990) have argued that individuals who are unable to form temporary phonological representations of novel non-words are likely to experience difficulties in constructing a stable phonological representation in long-term memory within the process of vocabulary acquisition. Snowling, Chiat, and Hulme (1991) argue that non-word repetition is a complex psycholinguistic task involving a number of different components, including speech perception, construction of a phonological representation, phonological memory, segmentation of the phonological

representation, assembly of articulatory instructions, and articulation. Difficulties in any one of these components can impair performance on this task. This poses a challenge in the use of this type of task to isolate a specific breakdown within the psycholinguistic model of speech impairment at the level of either input, phonological representation or output.

In accordance with Stackhouse and Wells' (1997) psycholinguistic model of speech problems the objective of testing auditory discrimination is to establish if a child has enough input processing skills to distinguish between similar sounding words and to store precise representations of those words in the lexicon. Stackhouse and Wells assert that intact input processing skills are necessary for developing phonological representations as a basis for speech production and spelling. A study by Reuterkiöld-Wagner, Sahlen & Nyman (2005) indicates that a non-word discrimination task is an effective alternative to non-word repetition in gaining a measure of phonological representation for children with language impairment and associated expressive phonology deficits, while controlling for the confounding variables of articulation planning and execution. Stackhouse and Wells (1997) refer to non-word discrimination and real-word discrimination as both being tests of auditory discrimination but tapping different levels of input processing within their psycholinguistic model of speech. Real-word discrimination may consist of a decision on a comparison of minimal pairs (e.g. "Car, Tar – are they the same?") or Yes/No decisions for pictures named correctly or incorrectly (e.g. "Is this a Tar?"). The latter task may be more challenging since finer phonetic discriminations between target sounds can be made. Tasks involving pictures of real words for the child to discriminate also call upon the child's lexical representations and therefore have to be processed at a higher level within the psycholinguistic model according to Stackhouse and Wells. Research also indicates that the form of stimulus words used can indicate differential speech processing difficulties within and between children with speech sound disorders. Bridgeman and Snowling (1988) conducted auditory discrimination tasks using a combination of real words and non-words with a group of children aged 7; 02 -11 years, with developmental verbal dyspraxia. No difference was found in the ability to discriminate CVC words, however in comparison to a control group, children with speech problems performed worse in a CVCC task, particularly

when using non-words (e.g. VOST vs VOTS). This suggests possible specific difficulty processing sound sequences even though simple minimal pair discrimination may be intact at single syllable level. These findings also suggest that a test of non-word discrimination may more accurately reflect deficits in the child's phonological processing system that may not be evident from a test of real-word discrimination alone.

### Evidence from intervention studies

Further evidence that some children with speech sound disorders have deficits at the input level which affect their speech accuracy may be gained through establishing the success of intervention treatments for input difficulties in improving speech production. One might infer that such children may benefit from enhanced access to high-quality, structured speech input as a means of improving their processing efficiency and strengthening their phonological representations (Rvachew & Brosseau-Lapr e, 2012b), which in turn would improve their speech output.

A number of studies have demonstrated a link between phonological perception deficits and speech production errors via single-subject experimental designs. Jamieson and Rvachew (1992) demonstrated that training in sound discriminations reflective of error substitutions made by individual children effected an improvement in their production of target phonemes in speech. Rvachew (1994) meanwhile found that discrimination training of /s/ vs. /ʃ/ target phonemes within words resulted in improved production of these speech sounds across a sample of 27 children with speech sound disorders. In another group study of 5 to 7 year old children with speech sound disorders, Shiller & Rochon (2014) found that children's ability to perceive relevant acoustic speech properties has a direct influence on their ability to modify motor-speech output on the basis of sensory feedback.

In Rvachew and Brosseau-Lapr e's (2012b) study the effectiveness of an input-focused intervention was assessed in a randomized controlled trial involving 64 native French-speaking children. Eighteen children received a speech perception intervention in the clinic

along with parent-administered dialogic reading; alternative conditions compared speech production practice coupled with parent-administered articulation therapy, or a mixture of these components. The speech perception groups showed best outcomes in terms of both phonological awareness and articulation accuracy. The authors conclude that an input-focused intervention provides as much benefit to the acquisition of articulation accuracy as a traditional intervention that focuses on speech production. However findings within the study are moderated as a function of treatment intensity across conditions. The authors caution against a 'one-size fits all' approach and emphasise the importance of tailoring the intervention approach to address the specific underlying deficits within the individual's speech system.

The challenge therefore remains for clinicians to determine the underlying deficit relevant to a presenting client in designing an appropriate intervention. To this end an effective screening measure to establish underlying speech perception deficits, such as a non-word discrimination task, may point to the suitability of an input-based approach as part of an intervention package. It would also allow investigation of whether a child who has input as well as output deficits in speech processing and production is less likely to resolve or improve without therapy.

### Summary and research questions

Given the consideration of the available literature with regard to speech development and speech sound disorders; the potential underlying speech perception deficits associated with some presentations of speech sound disorder, and the potential for such deficits to be established using a test of non-word discrimination; the current study aims to investigate:

- 1) What proportion, in a sample of children with speech sound disorders, show deficits in non-word discrimination;
- 2) Whether scores on a test of non-word discrimination correlate with other measures of phonological representation reflected in a test of real-word discrimination;

3) Whether scores on a test of non-word discrimination are a useful predictor of which children with speech sound disorders will improve, with or without therapy.

## **Methodology**

### Ethical Approval and Consent

Ethical approval for the current study was granted by the Research Ethics Committee University Hospital Limerick. Informed written consent was obtained from parents prior to their child's participation.

### Experimental Design

The data for this study were obtained from a larger study investigating the efficacy of an intervention programme. That study had a between groups repeated measures design with pre- and post-treatment measures for the intervention group compared to a control group (i.e. Treatment Now vs. Treatment Later).

Children were randomly allocated to a treatment now or a treatment later group. Each child's performance on tests of non-word discrimination and real-word discrimination prior to the treatment onset was compared to their treatment outcome in terms of change in Percent Consonants Correct (PCC) between Assessment Time 1 and Assessment Time 2.

### Participants

Participants were recruited from waiting lists of local Speech and Language Therapy services. Speech and Language Therapy service managers acted as gatekeepers and sent out information sheets to all parents of children who had been referred due to speech sound difficulties and who were currently awaiting assessment or intervention, offering them the



opportunity to take part in the research study. Parents who wished to take part sent back consent forms to the principal investigator. Children included in the study were all monolingual English-speaking and aged between 3;0 and 4;11. Those children currently in receipt of speech and language therapy; those with speech deficits due to organic/ structural causes; and those with an additional diagnosis of cognitive or sensory difficulties were excluded from the study. Thirteen participants, eight boys and five girls, took part in the study ranging in age from 3;02 to 4;08 with a mean age of 3;10. All children were reported to have normal hearing at the time of participating in the study; three of the children had a history of recurrent ear infections and conductive hearing problems requiring grommets.

### Procedure

Participants were allocated to the Treatment Now vs. Treatment Later group on a random basis through parental blind selection of a coloured token at the end of the initial assessment session. Seven children were randomly assigned to the Treatment Now group (five boys, two girls, age range 3;02 – 4;08, Mean age = 3;09) with six children in the Treatment Later group (three boys, three girls, age range 3;04 – 4;05, Mean age = 4;0).

### Assessment Time 1

Each child was assessed in a quiet clinic room with one Speech and Language Therapy (SLT) student researcher acting as lead assessor and one acting as observer. Both student SLTs transcribed responses to allow later checking of reliability. Each assessment session lasted approximately 45 minutes and one or both parents were present throughout the assessment.

#### *Assessments administered at Time 1:*

*Case history* information obtained through parental completion of a case history form and discussion with student therapist at the end of the session.

*Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Hua, Crosbie, Holm and Ozanne 2006):* The phonology subtest of the DEAP was administered to obtain a baseline measure of Percent Consonants Correct (PCC). The assessment was administered according to the instructions in the manual.

*Test of Non-word Discrimination (NWD):*

This was an input processing task using a procedure similar to that described in Dodd and McIntosh (2008); Reuterskiöld-Wagner et al (2005); and Byun (2012) and previously used by Wright (2013). It was intended to provide insight into the child's phonological encoding ability and/or auditory discrimination

The stimuli comprised 16 pairs of non-words, 7 of one syllable and 9 of 3 syllables, where 8 pairs were identical, and eight differed. Three 1 syllable and 5 three-syllable non-words were repeated identically. The remaining non-word pairs differed by one phoneme in word medial or word final position, which was substituted by another that differed by one feature of place, voice or manner. Medial and word final position were chosen to make sure the task was challenging: experimental studies of adult perception have found that phonemic contrasts are perceived more accurately in initial/prevocalic relative to final/postvocalic contexts (Fujimura, Macchi, and Streeter 1978; Redford and Diehl 1999). The stimuli were presented in a predefined order where the discrepant pairs were randomly interspersed with the identical pairs. Children were asked to make a same/different judgement about non-word utterances produced by two speakers of Hiberno-English.

The stimuli were presented to children on a computer screen showing a video of two young women (sisters) who were side by side. Shoulders, neck and full head were included in the screen image. The woman on the left presented the first item of the trial while the woman on the right watched. The second woman then turned to the camera and

repeated the non-word, with or without a discrepancy. The child was told that the first girl was going to say a “funny word” and her sister had to copy her and say it “just like her”. After the presentation of each trial the child was asked “Did she say just what her sister said?” or “Did she get it right?” by the investigator. This phrasing was chosen to avoid the same/different concept, which might not be established in the younger children. Children had to answer “yes” or “no” and their response was marked on a score sheet. The score awarded was the number of items that the child correctly discriminated as same or different. The stimuli for the task are shown in Appendix A.

The task was designed to avoid the subject completing it by comparing targets at a superficial, strictly phonetic level. In tasks with a low memory load, listeners show sensitivity to within-category phonetic distinctions as well as phonemic contrasts (Werker and Logan 1985). In this task, non-words in a pair were separated by a pause while the second speaker turned to the camera, and were also produced by different voices. To compare the members of a pair, the child must hold the target non-words in memory and adapt to phonetic qualities of a different voice. It was thus designed to induce phonological encoding of non-word targets and rule out a superficial phonetic comparison.

#### *Test of Real Word Discrimination (RWD):*

This test was developed for the purposes of the current study with reference to the literature to date on tests of phonological representation that are input-based rather than requiring a speech production response for the child. Such assessments of phonological representation have previously been employed by Constable, Stackhouse and Wells (1997) within a single-subject design and most notably by Locke (1980) in the development of the Locke Speech Perception Task. To date these tests have involved confronting children with their own error productions alongside accurate target productions and, in the case of the Locke task, control items. The aim within the current study was to move beyond single-case research and develop a test to be used to assess a group of children with speech sound

disorders, regardless of the form of their individual errors. A list of 25 comparisons was used (See Appendix B). Words used were high frequency and low age of acquisition, as listed within the Macarthur-Bates Communicative Development Inventory for typically developing children aged 16-30 months (Fenson, Marchman, Thal, Dale, Reznick and Bates 2007). Each picture was presented singly and the child was told that a puppet (e.g. "Froggy") held by the therapist was going to attempt to say the word for the picture. The therapist named the picture either using the correct production of the word or an incorrect production with one phoneme altered. Within the incorrect production the syllable structure of the word was maintained. Incorrect productions reflected typical developmental phonological processes including: stopping of fricatives, fronting of velars, cluster reduction, deaffrication, and gliding. The child was asked to identify if the puppet (i.e. therapist) had named the picture correctly (e.g. "Did Froggy say it right?"). Visual aids were provided for the child to indicate whether the word had been said correctly by pointing to a happy face symbol for "yes" or a sad face symbol for "no" (See Appendix C). Four training trials were conducted using the above procedure to ensure the child understood the test items and response required before data collection on the test items commenced. This test procedure confirms if the child can recognise the correct form when it is spoken by another person, even if he/ she is unable to produce it.

Three other tests: DEAP Diagnostic screener (Dodd, Hua, Crosbie, Holm and Ozanne 2006); Renfrew Action Picture Test (RAPT; Renfrew 2003); and the Focus on the Outcomes of Communication Under Six (FOCUS) tool (Thomas-Stonell, Oddson, Robertson and Rosenbaum 2010); were also administered as part of the larger study but are not reported here.

### Treatment Now vs Treatment Later

For the Treatment Now group, parents were given the Mixed-Up Marty programme; a parent administered programme based on phonological principles. Parents attended one training session and carried out the programme as instructed over 8 weeks.

For the Treatment Later group, parents were informed that training and programme resources would be provided in 8 weeks.

### Assessment Time 2

All children were reassessed after 8 weeks, using the same procedure as described above for assessment at Time 1.

#### *Assessments administered at Time 2:*

*Adapted version of DEAP Phonology sub-test:* The same target words from the DEAP were presented using alternative pictures not previously seen, and presented in a different order from the original assessment to counteract any potential practise effect.

The RAPT, FOCUS tool and a parental rating scale of the acceptability of the intervention programme were also administered at Assessment Time 2 as part of the larger study, but are not reported here.

### Reliability

Both student SLT researchers made online broad phonetic transcriptions of the children's responses on the DEAP subtest. All responses were recorded using an Olympus Digital Voice Recorder VN-8500PC and were verified against the audio recordings following each assessment to ensure accuracy. Agreement was reached between the lead assessor and observer for each speech token. In the case of non-agreement, the lead assessor's version was accepted. Percent Consonants Correct (PCC) was calculated for each DEAP assessment by both assessors. In the case of a difference between the assessors' calculations a third student SLT researcher was recruited to independently re-check the calculations. Final PCC scores reported constitute 100% agreement across at least 2 scorers.

Data for the tests of non-word discrimination and real word discrimination were collected by the observing assessor in situ only, due to the need for the lead assessor to manipulate materials in the administration of the tests. Therefore no inter-rater reliability was calculated for the tests of non-word discrimination and real word discrimination.

## Results

Data from 2 children were excluded as they did not complete the test of non-word discrimination. Due to the small sample size, all statistical analysis was carried out using non-parametric tests. Raw data from the study are laid out in Table 1 below. Data were analysed with reference to the three research questions posed in the study.

**Table 1:**  
**Non-word Discrimination (NWD), Real Word Discrimination (RWD), and Percent Consonants Correct (PCC) Scores at Assessment Time 1 and Assessment Time 2**

Participant:	Gender	Age	NWD/16	RWD/25	DEAP PCC Ax Time 1	DEAP PCC Ax Time 2
1	Male	3;06	10	14	75	84
2	Male	3;11	9	24	65	65
3	Female	4;05	14	25	71	82
4	Female	3;10	8	16	62	62
5	Male	3;02	8	18	29	33
6	Female	3;04	8	19	55	50
7	Female	3;11	10	13	50	49
8	Female	3;06	10	19	63	61
9	Male	4;02	8	21	63	62
10	Male	4;01	15	24	64	71
13	Male	4;05	8	24	59	60

1) What proportion, in a sample of children with speech sound disorders, show deficits in non-word discrimination?

Scores on the test of non-word discrimination ranged from 8-15 out of a possible 16, with a Mean score of 10. Only two children (18%) scored above the threshold score of 11 previously established as criterion for good performance on the test of non-word discrimination used in the current study by Wright (2013). This was a much smaller proportion of children with good non-word discrimination than shown in the study by Wright (2013) where 39% of children with speech sound disorders presented with good non-word discrimination (A. Wright, personal communication, 04 May 2015). The remaining 9 children (82%) in the current study showed deficits in non-word discrimination. This suggests that within the current sample, as with that of Wright (2013), children presenting with speech sound disorders comprise subsets of children with different underlying deficits; at least some of which may involve a combined difficulty with input and output processing.

2) Do scores on a test of non-word discrimination correlate with other measures of phonological representation reflected in a test of real-word discrimination?

Scores on the test of real word discrimination ranged from 13-25 out of a possible 25 with a Mean score of 20. Analysis using Spearman's rank correlation indicated that there was no statistically significant correlation between participants' scores on the test of non-word discrimination and the test of real word discrimination ( $\rho = 0.2$ ;  $p = 0.556$ ). It is notable that those children who scored above the threshold on the test of non-word discrimination also scored highly on the test of real word discrimination (Participant 3 = 25/25 and Participant 10 = 24/25). However similarly high scores of 24/25 on real word discrimination for Participants 2 and 13 were not associated with high scores on non-word discrimination, scoring 9 and 8 respectively (See Table 1). This suggests that the test of non-word discrimination may indeed measure a different level of phonological processing than that measured by the test of real word discrimination.

3) Are scores on a test of non-word discrimination a useful predictor of which children with speech sound disorders will improve, with or without therapy?

Only three children made clinically significant change in the 8 weeks. Clinically significant change was considered within this study to be an improvement in PCC scores of a magnitude sufficient to effect an increase in the child's standard score on the DEAP assessment. Of the three children achieving an increase in standard score over the course of the study, two were those children who demonstrated good non-word discrimination at the outset. Participant 3 scored 14 and Participant 10 scored 15 (See Table 1); both made clinically significant improvement in PCC over the 8 weeks, despite not receiving therapy. The only other child with a clinically significant increase in PCC received therapy (Participant 1); this child scored just below the threshold performance on the test of non-word discrimination (Score = 10/16).

Performance on the test of non-word discrimination was not shown to have a statistically significant correlation with the magnitude of improvement in PCC from Assessment Time 1 to Assessment Time 2 across the group ( $\rho = 0.435$ ;  $p = 0.181$ ). Likewise there was no significant correlation between real word discrimination and PCC change from Time 1 to Time 2 ( $\rho = 0.291$ ;  $p = 0.385$ ).

Division of the data set into independent groups delineated by performance on non-word discrimination enables comparison of data from two participants with good non-word discrimination (i.e. scores of 11 and above) to data from nine participants with poor non-word discrimination (i.e. scores of 10 and below). A Mann-Whitney U test was used to investigate whether children with good non-word discrimination made more change in DEAP standard score and PCC than those with poor non-word discrimination. This showed that the group with good non-word discrimination made significantly more improvement in standard score ( $U=1.5$ ,  $Z=-2.054$ ,  $p=0,04$ ); the improvement in PCC was near but did not reach significance ( $U=1$ ,  $Z=-1.894$ ,  $p=0.058$ ). This indicates that there may be some meaningful difference in outcomes between groups with good versus poor non-word



discrimination; however the current sample is too small to draw any firm conclusions from these findings.

## **Discussion**

The aim of this study was to investigate: 1) What proportion, in a sample of children with speech sound disorders, show deficits in non-word discrimination; 2) Whether scores on a test of non-word discrimination correlate with other measures of phonological representation reflected in a test of real-word discrimination; and 3) Whether scores on a test of non-word discrimination are a useful predictor of which children with speech sound disorders will improve, with or without therapy. The results of the study reveal that the majority of the children in this small sample presented with deficits in non-word discrimination as reflected in their scores on the test of non-word discrimination. These scores were not correlated with measures of phonological representation developed for the purpose of the current study via the test of real word discrimination. A noteworthy outcome of the study was the finding that those children with good non-word discrimination ability showed more improvement from assessment at Time 1 to Time 2 than children with poor non-word discrimination and that this was achieved in the absence of any therapy input. The specific results and implications from the study are discussed below in the context of the research literature; together with the study limitations, and recommendations for future research.

- 1) What proportion, in a sample of children with speech sound disorders, show deficits in non-word discrimination

Nine of the eleven participants in the current study scored below the threshold score of 11/16 established as good non-word discrimination ability by Wright (2013). This represents 82% of the current sample. In Wright's study 61% of the children within the sample had poor non-word discrimination. While the proportion in the current study is much larger, the much smaller sample size means that the current sample may be somewhat skewed and less

representative of the wider population of children with speech sound disorders. Nonetheless the consistent finding of a subset of children with speech sound disorders presenting with poor non-word discrimination is in keeping with the research literature to date; including findings by Edwards, Fox and Rogers (2002), Schuster (1998), Rvachew and Jamieson (1989) and Locke (1980) of speech perception difficulties within phoneme discrimination tasks for some children with speech sound disorders. The findings of the current study require further replication within a larger sample; however results across studies to date point to the likelihood of at least some children with speech sound disorders having underlying deficits in a combination of speech input and output processing and this is likely to be relevant for clinician approach to assessment and treatment.

- 2) Do scores on a test of non-word discrimination correlate with other measures of phonological representation reflected in a test of real-word discrimination?

The relationship between non-word discrimination and real word discrimination within this study is unclear. While those children with high non-word discrimination scores had high real word discrimination scores, this relationship was not always reciprocal as some children with high real word discrimination scores did not score highly on non-word discrimination. The first thing to consider in exploring this finding is a comparison of what is being measured by the two tests. Stackhouse and Wells (1997) assert that a child who has bottom-up processing difficulties (i.e. trouble with auditory processing of speech sounds as measured by the test of non-word discrimination) may perform significantly better on an auditory discrimination task comprising real words, because they are able to draw on their semantic knowledge for support. In particular the use of high frequency words within the test of real word discrimination employed in the current study carries a level of redundancy since the children will have had multiple previous opportunities to hear these words and build complete and robust phonological representations. Thus the child may not be discriminating between correct and incorrect phonemes presented aurally, but rather making a yes/ no decision on the basis of the recognition of a familiar/ known versus unknown word. This may lead to better performance on the test of real word discrimination compared to the test of non-

word discrimination. This poses the question as to whether tests of real-word discrimination, commonly used in assessment by speech and language therapists, are true indicators of a child's phonological processing capability or are likely to be confounded by the child's language experience to date. Preliminary evidence from this study reflects previous research by Bridgeman and Snowling (1988) and Edwards, Beckman and Munson (2004) that sequences of phonemes that are evident in few or no real words are perceived less accurately than those that are evident in many real words. This suggests that a test of non-word discrimination warrants further investigation as potentially having better accuracy than a test of real word discrimination in detecting specific phonological processing difficulties.

- 3) Are scores on a test of non-word discrimination a useful predictor of which children with speech sound disorders will improve, with or without therapy?

While differences in PCC from Time 1 to Time 2 for those children with good non-word discrimination compared to those children with poor non-word discrimination were not statistically significant within the current study; the lack of statistical strength may be due at least in part to the small sample available. The finding in the raw data of those children with good non-word discrimination showing greatest improvement in PCC from Assessment Time 1 to Assessment Time 2, without therapy input, is nonetheless noteworthy. This is in keeping with the findings of Wright (2013) where all of those children showing good non-word discrimination scores at the outset had speech sound disorders resolved at a two year follow-up assessment, regardless of the severity of the presenting disorder, or whether or not they received therapy. The current study sample had a high proportion of children with poor non-word discrimination. An overall lack of improvement was evident from Assessment Time 1 to Time 2 across the group of children. This is reflective of previous research on the correlation between speech perception deficits and the persistence of speech sound disorders over time; such as Rvachew's (2006) finding that speech perception skills at prekindergarten age were predictive of articulation development at kindergarten age and that of Kenney, Barac-Cikoja, Finnegan, Jeffries, and Ludlow (2006) whereby adults with

persistent speech sound disorders had speech perception deficits relative to adults with no history of speech sound disorders. This may in part explain the lack of overall improvement evident within the current study and has implications for the prognosis for such children within clinical treatment.

### Clinical implications

According to Stackhouse and Wells' (1997) psycholinguistic model of speech impairment, speech processing problems, such as are indicated by poor non-word discrimination scores, may adversely impact the child's ability to discriminate between similar sounding words, or result in the child having a limited memory for spoken words. This has implications for vocabulary development as well as the persistence of a speech sound disorder since, as Stackhouse and Wells propose, impairment at the level of phonological/ speech processing is likely to lead to inaccurate or imprecise phonological representations of words, and have a subsequent effect on inaccurate or imprecise speech production.

While deficits in phonological processing cannot be said to be causal of speech sound disorder, as evident in the current study where two children with good non-word discrimination presented with speech sound disorders; a child with difficulties in phonological processing together with speech output difficulties may be considered to have a dual deficit. The child with good phonological processing ability, as reflected in good non-word discrimination scores, may be considered to have fewer deficits to overcome and be more likely to resolve. This hypothesis is tentative in light of the findings of the current study which are consistent with those of Wright (2013); further investigation within a larger sample is required. The preliminary indication of the potential use of a test of non-word discrimination as a prognostic indicator for children with speech sound disorders suggests that this is an area worthy of further longitudinal investigation within a larger sample. Should a screening tool such as the test of non-word discrimination be validated as a prognostic indicator for children with speech sound disorders this would greatly aid clinicians' caseload management in the context of current high demands for therapeutic

input in speech sound disorders. The determination of underlying phonological processing deficits within a child's speech sound disorder would also enable the clinician to more appropriately tailor an intervention approach to target these deficits via an input-based approach as well as working on speech production where appropriate.

### Limitations

The current study was limited due to the small sample size. This impacted the statistical strength of the findings and prevented any firm conclusions being drawn from the results. The study was also confined to an 8 week period between initial assessment and follow-up assessment; given research evidence to date such as that of Wright (2013) the potential of a test of non-word discrimination as a prognostic indicator may be more evident within a longitudinal study over a more extended period of time.

### Recommendations for future research

Thus the question remains: How do we know which children's speech sound disorders will resolve without therapy? The psycholinguistic model of speech problems utilised by Stackhouse and Wells (1997) provides a framework within which clinicians and researchers may work to identify underlying deficits impacting each individual child's speech sound disorder. A test of non-word discrimination such as that employed in the current study may represent one tool in identifying suitable care pathways for presenting clients. Further research is needed in the context of: 1) the longitudinal impact of underlying deficits in phonological processing; 2) the validity and reliability of a test of non-word discrimination as a measure of these deficits; and 3) the interrelationship between the development of real-word phonological representations and phonological processing abilities as reflected in a non-word discrimination measure.

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Appendix A: Test of Non-word Discrimination

**Test of non-word discrimination**                      **Code:** \_\_\_\_\_

**Total Correct: 1 syll.:** \_\_\_\_\_ **3 syll.:** \_\_\_\_\_ **Total:** \_\_\_\_\_

	<b>Production 1</b>	<b>Production 2</b>	<b>Feature diff.</b>	<b>Score</b>
1.	mɛp	mɛp		<b>S D</b>
2.	tɪfəlɒn	tɪsəlɒn	Place	<b>S D</b>
3.	tʌz	tʌd	Manner	<b>S D</b>
4.	ɡʌməlʌm	ɡʌməlʌm		<b>S D</b>
5.	nɪɡ	nɪd	Place	<b>S D</b>
6.	taz	taz		<b>S D</b>
7.	sɪləbɒn	sɪləbɒn		<b>S D</b>
8.	vɔzəlɪn	vɔdəlɪn	Manner	<b>S D</b>
9.	tɛməti	tɛməti		<b>S D</b>
10.	dat	dat		<b>S D</b>
11.	dɪzəlɹp	dɪzəlɹp		<b>S D</b>
12.	fas	fɑʃ	Place	<b>S D</b>
13.	sɪdʒali	sɪdali	Affrication	<b>S D</b>
14.	bɛnɪsən	bɛnɪsən		<b>S D</b>
15.	tɛp	tɛb	Voice	<b>S D</b>
16.	mɛtɪmən	mɛkɪmən	Place	<b>S D</b>

**Administration:**

Each slide contains a video clip of Girl 1 and Girl 2, side by side

Administrator clicks to play clip: Girl 1 says production 1, then Girl 2 says production 2

Child is asked “Did she say just what her sister said?”

## Appendix B: Test of Real Word Discrimination

Test of Real Word Discrimination					
Participant code:			Date:		
Assessor 1:		Assessor 2:			
		Response		Scoring	Notes
T1	fish	Yes	No		
T2	haut	Yes	No		
T3	fts	Yes	No		
T4	house	Yes	No		
	1 bouk	Yes	No		
	2 tɑ	Yes	No		
	3 gɛti	Yes	No		
	4 pɛnθɪl	Yes	No		
	5 bridge	Yes	No		
	6 spaghetti	Yes	No		
	7 flower	Yes	No		
	8 crocodile	Yes	No		
	9 tat	Yes	No		
	10 dɛdi	Yes	No		
	11 jauən	Yes	No		
	12 window	Yes	No		
	13 television	Yes	No		
	14 chicken	Yes	No		
	15 table	Yes	No		
	16 toes	Yes	No		
	17 toast	Yes	No		
	18 peik	Yes	No		
	19 sweets	Yes	No		
	20 lion	Yes	No		
	21 hɑ:t	Yes	No		
	22 pun	Yes	No		
	23 pillow	Yes	No		
	24 tɛlibɪʒən	Yes	No		
	25 su	Yes	No		
Total score				/25	

Appendix C: Visual supports used for Real Word Discrimination task



Yes



No