Hidden behind a smile: acquisition and societal perception of speech sounds in children with cleft lip and palate.

A perception study into the response towards the speech of children with cleft lip and palate, and the success of speech and language therapy in developing the intelligibility of children with cleft lip and palate.

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Contents

Introduction

Cleft lip and palate (CLP) is a genetic mutation which causes the upper lip, and the palates, to not fuse together correctly in the womb. CLP is the most common facial birth defect in the UK, affecting 1 in 700 babies (NHS, 2019) and does not only affect eating and drinking, but also speech sound production. In this perception study, I aim to detail how people perceive the quality of speech in children with CLP, as well as concluding the accuracy of the claims that speech and language therapy will offer a child with CLP "good quality, intelligible (understandable) speech by age 5-6" (CLAPA, 2021). This research aims to provide a basis for future research into the intelligibility of plosives and fricatives produced by children with CLP.

The Effects on Speech Sound Acquisition

Cleft lip and palate (CLP) is, as explained previously, a genetic mutation causing a lack of fusing in the lip and palate in the womb. Despite surgeons aiming to have these spaces closed in surgery by around 12 months (CLAPA, 2021), speech sound acquisition has already begun (Kuhl, 2004). This means that there will likely be delays to acquisition of speech, as well as compensatory articulations produced subconsciously by the child to compensate for their inability to produce certain sounds.

The sounds predominantly affected are plosives (/p/,/d/,/k/) and fricatives (/f/,/θ/,/s/,/ʃ/) and by extension affricates (/ʧ/,/dʒ/). They are affected as they require a degree of closure in the oral cavity to be produced which is often lost through the air escaping through the palate and out from the nasal cavity. This denies the plosive of its required 'pop' on the release of air, and the fricative of the air being released orally through a narrow channel to produce the necessary vibrations. CLP is also noted to cause hypernasality in speech due to the air being allowed to exit through the nasal cavity, however this area will not be discussed to any length in the report as measuring nasality would require this data to have been collected in a lab using a Nasometer which was not possible for this project.

Selecting Participants

As this is a perception study, it was vital that I create a list of key demographics whom I wanted to collect my data from. From here, it was concluded that in order to judge where children may have errors in their speech sound production, participants would need to be native or fluent speakers of English. The research is also audio based and so it was imperative that participants had a high quality of hearing with no known hearing loss.

Research Method

To collect this data, I used a survey which asks participants to listen to an audio clip of a child saying 1 or 2 words and answer a range of questions. These questions asked participants to decide whether the child has cleft lip and palate (CLP) or not, how they reached their conclusion, to transcribe the speech, and a scale from 1-5 stating how intelligible they believe the speech to be - 1 being completely unintelligible and 5 being adultlike. I selected the audios from a CLP corpus (Cleland et al., 2020) and a control group from a typically developing corpus (Eshky et al., 2018). As only 50% of children with CLP have access to speech and language therapies (NHS, 2016), it was also vital that I select a corpus in which the CLP children have undergone, or are currently undergoing, speech and language therapy (SLT) which is confirmed by the fact that the CLP corpus is collected throughout regular SLT sessions.

To select the audios, I chose the manners of articulation which are most affected by CLP - plosive, fricative and affricate (Nagarajan et al., 2009) - and found words in the CLP corpus which include these sounds for each place of articulation in the English Phoneme Inventory. I have selected one sound from either voiced or voiceless to represent each sound due to the constraints of the corpora. Then, I matched a child with CLP to a typically developing child by age and gender to ensure speech has been allowed to develop in a similar environment over the same period of time. This allowed the intelligibility of speech sounds in children

with CLP and typically developing children to be directly compared to one another with accuracy.

Research Findings

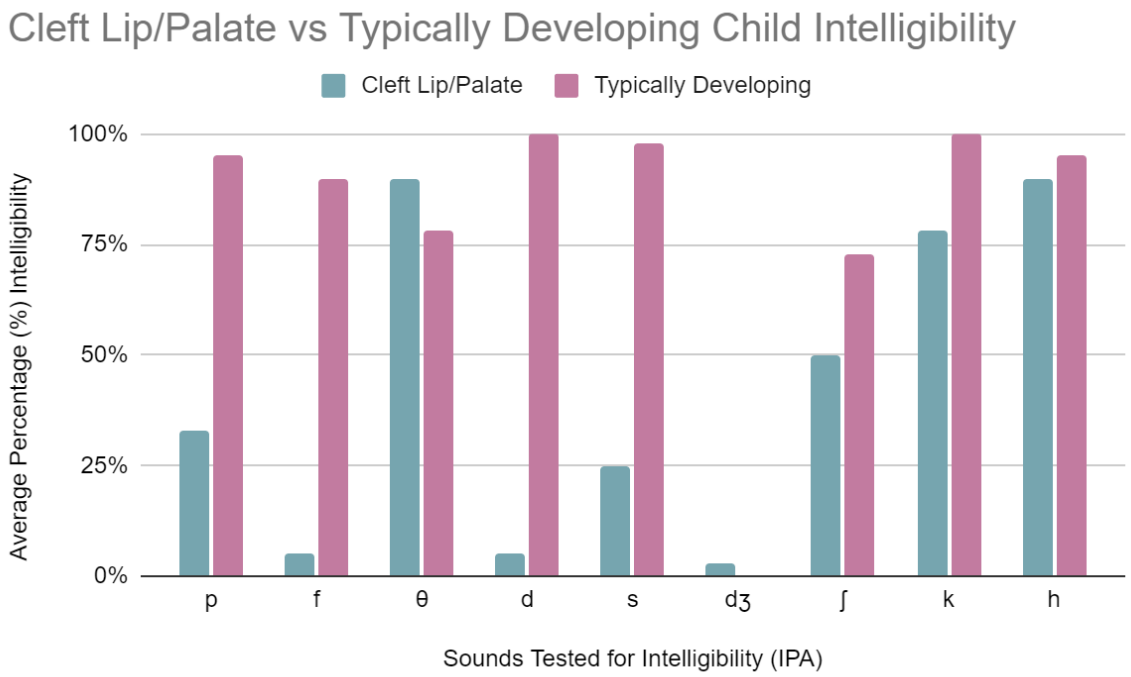
In this section, I will be exploring the findings of my research through the analysis of the responses to my survey. This section will address the intelligibility of the sounds produced by children with cleft lip and palate (CLP) in comparison to the intelligibility of their typically developing (TD) peers, as well as looking into the overall quality of speech from both groups. I also aim to conduct targeted analysis of the individual speech sounds to investigate possible issue points and possible instances of compensatory articulations. After this initial exploration, I also aim to determine whether the general public view children with CLP as beginning to assimilate to the speech of their TD peers through their perception of what determines the presence of a phonological development disorder such as CLP.

Intelligibility of Speech Sounds

To begin my exploration into the intelligibility of this speech, I first looked further into literature discussing the level of intelligibility that a typically developing child should have at various ages. Flipsen (2006) conducted a study into child intelligibility and found that 4 year olds have an average intelligibility of 96.82%. Another study conducted by Gordon-Brannan & Hodson (2000), also researching child intelligibility proposed that children with an intelligibility rating of 66% or less by the age of 4 likely have a phonological development disorder requiring intervention. When reporting on the intelligibility of child speech in this report, I will be using these percentages as a basis to judge the quality of speech. All speakers in this research are between the ages of 5 and 9, therefore these ratings should provide a good point of comparison for where the child should be in their intelligibility. During this analysis, it is vital to remember that the quality of speech is likely to vary between each child so these percentages are simply a point of reference rather than a fixed rating.

To find a percentage of intelligibility from my data, I based instances of 'correct transcriptions' on the inclusion of the highlighted phoneme in one or more appropriate positions in the word. I have also made allowances for minor errors in the understanding of each phoneme - for example, 'happy' was allowed where the correct transcription was 'puppy'. I also allowed homophones as correct transcriptions. From here, I was able to find my percentage intelligibility through the sum of:

$$100\ x\left(\frac{Number\ of\ participants\ able\ to\ correctly\ identify\ the\ phoneme}{Number\ of\ overall\ participants\ (40)}\right)$$



GRAPH 1: Graph showing the average percentage of phoneme intelligibility in CLP vs TD

To look first at the case of the typically developing children, we can see that there is a significantly high proportion of these children able to be identified as producing these sounds correctly by unfamiliar adults. Although there seems to be this high level of correct identification, it is interesting to note that only 1/3 of phonemes were produced to a standard

that allowed the children to reach to or go beyond the proposed 96.82% intelligibility that children of this age have previously been seen to achieve. These phonemes are /d/ (100%), /s/ (98%), and /k/ (100%) - although, /p/ and /h/ came close to reaching this bracket of intelligibility as they both achieved a 95% intelligibility rating. In fact, these TD children were only able to achieve an average intelligibility of 81% in their production of plosives and fricatives. Perhaps this is due to the children being Scottish and therefore producing phonemes in a way that was unfamiliar to a largely English participation group.

This percentage is also heavily influenced by the 0% intelligibility rating of the voiced postalveolar affricate /dʒ/ in which 90% of participants transcribed 'bridge' as 'bread'. However, this is possibly not an issue of the intelligibility of the affricate, but instead due to an assumption of the transcription through the use of vowels. The Scottish child in this audio produces the word 'bridge' as /bɹɛd͡ʒ/ whereas an English participant may anticipate the vowel in this word to be the near-close front unrounded vowel /ɪ/. Therefore, they may have unintentionally opted to transcribe a word which is familiar in English pronunciation with an almost identical set of phonemes which, in this case, is /bɹɛd/ (bread). This perhaps invites an exploration into the perception and production of vowels in a future study, but does not offer an accurate intelligibility rating for /dʒ/ due to multiple outside sociophonetic factors. If this was removed from the data as an anomaly, the average intelligibility would be 91% which is still lower than expected but much closer to 96.82%.

To look now at the intelligibility of the sounds produced by children with cleft lip and palate, it is noticeable that very few of the children producing speech sounds have been able to reach or even come close to an intelligibility of 66%. We again only see 1/3 of the phonemes reaching the 66% that is seen as the upper boundary for identification of intervention being required for a possible phonological developmental disorder. The sounds that reached and exceeded this rating are /θ/ (90%), /k/ (78%), and /h/ (90%). In fact, the average intelligibility of the plosives, fricatives and affricates produced by children with CLP is just

42%. This is considerably lower than the 66% boundary that suggests issues with phonological development, and suggests a lack of assimilation to the level of speech of their TD peers. It also suggests that the impact that CLP has had is still very much noticeable in their speech and this contradicts claims that speech and language therapy should allow speech to be intelligible by the age of 5-6 years (CLAPA, 2021).

First to address the voiceless glottal fricative /h/, it is interesting to see such a high level of intelligibility, but it is not unexpected. This is a sound that is produced in the glottis with no other constrictions of the tongue or lips meaning that its production is not particularly affiliated with any issues that CLP may cause. It is, however, produced orally which has previously been explored as an issue of CLP as the gaps in the palate can cause air to leave through the nasal cavity, causing hypernasality in some articulations. As previously addressed, these are not the appropriate circumstances in which to properly explore nasality of sounds but some of these findings could be used as a basis for further study.

The 78% intelligibility of /k/ is also a noteworthy feature as it is not only a plosive meaning that air being released nasally hinders the 'pop' of air required, and therefore the production of this sound, it is also a velar plosive - the velum, where this sound is produced, is also known as the soft palate. As CLP often affects mainly the soft palate or both the hard and soft palates (CLAPA, 2021), I had anticipated a considerably lower intelligibility rating. However, as I will explore further later in this paper (pg.11-12) there is evidence suggesting that dorsal sounds are produced to a higher quality with fewer compensatory articulations. Along with this, the high level of intelligibility also insinuates a high standard of speech and language therapy in allowing this child to have clarity in their speech sound articulation.

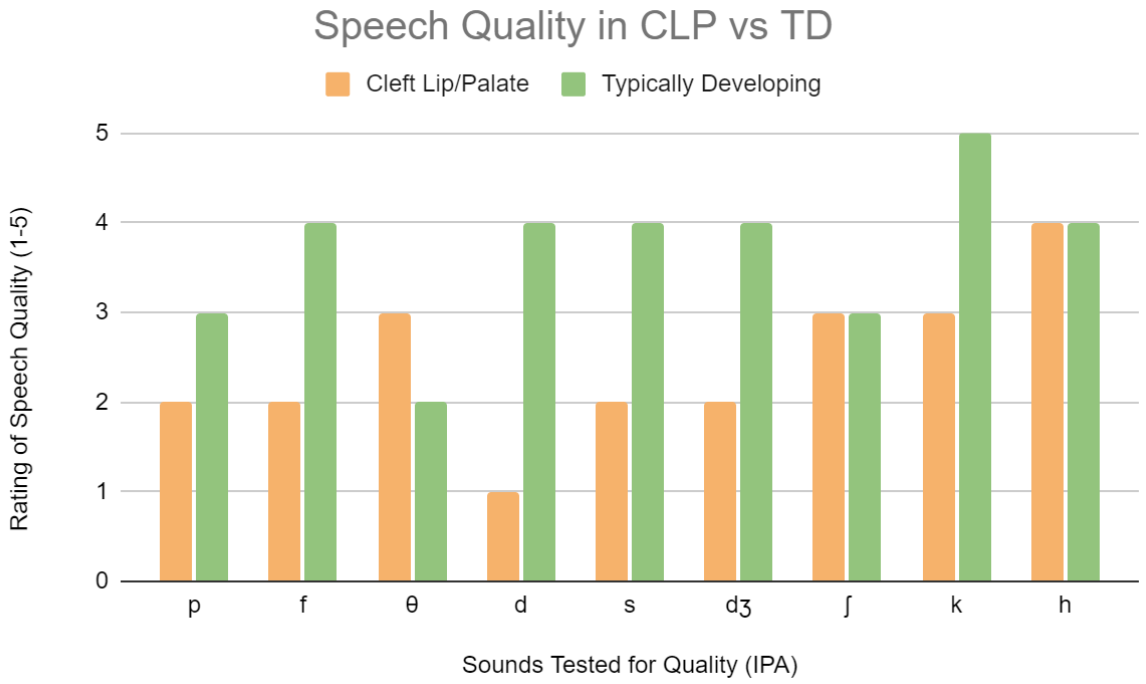
Again to refer to outside sociophonetic influences on responses, I believe that the incredibly high 90% intelligibility of the voiceless dental fricative /θ/ is likely an anomaly. This is because the dental sounds can be heavily impacted by CLP as there can be an impact on the

development of the teeth (Haque & Alam, 2015). Here, I believe that a majority of participants have understood the word 'teeth' as /tiːf/ as 7.5% of participants stated they had, but through context allowed themselves to orthographically transcribe the word simply as 'teeth' - creating the assumption that they must have understood the word as /tiːθ/. Though this is speculation, I believe that context is evidence enough to assume that this rating may not be the most accurate representation of a child's intelligibility of the /θ/ phoneme.

As well as the higher ratings of intelligibility, it is also important to mention the lowest ratings of intelligibility. These come from /f/ (5%), /d/ (5%), /s/ (25%) and /dʒ/ (3%). In this section, I will not be addressing /dʒ/ as the lower rating is likely due to similar circumstances as previously discussed for the sound in the typically developing dataset. To look first at the voiced alveolar plosive /d/ and the voiceless alveolar fricative /s/, the intelligibility is expected to be lower due to the impact of CLP on the alveolar. At the ages of 5 and 8 years respectively, these children will likely not have ungone often necessary alveolar bone grafting surgery which aims to build up the alveolar bone that may not have been developed in the womb due to the cleft (Guo et al., 2011). Though the lower intelligibility is expected, 25% intelligibility is an interesting feature as it is fairly high for the circumstances.

The voiceless labiodental fricative is another of the sounds that was anticipated to be largely affected by CLP as it is both a fricative and also involves labial articulation. An interesting feature is the fact that unlike many of the other sounds where participants have identified articulatory compensations in phonemes such as /h/, this sound is most frequently completely omitted from transcriptions. 42.5% of participants identified the word 'phone' as some variation of the word 'own' which shows the child has either made little attempt to produce this sound and suggests an inability to do so. I would agree with this verdict as I would transcribe the audio as /əʊn/.

<u>Quality of Speech</u>



GRAPH 2: Graph showing the average quality of speech in CLP vs TD children from a rating of 1-5

As previously stated, one of the defining aims of the speech and language therapy that is provided to children with CLP is to ensure children have a good quality of speech by 5-6 years in order to be understood when entering into school (CLAPA, 2021). To test this, I have asked participants to give each audio a rating of 1-5. 1 being completely incomprehensible and 5 being almost adultlike. Of course, it must be considered that the children are only speaking single words and so this may not be an indication of their speech quality on a whole, but it does allow participants to consider how individual phonemes contribute to the overall quality of speech. From this, we can determine the quality of the child's ability to produce individual phonemes to affect speech quality. The above graph shows an average rating for the quality of speech for each of the phonemes.

One noticeable point is the considerably higher quality of speech in typically developing children than in their CLP peers with an average quality of speech at 4 whereas the children with CLP only reach an average of 2. However, it is perhaps unreasonable to make a direct comparison between the two as TD children will of course have a higher quality of speech

due to there being little to no delay in their speech sound acquisition. As such, this data set should simply remain a demonstration of what is possible for children of a certain age to achieve, rather than a point to make criticisms towards delayed speech sound acquisition.

To return to the point of the average rating of the quality of speech for CLP being just 2, this suggests that the quality of speech is, overall, relatively low as it indicates that the speech is, for the most part, unintelligible. This disputes claims that speech by these ages should be to a good standard after SLT intervention.

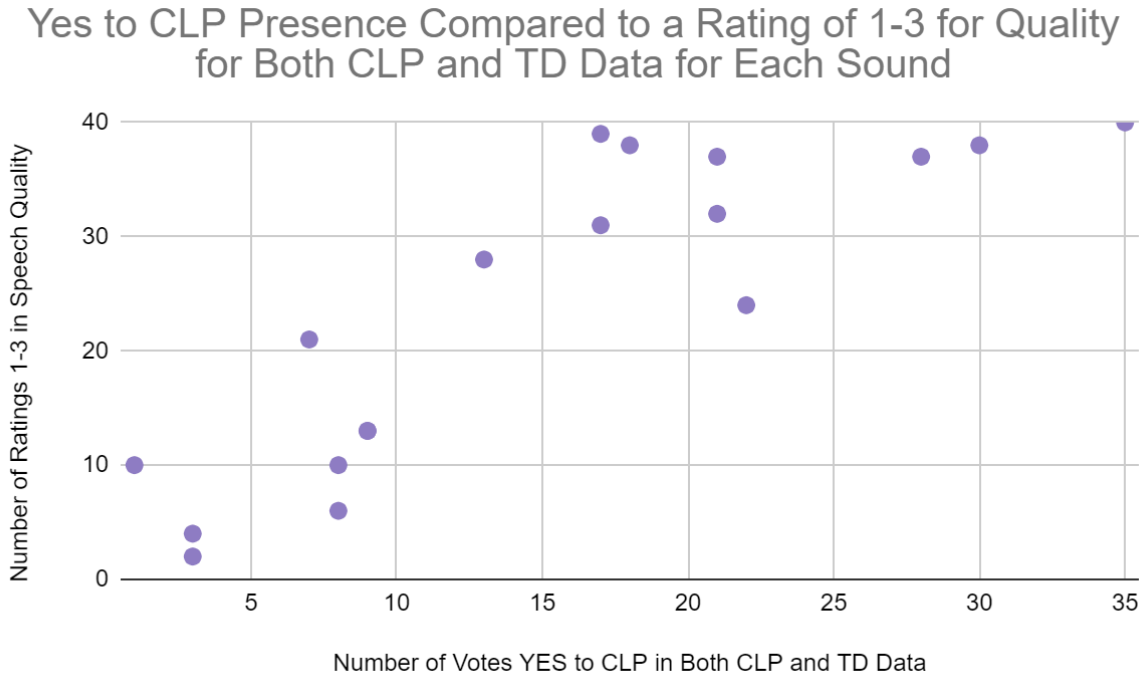
To begin a discussion of the individual qualities of speech, I would first like to address the phoneme with the lowest quality of speech - /d/ - which was the only of the CLP phonemes to be scored an average of just 1. Personally, I would transcribe the speech of 'daddy mended' in the audio as /gæ.gi mɛn.gɛg/ as the voiced velar plosive/g/ is very prominent in the articulation. The participants often agreed with this verdict with 32.5% producing a transcription containing the /g/ phoneme. This offers an interesting insight into how speech quality can be greatly affected by the compensatory articulations produced by children with CLP. In this case, we see difficulty in producing an alveolar sound - which as previously mentioned is impacted by CLP and is often not improved until surgery at a later age (Coots, 2012) - being compensated for with a velar sound while maintaining the voicing and manner.

Though in this instance, it can be somewhat explained as a necessary compensation due to this being prior to alveolar bone grafting surgery, this is a common and yet often unexplained phenomenon in people with repaired cleft and alveolar ridge. Gibbon and Crampin (2001) explored the "retracted or 'backed' tongue placement" in CLP patients with repaired palates who were seemingly still attempting to "compensate for previous structural deficiencies" (K Govathi & Hari, 2017), particularly in producing alveolar stops. In this data, we begin to see the startings of such a pattern with the children often having a higher quality of speech in their production of the dorsal sounds. This is because there are fewer

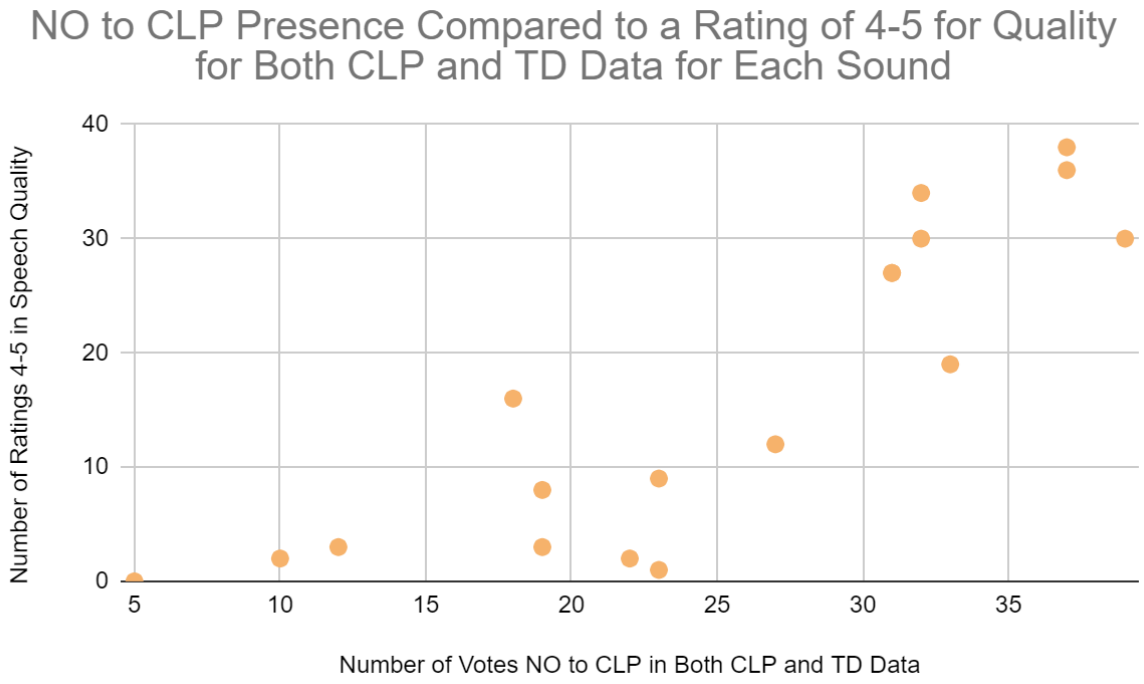
misarticulations that require compensations due to the predisposition of the child retracting the tongue as a remnant from producing so many of their other sounds this way out of necessity. The quality of speech ratings for dorsal sounds are also often higher as some compensations for the coronal and dorsal sounds can make the child seem as though they are speaking gibberish, which is of course not intelligible or good quality speech to an unfamiliar adult.

Other examples of the dorsal sounds being of a higher quality are that the voiceless palato-alveolar fricative /ʃ/ and the voiceless velar fricative /k/ are both rating a 3. While still relatively low overall as we must remember that CLP is still present, the quality exceeds the average rating.

The Public's Perception of CLP Speech



GRAPH 3: Graph of votes for YES to speaker having CLP compared to number of 1-3 quality ratings



GRAPH 4: Graph of votes for NO to speaker having CLP compared to number of 4-5 quality ratings

Now to move away from how the children produce the sounds, I have also chosen to look further into how cleft lip and palate as a whole is perceived by the general public. First, I must note that in order to analyse these ratings, I have chosen to categorise a speech quality rating of 1-3 as the lower quality band, and 4-5 as the higher quality band. To represent this data, I have produced scatter graphs displaying the correlation first between the number of people who voted "Yes" when asked if they believed the child in the audio has CLP compared to those who gave a rating of 1-3 (the lower band of speech quality rating), and then another representing those who voted "No" when asked the same question compared to those who gave a rating of 4-5 (the higher band of speech quality rating). This is to determine how people perceive CLP, as well as offering an interpretation of how well speech and language therapy has allowed the children with CLP to assimilate with their TD peers. This data has been included for each of the sounds, both from the CLP and TD corpora. Though the typically developing children of course do not have CLP and can therefore not be directly associated with the speech development issue that come with CLP, it is still interesting to

assess if there is a general consensus of the public assuming that a lower quality of speech equals the presence of CLP.

Though the correlation in both graphs is relatively weak, it is very apparent that there is a positive correlation between saying that a child does have cleft lip and palate and rating the speech as a lower quality, the same can also be said for the opposite. Although it is possible that the children who do have CLP generally tend to have a lower quality of speech, it is interesting that this correlation continues with the typically developing children who were incorrectly assumed to have CLP presumably somewhat based on the rating of a lower quality of speech. This suggests that there is a general assumption among the public that a lower quality of speech directly corresponds to the presence of CLP.

The clear consensus that CLP is associated with a poorer, less intelligible quality of speech suggests that there are perhaps issue points to be addressed in claims of speech being intelligible and of a good quality by the ages of the children involved in this study.

Although we can suggest that there are some points to explore with the quality and intelligibility of speech being less than expected by the ages of these participants, we must also look into how CLP is perceived by society as a whole. As part of this study, participants were also asked to explain how they had reached their conclusions with regard to the child having CLP or not. I feel that some of the responses raise issue points behind the education sounding CLP, especially given it is the most common facial birth defect in the UK. Conclusions included multiple mentions of the participant saying that the child has a cleft lip and palate because there seems to be the presence of a lisp. Though CLP certainly can cause similar problems in producing alveolar fricatives /s/ and /z/, they are certainly not the same articulatory issue. There were also multiple mentions of a “Yes” vote for CLP being based on a child’s issues seemingly with intonation. Again, CLP can certainly have an impact on this but they are not synonymous speech issues. This suggests that generally, the public appear to

have a poor understanding both of what a typically developing child may sound like at each age, and generally of phonological development disorders as a whole. This could present a wider issue of guardians of children not being able to properly identify deficiencies in the quality of speech and possibly unintentionally allow a child to go without SLT intervention. This invites a further exploration into education around this subject.

Conclusion

Through this perception study, it is apparent that there are perhaps issues that are not allowing children to reach their full potential of speech. This data suggest that children with CLP overall have not been able to achieve the assumed position of having good quality and relatively high intelligibility of speech by the ages of 5-6 and beyond. This highlights areas to focus on in the continued support of a child's developing speech and possibility invites a reassessment of the constraints on improving a child's speech.

To note, this work is not intended to be a criticism of speech and language therapists who do vital work in improving the speech of children, and in turn improving their confidence and wellbeing. This research does, however, perhaps offer insight into how we, as a society, view the speech of people with atypical speech patterns. It also provides a basis for further research in speech acquisition and perception, and contributes to the knowledge which will inevitably aid in children having access to their fundamental right of communication.

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