Improving the Speech and Communication Abilities of Children with Down's Syndrome: A New Model of Service Delivery using Electropalatography

Sara E Wood

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Author Contact details:

- 2016 onwards at swood@qmu.ac.uk

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Abstract

Children with Down's syndrome (DS) present with specific difficulties with speech production which are not in line with their cognitive abilities. These difficulties often lead to poor speech intelligibility and communication breakdown. This in turn can cause frustration, behaviour difficulties, academic failure and social exclusion all of which can have a negative impact on the child's psychosocial wellbeing. Furthermore, the speech of children with DS tends to be resistant to traditional methods of speech therapy so speech and language therapists often focus on total communication, which may involve signing or picture symbols.

This project set out to investigate the use of Electropalatography (EPG), a visual biofeedback technique used in specialist research clinics, to improve the speech intelligibility of children aged 6 to 10 years with DS. Previous research conducted at Queen Margaret University (QMU) trialling the use of EPG with children with DS had shown that speech intelligibility could be significantly improved. This project planned to extend the success of earlier research by taking the specialised intervention into schools thereby making the technique more readily available. The aim was to develop and evaluate a consultative model of intervention which would provide specialised training to educational support staff who would deliver speech input within the child's normal school environment. It was proposed that this would allow for more intensive intervention which children with DS require due to learning and memory difficulties. Results indicate that a consultative model is viable and that improvements in intelligibility as measured by pre and post therapy questionnaires were evident. A significant improvement in speech accuracy as measured by an increase in percent consonants correct was also recorded.

1 Introduction

Down's syndrome is the most common genetic cause of mild to moderate learning difficulties (LD), affecting 1 in every 1000 live births in the UK (Down's Syndrome Association, 2015). The speech skills of individuals with DS are poorer than would be anticipated in relation to both their general cognitive ability and their skills in expressive language (Roberts et al., 2007). These specific difficulties in speech production can lead to significantly reduced intelligibility (Kumin, 2006) which in turn affects the ability to communicate effectively. This often places considerable constraints on educational progress, affects friendship formation and impedes integration into the wider community. The specific speech production difficulties encountered by individuals with DS are often considered to be intractable as they have proved to be resistant

to conventional methods of intervention delivered by speech and language therapists (Kumin, 2006; Gibbon, McNeill, Wood & Watson, 2003). These difficulties persist into adulthood which can negatively impact life outcomes, affect employability and contribute to social exclusion (Shriberg & Widder, 1990).

Our previous research funded by the Medical Research Council investigated the speech difficulties experienced by 27 children and young people, aged 9 to 18 years, with DS. As well as increasing our understanding of the types of speech errors made by this population, it experimented with the use of an intervention technique called electropalatography (EPG), not currently routinely available within the NHS, as a method of correcting speech errors in children with DS with a view to improving their intelligibility. Findings from the previous research informed the development of this project, which was subsequently funded by the Nuffield Foundation.

2 Electropalatography (EPG)

EPG is a long-established tool for clinical and non-clinical speech research. It displays the timing and movement of the tongue's contact with the hard palate in real-time during continuous speech (Hardcastle & Gibbon 1997). It requires the individual to have a custom-made artificial palate (figure 1) which fits snugly against the roof of the mouth. Embedded into the artificial palate are 62 electrodes that register on a computer screen when the tongue is touching them. An individual's articulation can be compared to standard patterns for English consonants (see examples in figure 2) and error patterns noted. EPG is a particularly valuable diagnostic tool in a clinical setting because it gives objective and detailed analysis of the child's articulation patterns and may identify errors which cannot be detected by perceptual analysis alone yet are vital for accurate diagnosis and subsequent effective intervention (Wood and Hardcastle 2000).

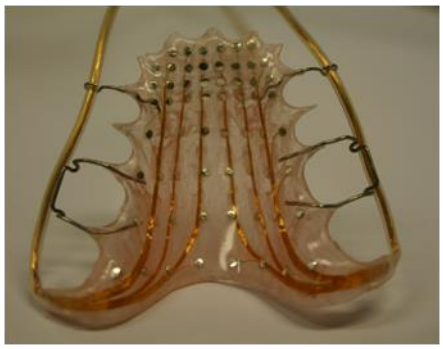

Figure 1. EPG palate

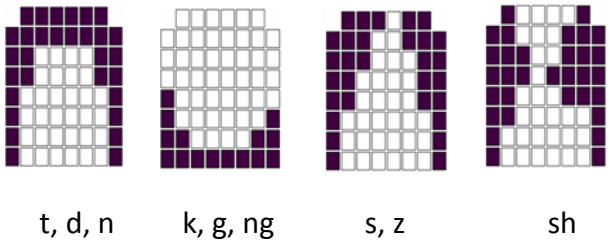

Figure 2. Standard articulatory patterns for consonants involving the tongue

In addition to providing vital diagnostic information, EPG can also be used to modify articulatory patterns by using visual feedback for normally inaccessible and hard-to-describe aspects of speech production. The speech and language therapist (SLT) selects a target articulation pattern characteristic of a particular sound which is currently incorrectly produced by the client and displays this on a computer screen. During a therapy session the child

attempts to copy this correct articulation by monitoring their own contact patterns in real time (see figure 3).

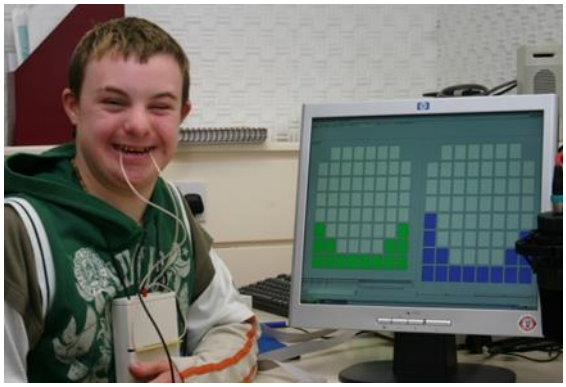

Figure 3. Child during therapy session. The target articulation is displayed on the right hand side of the computer screen. The left hand side shows the individual's successful attempt to match the target articulation.

EPG is particularly suited to children with DS for a number of reasons. In therapy sessions, the link between the child's own speech movements and the real-time visual display on the screen is the focus of attention; this circumvents complex explanations of the training task involved in learning to produce correct articulatory patterns. In utilising visual feedback EPG is particularly suited to this group as they can respond better to visual stimuli than verbal instructions (Heath et al, 2000) and their visual processing skills are described as a relative strength (Fidler and Nadel, 2007). There is also evidence that children with DS particularly enjoy interacting with computer-generated presentations (Iacano and Miller, 1989).
Home practice, achieved by using a portable training unit (PTU - see figure 4), allows the child to capitalise on gains made during therapy sessions. This provides visual feedback similar to the full clinic-based recording and analysis system. Individuals with DS have particular difficulties in retaining new information (Conners, Rosenquist and Taylor, 2011) and the increased repetition offered via a PTU has the potential to improve or mitigate for deficits in this aspect of functioning.

Figure 4. A Portable Training Unit (PTU) used for home practice with parental/carer guidance.

Results from the MRC-funded project showed a positive change in articulatory patterns, an increase in the number of consonants that were perceived correctly and an improvement in intelligibility. The findings also demonstrated the potential benefits of EPG over conventional therapy for children with DS, specifically the increased maintenance and continued progress once therapy was completed when compared to a group of children who received conventional (non EPG) therapy (Cleland et al. 2009, Wood et al. 2009a, Wood et al. 2009b).

It was proposed that in addition to the detailed and specific assessment information provided by the EPG methodology, the success of this intervention was also due in part to the additional visual feedback available to these children through EPG in therapy and which played to their known relative visual processing strengths. The possibility of continued practice between sessions using the PTU further strengthened this learning opportunity.

3 Reflections and a proposed new model of service delivery

Despite the successes of the previous grant, there were a number of limitations that we identified which we wanted to address:

1. *Location*: Therapy was carried out at QMU. This necessitated frequent and lengthy journeys for some participants and meant some children were unable to take part in the study. It was felt that providing therapy within the child's own school would overcome this barrier.
2. *Intensity of intervention:* Whilst twice a week was, in all cases, an increase on the amount of direct speech intervention usually received, based on our understanding of working memory in DS, we felt more regular intensive therapy might lead to increased gains.
3. *Delivery of therapy*: We felt that a consultative model, whereby the SLT trains support assistants in the child's school and monitors progress would be advantageous because the support assistants would be already known to the child and able to deliver therapy at a time when they know s/he is most likely to be receptive to input.

4 Aims and objectives

The aim of current project was to evaluate an EPG-based model of therapeutic delivery. The research had 2 main objectives:

1. to evaluate a consultative model of speech and language therapy by training support assistants, who were already working with children with DS in schools, to use a specialised computerised technique which has proven to be effective in increasing intelligibility yet is currently not available to children with DS in everyday SLT practice and is normally only delivered by research SLTs.
2. to evaluate speech production problems and the role of visual training with EPG in improving speech intelligibility in primary school-aged children with DS (6 to 10 years).

5 Participant recruitment

Eighteen children with DS demonstrating speech intelligibility difficulties were recruited from across the Lothians with help from local authorities and through Down's Syndrome Scotland's network of professional contacts. Children were eligible for inclusion if they were between the ages of 6 and 10 (inclusive) at project outset and did not have a significant visual impairment.

All participants had a receptive vocabulary age equivalence, as measured by the British Picture Vocabulary Scales II (BPVS: Dunn et al. 1997) of 3 years or more as it has been shown that this measure correlates well with measures of cognitive ability. Previous research with EPG has suggested that this level of cognitive ability/receptive language is necessary for comprehension of the feedback provided by EPG. Children with severe autism and those with a functional hearing loss of more than 40db were excluded.

6 Data collection

Prior to therapy, each participant underwent a series of assessments to establish the level and detail of speech problems experienced and to provide a pre-EPG intervention baseline. The speech production of each child was recorded using EPG and analysed by the specialist SLT employed on the project. Following this, an individualised EPG-based therapy programme was developed. This is normal good practice in speech and language therapy where treatment is specific to each child but was greatly aided by the ongoing additional EPG data available to the SLT.

7 Assessment of speech

For the EPG speech assessment each child was fitted with an individualised artificial palate molded to fit comfortably on the hard palate. Prior to the assessment of the child's speech, the child was asked to spend time acclimatising to the feel of the palate in the mouth before recordings began to ensure the palate was not affecting speech production. The palates are made from a conventional dental impression of the roof of the mouth and teeth. A local orthodontist made the casts of the upper palates and ensured the completed EPG artificial palates fitted.

Assessment measures:

- *Diagnostic Evaluation of Articulation and Phonology* (DEAP) (Dodd, Hua, Crosbie, & Holm, 2002) provided a subjective assessment of speech articulation ability and age equivalence measures of phonetic and phonological ability. This test was administered with the EPG palate in situ.
- *Parental and Teacher Questionnaire* provided a measure of speech intelligibility as noted by those closest to the child.
- *Additional EPG assessment:*
    - An additional targeted word list was compiled for each speech problem identified for therapy from the DEAP assessment. Each individualised list contained target problem sounds in a variety of words
    - A variety of additional qualitative and quantitative measurements were made to compile speech pattern profiles for each child, specifically highlighting articulatory accuracy, both spatial and temporal.

These objective EPG-generated speech profiles, coupled with the perceptually-based judgments from the DEAP and parental feedback were used to plan individually-tailored intervention for each participant.

8 EPG Therapy training

The project planned to develop the role of education support workers employed within the children's own schools, engaging their collaboration as speech therapy partners. An EPG training and implementation programme appropriate for education staff in all primary settings was designed and delivered to the relevant support workers. The programme included the following core elements:

1. a workshop targeting speech and language development and learning styles in DS
2. training for relevant education staff in the use of EPG
3. an individualised EPG-based therapy programme for each child
4. support through weekly or bi-weekly scheduled consultation visits to school staff involved in the project, plus regular contact via e-mail and phone.

9 EPG Therapy

Following completion of the training programme, support assistants were asked to deliver the individualised therapy programme daily, for 12 weeks, within the child's school environment. A portable training unit (PTU) was provided to each child. Print-outs of target contact patterns related to each sound to be practised were provided, and advice on how to move from single sounds to word level and carry over into sentences was given where appropriate. Therapy delivery was monitored and supported via regular on-site visits by the SLT with additional phone or e-mail support available as necessary throughout. The SLT monitored any changes in the speech production of each participant and adjusted the therapy goals and therapy programme accordingly.

10 Evaluation

Objective 1 To evaluate a consultative model of speech and language therapy by training support assistants who are already working with children with DS in schools to use a specialised computerised technique.

Each support assistant was asked to complete a questionnaire post intervention to allow evaluation of the consultative model. The questionnaire focussed on the training and information provided by the SLT, ongoing support provided by the research team, ease of use of EPG equipment and number of sessions which each support assistant delivered. There were also questions regarding effects of the intervention. Of the 18 participants that were recruited, 2 withdrew from the project. Fifteen out of the remaining 16 learning assistants returned the questionnaire giving a response rate of 94%.

Below is a summary of the rating scale responses to the questions which were designed to assess feasibility of the consultative approach. There was also opportunity for explanatory comments to be added to each question.

Training and information

The questionnaire asked the support assistants how informed they felt prior to the start of the project (see figure 5). From the free comments that accompanied this question it became obvious that this question was somewhat ambiguous. We were wanting to know how well informed the support assistants felt prior to the specific training but following initial discussion with the researchers. Four of the respondents who chose "extremely uninformed" and "very uninformed" made comments which indicated they were referring to information provided to them by the school prior to the researchers discussing the project with them. The other respondent mentioned that she was replacing a staff member who had gone off sick following the initial training and therefore she had missed the formal information and training sessions.

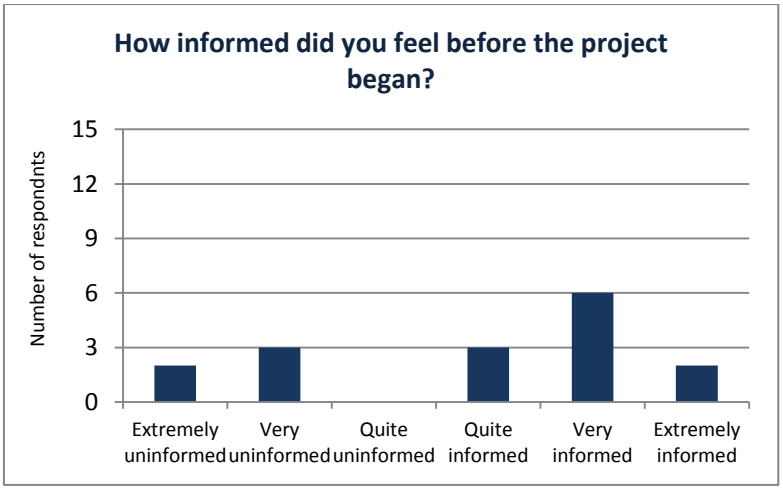

Figure 5

The next question focussed on what the support assistants felt about the amount of information that was shared with them in training prior to the start of intervention (see figure 6). Fourteen of the 15 respondents viewed this positively. The support assistant who rated this question as 'quite poor' qualified this stating that she had been asked to step in when a colleague went off on long term sick leave so intervention was already underway, but stated that she subsequently got 'excellent support' from the project SLT.

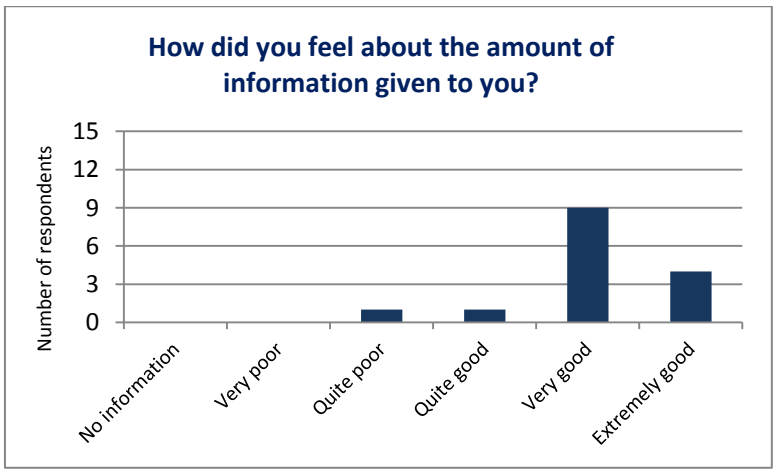

Figure 6

We were interested in the perceived relevance of the information provided in the training sessions (see figure 7). Again 14 of the 15 support assistants responded positively to this question. The same respondent who rated the previous question less positively qualified their choice of rating as before.

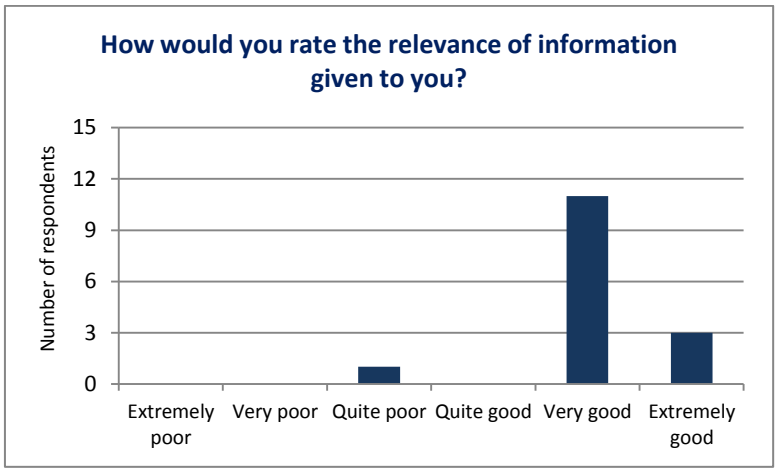

Figure 7

When asked how equipped the learning assistants felt to deliver the intervention to the children with DS all responded positively with 8 reporting with very well equipped or extremely well equipped (see figure 8).

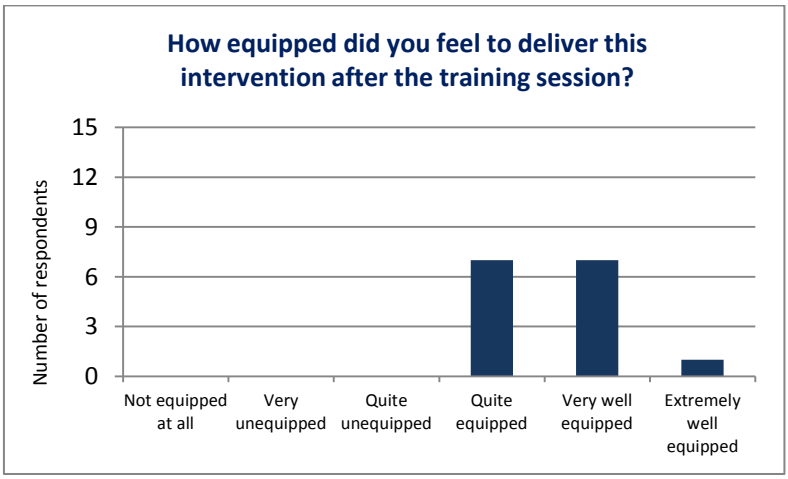

Figure 8

With respect to training and information the responses post therapy appear to indicate that the views of the support assistants were generally positive. There were no specific comments which identified any problem areas or information that they felt was missing from the training.

Liaison with the research team

We were also interested in how the support assistants found the research team; whether they were approachable and accessible (see figure 9). These two considerations were felt to be important for the successful implementation of the intervention in schools. Accessibility was generally rated very high, with 14 of the 15 respondents reporting the research team were either very accessible or extremely accessible. The one respondent who considered the team inaccessible qualified this by commenting 'by e-mail and phone'. This was in contrast to the other respondents, many of whom commented on the SLTs accessibility by e-mail and phone. It is possible that this relates more to accessibility within the school to phone or e-mail during the school day.

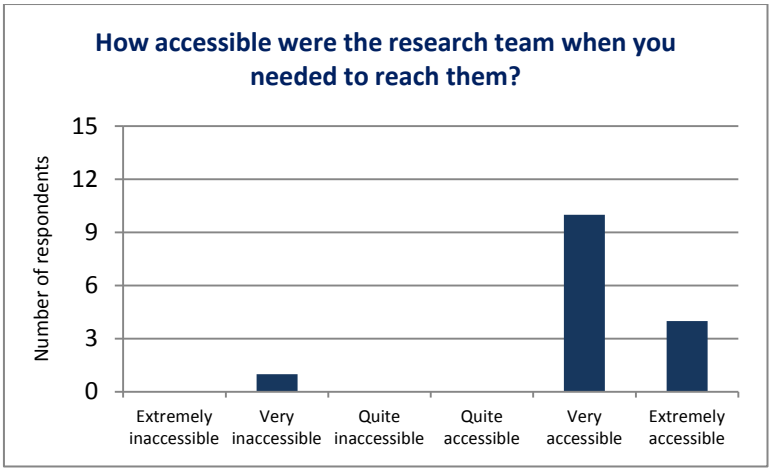

Figure 9

All support assistants considered support provided by the research team during the intervention period to be either very good or extremely good (see figure 10).

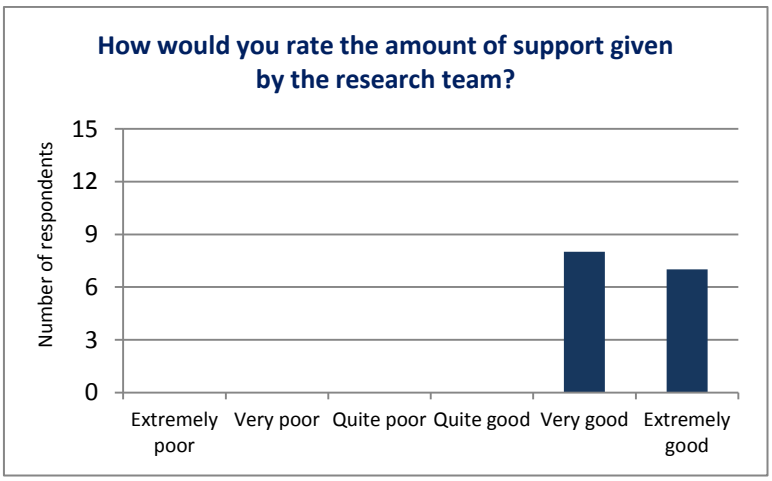

Figure 10

Equipment

Each learning assistant was required to be able to use a portable training unit (PTU) and assist the child with the handling of the EPG palate (see figure 11). They were also required to recognise when there was a problem with either of these pieces of equipment because without these the intervention was not possible. We were therefore interested in how the support assistants found handling and using the equipment. All of the respondents were positive about the use of the equipment despite many of them being quite unsure of their ability to manage this prior to the start of intervention.

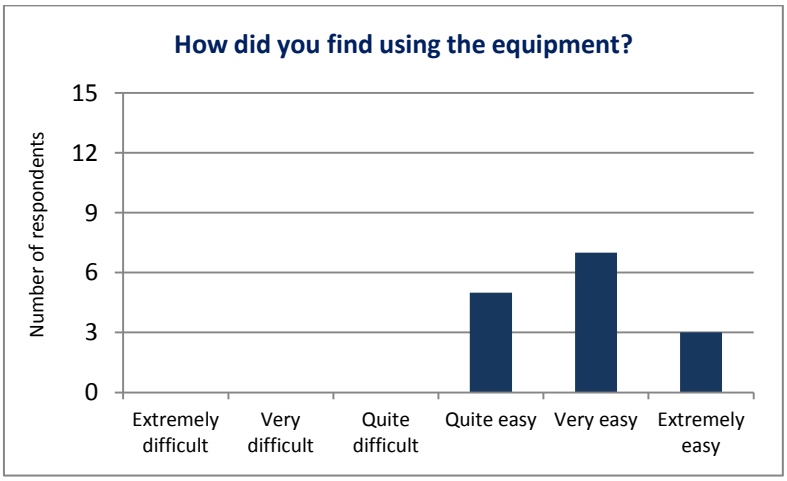

Figure 11

Number of sessions delivered

One of the goals of the study had been to increase the intensity of intervention since it is known that individuals with DS require a high level of repetition to learn new skills. By providing intervention in school and thereby removing the need for the child to travel to a clinic it was hoped that we could increase the amount of training that these children received. We therefore asked the support assistants to indicate how many times they had been able to see the child over the 12 week period (see figure 12). A maximum of 60 sessions was possible, with a minimum project target of 45 sessions.

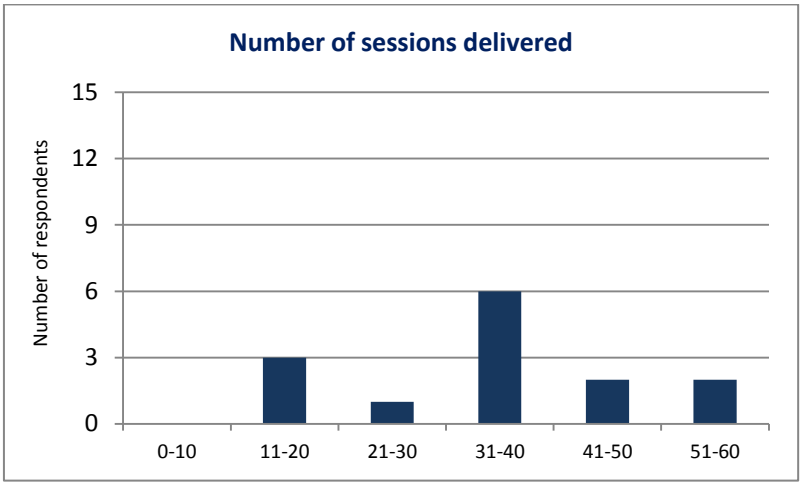

Figure 12

Only one respondent reported that they delivered 60 sessions of intervention. However the results in figure 12 indicate that most of the support assistants were unable to deliver therapy on a daily basis. There were numerous reasons given for this: staff absence and illness; child absence or illness; timetabled school events, especially leading up to holiday times; non-timetabled school events, for example a visitor; practical issues in school, for example finding a room; disruptions with school holidays; equipment difficulties.

From the post intervention questionnaires it would seem that a consultative approach to intervention had been rated positively by the learning assistants. There were a number of challenges identified by the research team which will be discussed.

Objective 2 To evaluate speech production problems and the role of visual training with EPG in improving speech intelligibility in primary school children with DS (6 to 10 years).

Intelligibility was measured by: a questionnaire containing a visual analogue scale which was completed pre and post therapy by the parents and the learning assistants; parental ratings on the Intelligibility in Context Scale (ICS), (McLeod, Harrison and McCormack, 2012) also completed pre and post intervention; and a measure of perceived percent consonants correct (PCC). PCC was calculated from phonetic transcriptions of the word-naming phonology subtest of the Diagnostic Evaluation of Articulation and Phonology (Dodd et al. 2002). PCC is a measure of speech accuracy which is closely linked to intelligibility (Yoon and Lee, 1998; McLeod et al. 2012).

We requested that the same person complete the questionnaires and the ICS pre and post therapy to allow comparison. There was one family where the mother completed the questionnaire pre intervention and the father post intervention so this was eliminated from the results. For schools we requested that the support assistants complete the questionnaires but unfortunately the questionnaires were variously completed by support assistants, class teachers, other school personnel often a different person pre and post intervention. We were therefore unable to use the schools' pre and post questionnaires to measure changes in intelligibility.

Figure 13 shows the changes in intelligibility rating pre and post intervention as measured by a 1 to 10 visual analogue scale, where 1 indicated poor intelligibility and 10 indicated fully intelligible, completed by parents. PP7 and PP38 did not complete the questionnaires post therapy and PP35 was eliminated because the same person did not complete both pre and post questionnaires (all marked by * in figure 13). Of the remaining 13 participants 8 were considered to have improved on this measure of intelligibility, 3 got worse and 2 participants remained the same. A related samples Wilcoxon signed rank test showed a significant difference between pre and post therapy intelligibility measures ($p=0.026$) indicating that intelligibility had improved.

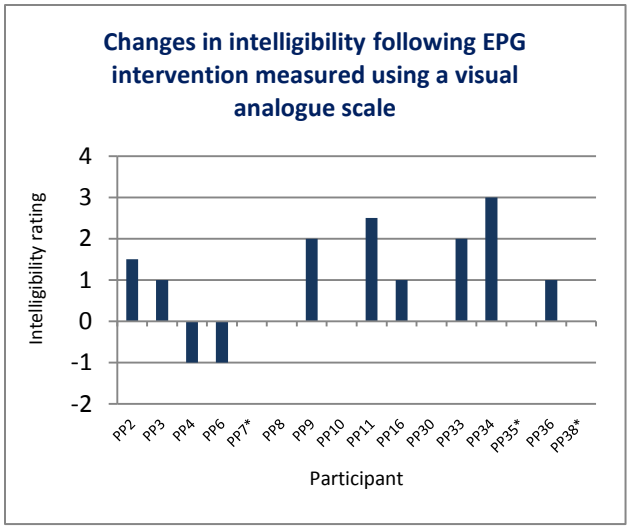

Figure 13

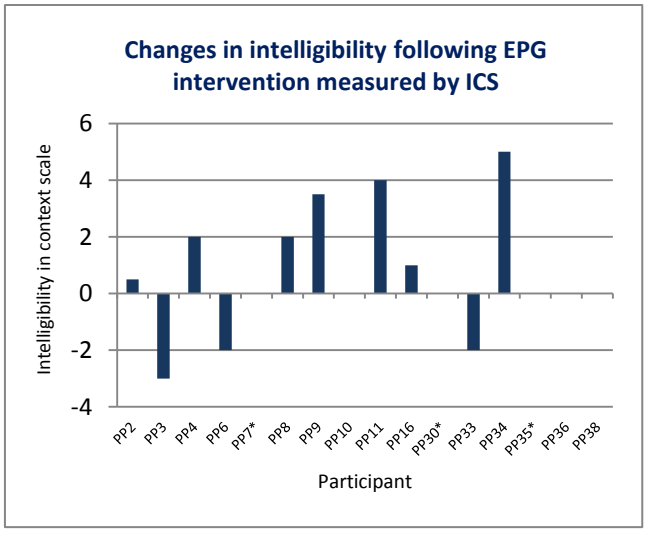

Figure 14

Changes in intelligibility following intervention as measured by the ICS are shown in figure 14. Whilst these results were not statistically significant (related samples Wilcoxon signed rank test, p=0.238) there was a trend towards improvement with 7 out of 13 participants showing an improvement on the ICS. Three participants were rated the same pre and post intervention, and 3 were rated poorer. A post questionnaire was not completed for PP7 and PP30. Questionnaires for PP35 were not completed by the same person pre and post intervention so were not included in the analysis. These three participants are indicated by * in figure 14.

A paired t test to compare PCC scores pre and post intervention also showed a significant difference t(13)=-3.16, p=0.007, indicating a positive change in speech accuracy post EPG intervention. Figure 15 shows the changes in PCC following intervention. P11 and P35 both had one data point where the data was corrupted and therefore no value is given.

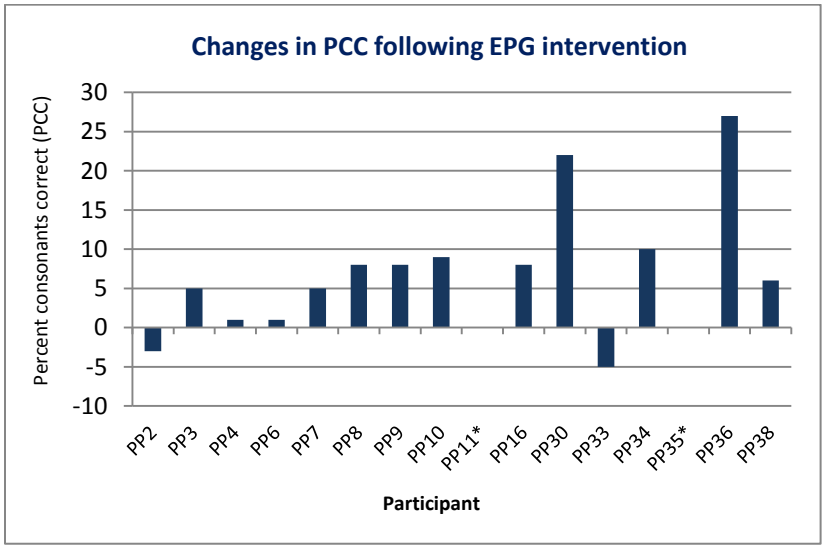

Figure 15

11 Implications and recommendations for wider practice

This study aimed to evaluate a new model of service delivery for EPG-based speech therapy and to assess whether there was an improvement in the overall level of speech intelligibility for children with DS who received this intervention. Results indicate that such a model is viable and that changes in intelligibility were evidenced. The main implications are as follows:

- It is possible to train learning assistants in primary schools, whom have no prior training in speech development or in EPG, to deliver EPG therapy to children with DS.
- Such provision requires collaboration between the specialist SLT at QMU and schools to facilitate ongoing training and support for learning assistants. The SLT would be responsible for the detailed initial assessment and diagnosis, ongoing assessment and evaluation of progress, continuous development of appropriate goals and appropriate therapy resources to achieve child specific goals.
- Daily EPG therapy requires dedicated resources, for example appropriate space and staff time, to ensure regular intervention to maximise potential gains.

To assist in the implementation of such a programme the following recommendations are proposed:

- Specialist EPG-trained SLTs to devise specific individualized goals to develop speech production and communication to be included in the child's Individualised Education Programmes (IEPs) to ensure that this provision is seen as integral to the child's learning and development. The coordinator of the IEP must ensure SLTs are consulted.
- Education authorities to identify protected time for direct speech work. This project relied on the good will of the support assistants and school management to provide the tailored input in addition to any provision that they were already providing to individual children. This had the potential to lead to tension between normal day-to-day schooling and the daily EPG intervention when resources became stretched, e.g. a staff member off sick. Ensuring that the EPG intervention targeted at speech development was part of the IEP would help protect time for regular speech work. This is essential for success since it is known that children with Down's syndrome require high levels of repetition and regular opportunities to practice and rehearse newly acquired skills (Down Syndrome Ireland, 2016).
- Education authorities to identify a select number of support assistants who would undertake the role of developing speech within the Curriculum for Excellence across schools under the guidance of specialist SLTs. This would reduce the need to train all support assistants and allow specialisation and development of expertise within individual local education authorities thereby developing efficiency of service.

The All Party Parliamentary Group on Down syndrome reported that failure to effectively support communication difficulties can significantly impede academic progress and socialisation in individuals with Down's syndrome (2012). Furthermore research has shown that individuals with communication difficulties have associated negative quality of life issues (Markham and Dean, 2006; Markam, van Laar and Dean 2009). It is therefore imperative to consider the provision of

techniques which are not currently available through the NHS but have been proven to be effective in remediating speech difficulties.
Findings from this project leads to the following recommendations for future research:

- Inclusion of a non intervention group to control for developmental/maturational effects.
- Widening the participant age to allow comparison across individuals and identify which children benefit most and if there is an optimum age for intervention.
- Investigating the use of alternative visual feedback techniques, specifically ultrasound tongue imaging (UTI), which is less expensive and does not require the use of a specialised artificial palate which is time limited but still capitalises on the relatively strong visual processing skills of individuals with DS. (http://www.qmu.ac.uk/casl/ultraphonix/default.htm)

Finally, whilst this research was restricted to children with Down's syndrome this model of intervention could be extended to other client groups where published research has indicated that EPG therapy could be advantageous.

12 Acknowledgements

The Nuffield Foundation is an endowed charitable trust that aims to improve social well-being in the widest sense. It funds research and innovation in education and social policy and also works to build capacity in education, science and social science research. The Nuffield Foundation has funded this project, but the views expressed are those of the authors and not necessarily those of the Foundation.

More information is available at www.nuffieldfoundation.org

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