

# **The role of quantitative linguistic feedback in early intervention for deaf children: using LENA to influence language environments and maternal self-efficacy**

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## Abbreviations

ACORN	A Classification of Residential Neighbourhoods
AWC	Adult Word Count
CHL	Child(ren) with a hearing loss
CI(s)	Cochlear implant(s)
CNH	Child(ren) with normal hearing
CTC	Conversational Turn Count
CVC	Child Vocalisation Count
DLP	Digital Language Processor
EAL	English as an Additional Language
EI	Early Intervention
EIP	Early Intervention Professional(s)
EIS	Early Intervention Services
HA(s)	Hearing aid(s)
HL	Hearing loss
LENA	Language ENvironment Analysis™
MSE	Maternal self-efficacy
NHSP	Newborn Hearing Screening Programme
PI	Parental involvement
PSE	Parental self-efficacy
SES	Socio-economic status

The terms “deaf children” and “children with a hearing loss” are used to represent the entire spectrum of children with varying hearing levels (from mild to profound). “Parent(s)” is used to describe parents or primary caregivers.

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## **Abstract**

This study investigates the use of quantitative linguistic feedback produced by Language ENvironment Analysis™ (LENA) to alter the language environments of deaf children in the Early Years. The study also aimed to investigate whether LENA has the potential to influence levels of maternal self-efficacy and parental involvement, particularly given the research to show the effect of these variables on child outcomes.

A mixed methods approach was used involving comparative case studies of 14 families. Quantitative data produced by LENA included information about the number of adult words and conversational turns to which the children were exposed throughout the recording day. This information formed the basis of a block of intervention sessions that focused primarily on coaching mothers to improve the quantity and quality of language produced during the daily routine around their children. The recording was then repeated at the end of the intervention block to monitor progress. Parents and professionals completed questionnaires regarding maternal self-efficacy and involvement levels pre- and post-intervention which provided supplementary quantitative data. Qualitative data was obtained through semi-structured interviews completed post-intervention that explored the participants' thoughts and opinions regarding LENA-based intervention.

The findings of this study suggest that LENA has the potential to be a useful clinical tool, giving professionals insight into the environments of the deaf children with whom they work. Participants were able to significantly improve their children's quantitative language environments as a result of the intervention. Furthermore, both participants and professionals identified an improvement in maternal self-efficacy levels, with participants feeling more knowledgeable and confident in their abilities to support their child's speech and language development. Participants also reported feeling less reliant on outside professionals to implement change, suggesting an increase in parental involvement. LENA therefore has the potential to significantly improve the language outcomes of deaf children both in the Early Years and beyond, should these results be sustained over time.

## 1. Introduction

In the past, parent-professional relationships within Early Intervention Services (EIS) for children with a hearing loss (CHL) were defined by professionals presuming a role of higher competence and greater knowledge than the parent (Davis & Meltzer, 2007). However, following research highlighting the advantages of early identification of hearing loss (HL) on child development (Newton, 2013; Korver, Konings, et al, 2010), the Universal Newborn Hearing Screening Programme (NHSP) was introduced across the UK in 2006, changing the landscape of early intervention (EI). CHL are now diagnosed as early as four-weeks-old (Harrop-Griffiths, 2016). EIS have adapted to meet the needs of these younger children and their families, the majority of whom have no prior experience of deafness (National Deaf Children's Society (NDCS), 2018) and are unprepared for the diagnosis and its implications.

The philosophical approach has changed from professional-led (Seligman & Darling, 1997) towards a family-centred approach (Glanemann, Reichmuth et al, 2013). A family-centred approach recognises that the diagnosis of HL in a young baby impacts the whole family (Knight & Swanwick, 1999) and the influence of family and environmental factors on child outcomes (Wallace, Gravel et al, 1996; Meadow-Orlans, 1994; Bodner-Johnson, 1986). A central tenet of the family-centred model is enhancing parental skills, confidence and competence to give the child the best opportunity to achieve their potential (McWilliam & Scott, 2001). Professionals now focus on supporting, involving and collaborating with families, developing an equal partnership that shares expertise and knowledge (DesGeorges, 2003), on the understanding that parents are the greatest potential influence in a child's life (Shonkoff, Hauser-Cram et al, 1992).

A child's quantitative language environment is a significant influence of child language outcomes in the Early Years and beyond (Hart & Risley, 1995; Walker, Greenwood et al, 1994). However, due to the time and resource demands of investigating this area, there was previously relatively little robust research regarding the language environments of CHL. The invention of Language ENvironment Analysis™ (LENA), which automatically records and

analyses a child's acoustic and language environment, has opened doors for researchers and clinicians working with children and families. However, its uptake as an intervention for CHL in the UK has so far been limited.

Although the benefits of a family-centred approach are well-documented (Moeller, Carr et al, 2013), it remains difficult for some services to instil families with a sense of ownership around the intervention, which impacts on child outcomes. Parental involvement (PI) and parental self-efficacy (PSE), two fundamental principles of family-centred intervention for CHL (Moeller et al, 2013), are known to be linked (Davis & Meltzer, 2007; DesJardin, 2006). Evidence shows the impact of these factors on the success of intervention and child outcomes (Stika, Eisenberg et al, 2015; Moeller, 2000). However, there are few evidence-based therapeutic interventions or techniques proven to lead to a change in these areas for parents of CHL.

This research seeks to evaluate whether a therapeutic intervention using the quantitative linguistic feedback provided by LENA can positively influence the language environment of CHL from a variety of cultural backgrounds. A further aim is to evaluate the impact of this type of intervention on maternal self-efficacy (MSE), to provide insight into methods that may contribute to improved PI in EI for deaf children.

## **2. Literature Review**

### **2.1. Introduction**

This literature review contains three sections. The first will review the published literature regarding the influence of family factors- namely, PSE and PI- on outcomes for deaf children. It also explores the link between these two areas and how they may influence each other. The second will discuss the impact of the child's linguistic environment on outcomes for CHL, focusing particularly on the influence of a child's quantitative language environment on their language development. Based on these findings, the final section will justify the current study.

### **2.2. Family factors affecting outcomes for deaf children: the role of self-efficacy and involvement**

#### **2.2.1. The relationship between parental self-efficacy and parental behaviour**

Self-efficacy is one's belief in one's capabilities to successfully perform in a way that produces a desired outcome (Bandura, 1977). PSE refers to parents' beliefs about their ability to function competently while raising their children (Coleman & Karraker, 2003), influencing their child and the environment in a way that fosters the child's success (Ardelt & Eccles, 2001).

Knowledge forms only part of self-efficacy beliefs (Bandura, 1982). The combined effect of knowledge and confidence is a better predictor of performance than the influence of either factor individually (Conrad, 1990). PSE beliefs incorporate parents' knowledge of appropriate parenting behaviours and their confidence in their ability to carry them out (Cole & Karraker, 2003). Conrad and colleagues (1992) illustrated this; when mothers perceived themselves as less competent, the quality of the adult-child interaction was no different regardless of MSE level. However, when mothers were more confident, the more knowledgeable individuals had more effective interactions with their children.

A mother's belief that she has knowledge and competence in her role as a parent (her MSE beliefs) translate into practices that enhance her parenting abilities and, subsequently, her child's outcomes (Gandy, 2014; Dunst, Trivette, & Hamby, 2008; Brody, Flor & Gibson, 1999; Teti & Gelfand, 1991). In a review of 47 studies investigating the role of PSE, researchers found a link between MSE, parenting stress and child developmental outcomes including language and social-emotional development and academic achievement (Jones & Prinz, 2005).

High MSE is linked with maternal responsiveness (Bogenschneider, Small & Tsay, 1997; Gondoli & Silverberg, 1997; Unger & Waudersman, 1985), even after controlling for other variables including mothers' competence with their infants, perceptions of infant difficulties, socio-marital support and positive maternal health (Shumow & Lomax, 2002; Kwok & Wong, 2000). Maternal depression and perceptions of child difficulties are associated with low MSE (Coleman & Karraker, 1998; Teti & Gelfand, 1991). Although much of this research involves parents of older children, it is relevant given the link between high maternal responsiveness and positive child language, cognition and socio-emotional growth and security (Brady, Warren & Stirling, 2009; Bornstein, Tamis-LaMonda et al, 2008; Landry, Smith et al, 2008).

#### **2.2.1.2. Impact of parental self-efficacy on children with a hearing loss**

Although much of her research has involved small population samples, DesJardin has provided crucial, up-to-date information about MSE of parents of CHL. In a study involving mothers of preschool deaf children, those who felt knowledgeable about and confident in supporting their child's language development had children with higher scores in formal language assessments one year later compared to mothers with lower MSE (DesJardin, 2006; 2004). Most children in these studies had a profound HL and were over three-years-old. However, the results were replicated for children with mild-severe HL aged 12-18 months (Stika et al, 2015), suggesting the impact of MSE on language is evident early in the child's life, regardless of the degree of HL. Highly self-effacious mothers also use higher-level language strategies that are associated

with better language outcomes for children, tailor their language to the child's level and follow-through with prescribed intervention activities and strategies more than mothers with low MSE (DesJardin, Eisenberg & Hodapp, 2006; DesJardin, 2004).

Parents of CHL have specific tasks to complete around their child's deafness (e.g. establishing consistent hearing aid (HA) use). Parents who have higher self-efficacy levels are more likely to persist and ultimately be successful compared to parents with lower self-efficacy levels (Hoover-Dempsey, Walker et al, 2005). Low self-efficacious parents may know how to succeed (i.e. understand the importance of establishing consistent device use and be aware of relevant strategies to use with their children) but lack the confidence to do so. Low MSE is associated with more difficulty acquiring new skills (Bandura, 1989); mothers of CHL with lower MSE may find it harder to learn and use the necessary skills required to parent a deaf child successfully (e.g. maintaining amplification devices or using new language teaching techniques). Supporting PSE is a core component of best practice guidelines for professionals working in EIS' with CHL (Moeller et al, 2013).

Stika and colleagues (2015) found that mothers of CHL had comparable MSE levels to mothers of children with normal hearing (CNH). However deaf children of highly self-efficacious mothers had better overall adaptive behaviour and social-emotional competence than those with less self-efficacious mothers. Parents with low MSE reported more issues including externalising, internalising and dysregulatory behaviour in their CHL. In this study, the researchers assessed MSE using the 'Maternal Self-Efficacy Scale' (Teti & Gelfand, 1991) which investigates efficacy around specific aspects of childcare and mothers' global feelings around mothering. However, Bandurian theory states that rating scales used to measure self-efficacy should be task-specific and perceptions of specific competencies should be assessed (DesJardin, 2003). Possibly, MSE levels of parents of CHL and those of CNH cannot be assessed using the same measures due to the differing requirements of each.

Approximately 90% of CHL are born to hearing parents (NDCS, 2018; Moores, 2001). These parents are sometimes reported as being less responsive to their

children (Koester & Lahti-Harper, 2010; Brady et al, 2009), perhaps due to difficulty communicating with them and interpreting their behaviours or grief associated with the diagnosis (Bess & Paradise, 1994). Given that highly self-effacious parents are more responsive (Stifter & Bono, 1998), this reduced responsiveness may be linked to reduced PSE.

There is also an association between later amplification and lower MSE levels for parents of HA users (DesJardin, 2005). This could be the result of a perceived sense of failing their child by not recognising the HL earlier or a higher level of communication breakdown as a result of the child's HL. Reduced MSE leads to the parent lacking belief in their ability to support change in their child, which reinforces the low MSE beliefs and created a negative feedback loop (Jones & Prinz, 2005). It is therefore critical that EIS for CHL aim to provide parents with positive parenting experiences early, to build MSE and increase responsiveness, thus supporting child language development.

### **2.2.2. Influence of parental involvement on child outcomes**

Definitions of PI vary, as have the methodological approaches used in research in this area (Fan & Chen, 2001), making it difficult to obtain a cumulative understanding across studies (Bruder, 2000). Included in most definitions are the constructs of 'active participation' and 'engagement' (Jeynes, 2005).

Definitions of PI for CHL have additional dimensions, including taking responsibility and initiative for the therapeutic process and establishing social relationships with other families (Ingber, 2004).

Regardless of the definition used, PI in their child's education is an important indicator of child outcomes including academic achievement (Dunst & Trivette, 2009; Fantuzzo, McWayne et al, 2004; McBride, Schoppe & Rane, 2002) and socio-emotional development (Department for Children, Schools and Families, 2008; Sylva, Melhuish et al, 2004; Fan & Chen, 2001). Despite much of the research focusing on school-aged children rather than those in the early years, because of these findings, PI is a fundamental component of early childhood

education (Sandall, Hemmeter et al, 2005; Shonkoff & Meisels, 2000; Smith & Zaslow cited Smith, 1995).

### **2.2.2.1. Impact of parental involvement in early intervention on children with a hearing loss**

PI in EI for deaf children is often the missing factor when explaining the level of success a deaf child achieves (DesJardin, 2003; Calderon, 2000). PI has considerable influence on language outcomes for CHL (Boons, Brokx, et al, 2012; Holzinger, Fellingner & Beitel, 2011; Hadadian & Merbler, 1995). PI is associated with increased use of higher-level language strategies (DesJardin & Eisenberg, 2007; DesJardin, 2004), increased generalisation of skills (Zaidman-Zait, Most et al, 2017) and better future language abilities (Moeller, 2000; Yoshinaga-Itano, 2000).

Moeller's (2000) study examined influences of language in a large cohort of five-year-old CHL. Age of enrolment in EI and PI had the strongest impact. Some children who received support late but had high levels of PI outperformed those who were supported early but had low levels of PI. These findings were replicated more recently (Yanbay, Hickson et al, 2014). Watkin and colleagues (2017) found that PI was positively related to speech and language scores for children diagnosed after nine-months-old, particularly those with severe-profound HL. Although there was on average a five-month delay between diagnosis and HA fitting (which is atypical of many services), these results supported research suggesting PI could partially compensate for late management of HL. Arguably, PI is even more critical for these children, who are at a considerable disadvantage regarding their speech and language development.

Calderon (2000) used interventionists' narratives to retrospectively assess PI, finding that maternal communication skills better predicted language and social-emotional development than PI. However conceivably, for hearing parents to develop positive communication skills with their CHL, high involvement in EI is required, particularly if the language is new to the parent (e.g. sign language).

Equally, as this study involved school-aged children, parents may have been less able to actively participate due to distance or work challenges. Finally, a retrospective rating by professionals may be less accurate or sensitive than self-reports or measures completed at the time of the intervention.

### **2.2.3. The relationship between parental self-efficacy and parental involvement**

PSE for parents of CHL is linked to involvement levels across multiple dimensions (Ingber & Most, 2012; DesJardin, 2004). Parents who positively rate their parenting ability are more likely to engage in their deaf child's intervention (Pelletier & Brent, 2002) because they have a belief in their ability to perform in intervention activities. If parents believe their skills or knowledge are inadequate, they may be reluctant to engage actively (Hoover-Dempsey & Sandler, 1995).

DesJardin's (2005) study demonstrated that parents of HA users were not only less self-efficacious when their children received later amplification and support but also felt less involved. In contrast, mothers of cochlear implant (CI) users felt equally involved regardless of whether MSE was high or low. The number of appointments required during the implant process and increased contact with professionals compared to HA users may account for this. In this study, the mean age of HA fitting and enrolment into the EIS was 16-months-old; parents of HA users who receive amplification and support earlier (as is generally the case now) may have different experiences.

## **2.3. Environmental factors affecting outcomes for deaf children: the language environment**

A child's early language environment is critical to their life trajectory (Phillips in Duncan & Murnane, 2011; Forget-Dubois & Dionne, 2009; Law & Rush, 2009). It predicts early language development more accurately than any other factor (Rowe, Pan & Ayoub, 2005; Hart & Risley, 1995), as well as cognition, socio-

emotional development and academic achievements (Roulstone, Law et al, 2010; Kashinath, Woods & Goldstein, 2006; Huttenlocher, Vasilyeva et al, 2002). The language environment contains qualitative and quantitative aspects, both equally important and required to achieve linguistic (and ultimately life) potential (Ambrose, Walker et al, 2015; Suskind, Leffel et al, 2013).

Children with developmental or intellectual disabilities (Warren, Gilkerson et al, 2010), developmental language disorders (Hammer, Toblin et al, 2001) and those from low socio-economic status (SES) backgrounds (Hoff & Tian, 2005; Hart & Risley, 1995) have significantly reduced language environments compared to typically-developing children. Interventions for these populations often target the parent as the catalyst for improving the child's language (Roberts & Kaiser, 2011; Reese, Sparks & Levya, 2010; Pickston, Golbart et al, 2009). In a review of parent-implemented language interventions, language skills of children aged 18-60 months significantly improved when intervention targeted the quality and quantity of adult speech used during the daily routine (Roberts & Kaiser, 2011). A number of interventions targeting the quality of adult-child interactions have been developed, although relatively few target the quantitative language environment. This is the focus of the next section.

### **2.3.1. Influence of quantity of adult words on child language development**

In their seminal study, Hart and Risley (1995) collected monthly, hour-long audio recordings and observations of children from professional, working class and low SES families. The quantity of adult talk in the child's language environment was shown to better predict children's language outcomes than any other feature of their early language experience (Ambrose, Thomas & Moeller, 2016). Children exposed to the greatest number and diversity of adult talk were more talkative, had more advanced vocabularies at age three and better language and literacy levels at age nine than children of less verbal parents (Walker et al, 1994). Parents from professional backgrounds were most talkative, using on average 3000 words per hour, compared to 500 for the least talkative group, the low SES families (Greenwood, Thiemann-Borque et al, 2011). A linear extrapolation estimated that by age four, there would be a gap of

30 million words between children from the highest and lowest SES families, highlighting the challenge interventions had to address to ensure equal language outcomes (Hart & Risley, 2003).

Other research has replicated these results regarding the link between exposure to adult language and child language skills (Hurtado, Marchman & Fernald, 2008; Hoff & Naigles, 2002; Paavola, Kunnari, et al, 2005). VanDam, Ambrose and Moeller (2012) suggest why this relationship exists. Children of talkative parents are exposed to individual words more often than those with less talkative parents, giving them more opportunities to make connections between the word and its meaning (Huttenlocher, Haight et al, 1991). Secondly, parents vary in their use of linguistic features (e.g. tense markers) that are important for children's language development, however, overall, the more talk to which children are exposed, the more opportunities they have to hear these features used in context (Hart & Risley, 1995). Finally, children who talk more in response to an adult have more opportunity to practice using language, which may further advance their language development.

#### **2.3.1.1. Influence of quantity of adult words on children with a hearing loss**

Although it is recognised that deaf children of hearing parents have disparities in their language experiences compared to CNH (Suskind et al, 2013; DesJardin & Eisenberg, 2007; Meadow-Orlans, 1997), their quantitative language environments are relatively unresearched. This is partially due to the extensive resources previously required to undertake research investigating children's natural language environments. Additionally, until relatively recently, paediatric HL was not diagnosed until children were approximately two-years-old (Davis, Bamford et al, 1997) making it difficult to examine the effect of parent talk on early child language development. Some studies report hearing mothers talk to their CHL less than CNH (Cole, 1994; Lederberg & Mobley, 1990; Meadow, Greenberg et al, 1981). However, these were implemented before the introduction of the NHSP and tended to focus on older children with a severe-profound HL only. The caseloads of most EIS contain a significant

proportion of children with mild-moderate HL, making it difficult to generalise these results to today's families. More recent research suggests that although there are differences in the quality of adult talk to CHL compared to CNH (Morgan, Meristo et al, 2014; Moeller & Schick, 2006), there is little change in quantity (VanDam et al, 2012; Aragon & Yoshinaga-Itano, 2012; Mulla, 2011; Nittrouer, 2010).

However, CHL require more exposure to a word to add it to their lexicon than CNH (Lederberg & Spencer, 2009; Pittman, Lewis et al, 2005; Lederberg, Prezbindowski & Spencer, 2000). This may be because, despite the use of digital HAs (Stiles, Bentler & McGregor, 2012) and radio aids, CHL often receive a degraded acoustic signal, particularly when listening in background noise or at a distance (Allen, Crawford & Mulla, 2017), limiting their access to language. Secondly, incidental language learning through overhearing is a recognised language learning technique for children from as early as 16-months-old (Floor & Akhtar, 2006); children acquire up to 90% of their spoken language through this approach (Gampe, Liebal & Tomasello, 2012; Cole & Flexer, 2011). Overhearing language is more challenging for CHL, meaning their ability to learn language incidentally is limited. Consequently, CHL may require more exposure to adult talk than CNH to achieve the same language outcomes (Aragon & Yoshinaga-Itano, 2012; VanDam et al, 2012).

### **2.3.2. Influence of quantity of conversational turns on child language development**

Conversational exchanges are central to child language development. They are episodes of joint attention between the adult and child, which are fundamental to child language development (MacWhinney & McTeague, 2004; Tomasello, Mannle, & Kruger, 1986). Some studies suggest that only maternal language provided within joint attention episodes is related to later child vocabulary (Weisleder & Fernald, 2013; Tomasello & Farrar, 1986). Furthermore, adult-child conversations tend to be longer within joint attention periods than outside (Tomasello & Farrar, 1986), giving children more exposure to and practice using language. Secondly, exposure to the child's language through conversations

offers parents the opportunity to develop an understanding of their child's abilities, allowing them to learn to maintain their language within the child's 'zone of proximal development'. This is where parent language is challenging enough for the child to learn from but not too challenging for them to access (Taumoepeau & Ruffman, 2008). Finally, conversations provide children with opportunities to experience active correction of their errors, known to improve child language (Chouinard & Clark, 2003).

The answer to the question regarding the direction of influence between the amount of adult talk and child language skills could lie in conversational exchanges. As children develop better language skills, adult-child conversations often become longer and involve more turns, meaning the adult produces more language (VanDam et al, 2012). This may explain why some studies find that parents talk more to older children (Rowe et al, 2005) despite a parent's tendency to be talkative (or not) being stable over time (Huttenlocher, Vasilyeva et al, 2007).

### **2.3.2.1. Influence of quantity of conversational turns on children with a hearing loss**

Conversation is linked to both receptive and expressive language development and vocalisations for CHL (Ambrose, VanDam & Moeller, 2011; Beams, Yoshinaga-Itano et al, 2012). Although some studies suggest CHL spend less time in joint attention episodes than CNH (Morgan et al, 2014; Gale & Schick, 2009), there is no significant difference in the number of conversational turns between parents with CHL and CNH (Vohr, Topol et al, 2014; Caskey & Vohr, 2013; VanDam et al, 2012). However, parents of children with better hearing thresholds and more aided audibility engage in more conversational turns than children with lower hearing levels (VanDam et al, 2012). Children with lower hearing thresholds may be less responsive to their parents' input and, because of delays in their language (Lederberg cited Lieven, 2006), have a higher number of conversation breakdowns. Over time, parents may reduce their attempts to engage the child in conversation, have fewer conversational turns within a conversation or limit their attempts to situations in which they are sure

of their child's access (Allen et al, 2017; Morgan, Meristo & Hjelmquist, 2016; VanDam et al, 2012). As a result, the CHL has fewer opportunities to engage and learn from conversations.

## **2.4. Justification for the current study**

EIS often seek new ways to increase PI in the home because of its links to child outcomes (Dunst & Trivette, 2009; Dempsey & Keen, 2008; Dunst, 2000).

Given the evidence to show the relationship between PI and MSE, working to increase MSE appears to be a viable line of intervention. However, there are relatively few therapeutic suggestions of how to target this area practically for parents of CHL.

With the development of new technology produced by the LENA foundation (see 3.5.1.), there is a renewed interest in the quantitative language environments of CHL. LENA collects and automatically analyses information about the child's auditory environment (Gilkerson & Richards, 2008), giving users quantitative feedback about the amount of adult talk around a child during a typical day (Caskey & Vohr, 2013). The quantitative data produced acts as an outcome measure and is used for goal setting and identifying strategies (Morrison, Lopez & Rodriguez, 2011).

LENA has been used to investigate the language environments of CHL and other populations of children (Suskind et al, 2013; Aragon & Yoshinaga-Itano, 2012; VanDam, Oller et al, 2015). The system has formed the basis of the projects such as "Project Aspire" and "The Thirty Million Words Project" in the USA which have been effective in changing children's language environments (Sacks, Shay et al, 2013). This study aims to investigate LENA's use as an intervention tool to alter language environments for CHL and furthermore, identify whether invention based on quantitative linguistic feedback has the potential to influence MSE and involvement levels.

## **3. Methods**

### **3.1. Design**

Action research integrates research and action, producing recommendations for good practice and improvements or resolution of a problem (Somekh, 1995).

This approach is used increasingly in the fields of education, health and social care by practitioners who want to use the research to improve their effectiveness (Denscombe, 2014). As it is often used to establish the value of the research area (e.g. a proposed new way of working (Robson, 2007) it was suited for use in this study.

Action research often takes place in the workplace, where there are conflicting time demands of implementing the research and continuing with duties.

Furthermore, integrating research with practice limits the researcher's ability to control variables and use control groups. However, the main advantage of this approach- that it addresses practical problems positively and the results feed directly back into practice- outweighs these potential challenges.

### **3.2. Sampling**

Non-probability convenience sampling, involving the researcher's discretion in the selection process (Denscombe, 2014; Banerjee & Choudhury, 2010), was used with parents of deaf children on the Early Years caseload. Potential participants were quickly identified and located (necessary given the limited time frame available) and were familiar with the researcher before the onset of the study. There is some debate as to whether non-probability convenience sampling reduces the accuracy and generalizability of the results (Robson, 2007). However, a pragmatic approach was taken; the aim was to reach accuracy levels that were "good enough" for research purposes, within the resources available (Denscombe, 2014).

### 3.3. Participants and Recruitment

Mothers of children with the characteristics listed in table 3.1 were approached during home or nursery visits and given information about the intervention. For more information regarding the recruitment process, see 3.6.

**Table 3.1 Criteria for entry into the intervention**

Mothers of children who:	
1	Have a diagnosis of a permanent HL*
2	Are under the age of 48 months
3	Have no other diagnosed additional need**
4	Use spoken language as their primary communication mode
* Parents of children with a conductive hearing loss were excluded due to possibilities their hearing loss would resolve during the intervention.	
** Parents of deaf children with additional needs were excluded as these children were undergoing alternative interventions targeted to their needs at the time.	

Twenty-two families were approached to partake in the intervention. Two declined outright. Three ultimately declined the intervention but completed the questionnaires and interview (see 3.5.). A further three families dropped-out due to issues related to equipment. A cohort of 14 participants is deemed to be a realistic number for a medium-sized project (Clarke, Braun & Hayfield cited Smith, 2015). Of the participants' children (eight female, 12 male) the average age was 29-months-old at the onset of data collection (range 3-45 months) and 33 months at the end (range 7–49 months). Two participants had children with a mild HL; 13 moderate; two severe and three profound. The children with a profound HL had bilateral CIs; all other participants had bilateral HAs. The average age of HA fitting was four months (range 1-24 months); the average age of CI activation was 26 months (range 13-40 months). Given the demographics of the area, most participants were from low SES backgrounds and used English as an additional language (EAL).

**Table 3.2 Characteristics of participants' children diagnosed with a hearing loss**

Participant	Degree of HL	Current Amplification	Home Language	Age (months)			
				At entry to the study	At diagnosis	At HA fit	At CI activation
P1	Profound	CI	English	32	1	2	24
P2	Moderate	HA	English	15	1	4	
*P3	Moderate	HA	Tamil	33	24	26	
P4	Moderate	HA	English	27	2	3	
P5	Moderate	HA	Gujarati	34	3	4	
P6	Moderate	HA	Gujarati	30	1	3	
P7	Moderate	HA	Romanian	25	3	3	
P8	Mild	HA	Gujarati	45	1	4	
P9	Moderate	HA	Romanian	18	2	3	
P10	Severe	HA	Malay	17	2	4	
P11	Moderate	HA	Urdu	43	1	6	
P12	Moderate	HA	Russian	40	1	2	
P13	Moderate	HA	Bengali	46	3	5	
P14	Severe	HA	Pashto	40	1	2	
P15	Mild	HA	Lingala	32	1	3	
P16	Moderate	HA	Urdu	3	1	2	
P17	Moderate	HA	Bengali	3	1	3	
P18	Profound	CI	Arabic	18	2	2	13
P19	Moderate	HA	English	28	1	3	
P20	Profound	CI	Urdu	45	2	3	40
<b>AVERAGE</b>				<b>29</b>	<b>3</b>	<b>4</b>	<b>26</b>

KEY
*Progressive hearing loss
HA- Hearing Aids
CI- Cochlear Implants

Information on the family context and background was collected given research showing the relevance of such variables (Cole & Flexer, 2011; Gilkerson & Richards, 2009).

**Table 3.3 Participant characteristics**

	<b>Characteristics</b>	<b>N</b>	<b>%</b>
<b>Parent/Carer</b>	Male	0	0
	Female	20	100
<b>Children (with hearing loss)</b>	Male	12	60
	Female	8	40
<b>Child's age</b>	0-12 months	2	10
	13-24 months	4	20
	25-36 months	8	40
	37-48 months	6	30
<b>Child's degree of hearing loss</b>	Mild	2	10
	Moderate	13	65
	Severe	2	10
	Profound	3	15
<b>Amplification</b>	Bilateral hearing aids	17	85
	Bilateral cochlear implants	3	15
<b>Highest level of maternal education</b>	Primary	4	20
	Secondary	5	25
	College	4	20
	University	7	35
<b>Highest level of paternal education</b>	Primary	3	15
	Secondary	6	30
	College	5	25
	University	6	30
<b>Socio-economic status*</b>	Comfortably well-off	2	10
	Moderate means	5	25
	Hard pressed	13	65
<b>Child's position in the family</b>	Only child at home	10	50
	Oldest	0	0
	Youngest	9	45

	Middle child	1	5
<b>Mother's employment status</b>	Unemployed	12	60
	Employed part-time	6	30
	Employed full-time	2	10
*ACORN (A Classification of Residential Neighbourhoods) system ( <a href="http://acorn.caci.co.uk/">http://acorn.caci.co.uk/</a> )- no families were identified as "Wealthy Achievers" or "Urban Prosperity".			

### 3.4. Ethics

Data was collected as part of the researcher's routine clinical work. Consent was sought from participants to use the data as the main body of this paper. Participants were provided with a Participant Information sheet and written consent forms were completed. Ethical approval was granted by the Research Ethics Committee, University of Hertfordshire. See Appendix A for copies of the approved documentation.

### 3.5. Data

A mixed methods approach was used, combining qualitative and quantitative methods. Triangulation of multiple methods of data collection allows the research problem to be viewed from different perspectives and gives the researcher a more detailed, deeper insight into the subject (Robson, 2007). By using this approach, the researcher aimed to obtain a more holistic understanding of how LENA can be used with parents of CHL. Although it takes longer than a mono-method approach, a mixed methods approach allows the strengths of each method to be exploited without leaving the research vulnerable to their weaknesses (Denscombe, 2014).

A mixed methods approach has been used by several researchers using LENA, triangulating LENA results with standardised language assessments, interviews and daily logs to provide a more holistic picture of children's language development and environments (Ganek & Eriks-Brophy, 2016).

### **3.5.1. Language Environment Analysis™ (LENA)**

LENA was designed to promote adult interaction with young children, responding to Hart and Risley's (1995) influential research identifying the amount of adult talk in the first 2-3 years of life as the most important influence of the child's later language development, IQ and success at school (LENA, 2018). Traditionally, short (usually video) recordings or observations have been used by professionals working with children with language delays (both in research and clinically), often focusing on the quality of parent-child interactions (Ganek & Eriks-Brophy, 2016; Rowe, 2008). However, collection and analysis of large quantities of data in this way is highly labour- and time-intensive. LENA is the first system to take day-long recordings in the child's natural language environment and analyse them automatically using advanced signal processing strategies (Mulla, 2011).

Over the last decade, researchers of early language development for CHL in numerous countries have used LENA (e.g. Aragon & Yoshinaga-Itano, 2012; Stremel-Thomas, 2010; Yoshinaga-Itano, 2010) however its use with families of deaf children in the UK have been limited.

#### **3.5.1.1. The Digital Language Processor (DLP)**

The DLP is a battery-powered device worn in the chest pocket of a t-shirt or vest designed to ensure the material does not impact on the quality of the recording and the device remains a steady distance from the child's mouth (VanDam, 2014). The device contains power and recording buttons, a USB port and an LCD screen. The buttons must be depressed for several seconds to begin and end the recording, making it child-proof (Mulla, 2011). The recorder weighs approximately 60g and can record and store up to 16 hours of information (Mulla, 2011).



**Figure 3.1 LENA DLP (Source: Mulla, 2011)**

### **3.5.1.2. LENA Software**

LENA Research v3.3.3 was used. Recordings are transferred via USB cable to the computer and uploaded to the LENA software (stored on a secure, password-protected laptop). Advanced speech recognition technology automatically analyses the audio file and segments data into 12 categorical components including male/female adult, key/other child, overlapping speech, noise, electronic noise and silence (Smyth & Brinkman, 2014; Mulla, 2011). A day-long recording consists of approximately 20,000-50,000 segments (VanDam, Warlaumont et al, 2016) and takes around an hour for analysis. A statistical model estimates the number of words spoken but does not recognise the content or meaning of the speech (Smyth & Brinkman, 2014). The data is then categorised (see table 3.4) and detailed, time-specific reports produced. This information formed part of the quantitative data for the study.

**Table 3.4 LENA analysis descriptors**

Adult Word Count (AWC)	The number of adult words spoken to and in the vicinity of the child during the recording. The analysis does not differentiate between words directed to the child and those directed elsewhere, nor whether the speech was near enough for it to be heard clearly by the child.
Child Word Count (CWC)	The number of meaningful vocalisations made by the child excluding non-speech sounds (e.g. crying).
Conversational Turn Count (CTC)	The total number of vocal interactions between the key child and an adult (defined as the number of times a speaker changes within a single conversation).

All three LENA descriptors have good reliability and fidelity, with high levels of agreement with human transcription analysis (Xu, Yapanel & Gray, 2009; Gilkerson, Coulter & Richards, 2008; Zimmerman, Gilkerson et al, 2009). In instances of overlapping talk (common in busy homes), LENA software discounts both utterances from the analysis (Warren et al, 2010; Xu, Yapanel et al, 2008) which may reduce the accuracy of the counts and underestimate the number of interactions that occur. Coding errors are also possible within the analysis, for example a female with a raised voice pitch may be coded as a child (Gilkerson, Zhang, et al, 2015). Because labelling errors and overlapping speech are likely to have less significance in larger data sets (Warren et al, 2010), a recording of at least 12 hours is recommended (Xu et al, 2008); participants were advised of this in both the verbal and written instructions.

As well as coding the language recorded, different types of noise are reported as percentages of the total sound (see table 4.6). Other studies provide further information about LENA software (Oller, Niyogi et al, 2010; Gilkerson & Richards, 2009; Ford, Baer et al, 2008). Data can be viewed in monthly, daily, hourly or five-minute segments as a histogram. Recordings are stored in the software, allowing repeated recordings from one participant to be compared over time (Ganek & Eriks-Brophy, 2016).



**Figure 3.2 Example of composite scores produced by LENA system**

Two recordings were completed (see 3.6.). Both the raw data and percentile ranks for each descriptor were noted in each recording. Participants were advised to ensure both recordings took place when similar activities were undertaken.

### **3.5.1.3. Use of LENA with families who use English as an Additional Language (EAL)**

Within the EIS, families are encouraged to use their family language (and the language in which they are most comfortable) with their deaf child, given the documented benefits of doing so (Shin, 2010). Languages used by participants include Bengali, Urdu and Romanian. LENA has been validated in several languages but not those many of those used here; consequently, results should be interpreted with some caution. Researchers have called for LENA to be used with families from more diverse backgrounds to develop a better understanding of child language acquisition (Ganek & Eriks-Brophy, 2016).

Use of EAL by participants made qualitative analysis of the recording more challenging. Where necessary, the researcher's colleagues (fluent in the target language) translated the recording to give the researcher insight into the interaction. They also attended the feedback, intervention and interview sessions. Colleagues received in-depth training regarding the LENA system, the DLP and the purpose of the intervention before embarking on the project.

Where a significant adult-child interaction was identified but there was no-one available to translate, the family were played the interaction and asked to describe it during an intervention session. This then formed the basis of the subsequent discussion.

#### **3.5.1.4. The Hawthorne Effect**

The Hawthorne effect is a bias that is difficult to account for or eliminate (Thomas, 2013). Although there is some debate as to the true definition of the Hawthorne effect, it is a process by which participants change their behaviour due to the knowledge of being studied (Shuttleworth, 2009). Participants in this study may alter their interactions with their children knowing they are being recorded, meaning the results are not “typical”. However, arguably, it is more difficult to sustain these changes for 12-16 hours compared to shorter observations or video recordings that are typically used in child intervention (Suskind et al, 2013). Furthermore, should the participants be “performing”, this would be the case over both recordings. In a pilot study involving LENA, 61.1% of participants indicated they were aware of the DLP during the recording period (Smyth & Brinkman, 2014). Quantitative analysis indicated these participants engaged in significantly more conversational turns with their child than those not consciously aware of the device. However, most of these participants reported this awareness ceased by mid-morning due to the business of the day (Smyth & Brinkman, 2014).

Trust in the person managing the recording has been highlighted as critical (Allen et al, 2017); participants in this study were reassured that recordings were confidential and would be deleted with no penalty should they be uncomfortable at any time.

#### **3.5.2. The Scale of Parental Involvement and Self-Efficacy (SPISE)**

The SPISE (DesJardin, 2004) was designed to investigate parents’ perspectives about specific skills necessary to parent their CHL. It includes the extent to which they perceive themselves as involved in activities related to their

child's amplification device and speech and language development (DesJardin, 2005). Other measures of general PSE and PSE of children with disabilities exist (e.g. Akey, Marquis & Ross, 2000; Abidin, 1991). However, to the researcher's knowledge, the SPISE is the only one that addresses the specific competencies necessary for families of CHL (DesJardin, 2003). The scale consists of three sections: demographic information, MSE and PI. A focus group consisting of a variety of professionals and parents of deaf children developed the SPISE, so offering secure content validity (DesJardin, 2005).

**Table 3.5 Description of the SPISE sections (DesJardin, 2005)**

Demographic information	Questions about the mother (e.g. marital status, ethnicity, primary language, level of education, etc) and the child (e.g. gender, age, age of identification/amplification, degree of hearing loss)
Maternal self-efficacy	Ten questions related to the parent's perspective about their degree of influence on their child's auditory development including competence in the care of the amplification equipment and knowledge and competence to follow through with speech and language activities, assessed on a Likert scale ranging from 1 (not at all) to 7 (very much)
Parental involvement	Eleven questions related to the parent's perception of their involvement in their child's early intervention, assessed on a Likert scale ranging from 1 (not at all) to 7 (very much)

The SPISE gives professionals insight into how parents perceive their role in the child's intervention and beliefs about their competencies (DesJardin, 2003). During development, exploratory factor analysis revealed two subscales for the self-efficacy and involvement measures: one related to the child's amplification device and use and one to the child's speech and language development (DesJardin, 2003). The latter was used in this study, completed by participants pre- and post-intervention (Appendix B). Simultaneously, two Early Years professionals (familiar with the family) independently completed an adapted version of the SPISE, investigating their perceptions of the participants' self-

efficacy (Appendix C). Where there were discrepancies between the professionals' scores, an average was taken.

The SPISE was designed as a self-report measure. However, the results of self-report measures may reflect participants' perceived "correct" responses rather than the reality (Akey et al, 2000). They offer limited opportunities for the researcher to check the truthfulness of the responses given (Denscombe, 2014). Consequently, and because most participants use EAL and have limited literacy skills, the SPISE was presented by the researcher verbally during a home visit.

#### **3.5.2.1. Likert scales**

Likert scales were designed to measure beliefs or attitudes (Likert, 1932) hence their use in the SPISE. However, where an odd number is used, there is a tendency for participants to be noncommittal in their responses and over-choose the middle number (Thomas, 2013). Consequently, the middle option was removed to encourage participants to consider their responses more carefully.

#### **3.5.3. Involvement Rating Scale**

The questions included in the Involvement section of the SPISE were deemed to be of a more personal nature than those regarding self-efficacy, requiring participants to comment on the researcher. Because it was deemed unlikely that participants would be comfortable responding to these questions honestly in front of the researcher, these questions were excluded. Instead, two professionals were asked to independently rate the participants regarding their involvement in the child's intervention according to the Involvement Rating Scale (Moeller, 2000- see Appendix D).

#### **3.5.4. Participant Interviews**

Post-intervention, an interview was conducted including questions examining the participants' thoughts and feelings about LENA equipment, results and feedback and the outcome of the intervention. A semi-structured interview allowed the researcher to clarify, expand on or probe the participants' responses to questions, giving her further insight into areas that could be missed in a self-completion questionnaire (Bell, 2005). It also ensured that participants understood the questions, avoiding misunderstandings and misinterpretations that may introduce a question bias. Participant comments during the interview provided qualitative data.

An interview can be considered an artificial situation that may prevent participants from expressing their true feelings (Rubin & Rubin, 2005). The participants were already familiar with the researcher and had established a rapport, a fundamental concept of semi-structured interviews (Willig, 2001). The researcher deemed that all participants were comfortable during the interviews and able to share their experiences.

The areas to be covered during the post-intervention interview were described in an interview schedule developed by the researcher and her supervisor to provide some structure to the conversation (Appendix E). Open-ended questions were used initially to ensure participants felt comfortable in the interview environment.

##### **3.5.4.1. Interviewer Bias**

Wherever possible, the interviewer should avoid introducing a bias by influencing the participants' responses (Bell, 2005). The "interviewer effect" suggests that a participant's responses can be affected by the interviewee's perception of the interviewer (Denscombe, 2014; Lavrakas, 2008). Interviewees may give answers they feel "fit" with what the researcher expects, especially when the interviewer is seen to be in a position of authority (Denscombe, 2014; Lavrakas, 2008). It was important to stress to participants that their responses (and the content of the recordings) would have no bearing on any subsequent

treatment or intervention. The researcher's understanding and interpretation of the responses given during the interviews is one opinion; it is possible that others analysing the same information would form a different opinion based on their own experiences (Thomas, 2013).

#### **3.5.4.2. Qualitative Analysis**

The interviews were audio recorded and transcribed verbatim by the researcher. Thematic analysis, a method for analysing most forms of qualitative data including interviews (Clarke, Braun & Hayfield in Smith, 2015), was executed. It is an organic approach to coding and theme development, responsive to the researcher's evolving engagement with the data and embraces the researcher's subjectivity rather than viewing it as a negative (Braun & Clarke, 2013).

Braun and Clarke (2006) describe the analysis process. The researcher read the transcripts multiple times and noted codes when anything potentially relevant was identified. The transcripts were re-analysed until saturation was reached. Quotes from individual transcripts were then placed under sub-theme headings on separate documents and key quotes highlighted. Codes were then clustered together to identify patterns in the data and produce themes. These were reviewed by the researcher and the supervisor (an Audiologist), with codes discarded or amalgamated as appropriate.

### **3.6. Procedure**

Table 3.6 outlines the intervention procedure.

**Table 3.6 Summary of the intervention package**

Information sharing	<p>The potential participant was given information about the proposed intervention during a regular home or nursery visit.</p> <p>The researcher arranged a further home visit to provide more information if the potential participant expressed an interest.</p>
Before session 1	Two Early Years professionals independently completed the adapted SPISE questionnaire (professional version) and rated the potential participant using the Involvement Rating Scale (Moeller, 2000).
Session 1	<p><u>Introductory Visit (approx. 1.5 hours):</u></p> <p>The researcher gave the potential participant more information about LENA and the proposed intervention, including an opportunity to explore the DLP and see an example of the graphical results produced.</p> <p>The participant gave verbal and written consent to take part. They were then given a DLP and LENA t-shirt/vest to borrow, as well as written and verbal information on how to use the DLP and instructions to:</p> <ul style="list-style-type: none"> <li>• Turn the recorder on as soon as the child woke in the morning</li> <li>• Leave the recorder on during any naps or periods of sleep</li> <li>• Leave the recorder in the t-shirt on a nearby shelf during baths or showers</li> <li>• Ensure the DLP recorded for no less than 12 consecutive hours</li> </ul> <p>The participant was encouraged to contact the researcher with any questions or concerns throughout the intervention.</p> <p>The researcher presented the questions in the adapted SPISE questionnaire (parent version) verbally to the participant, providing clarification to support understanding as needed (approx. 10-15 minutes).</p>
Week 1	<p>The participant completed the initial LENA recording and contacted the researcher to arrange collection of the DLP.</p> <p>The researcher uploaded the recording onto the LENA software for quantitative and qualitative analysis.</p>
Session 2	<p><u>Feedback visit (approx. 1.5 hours):</u></p> <p>The researcher shared the results of the recording with the participant, discussing the graphical and numerical results and key parts of the audio recording.</p> <p>Methods and strategies for increasing the amount of talk shared with the deaf child at key times were discussed.</p>
Sessions 3-4	<p><u>Coaching sessions (approx. 1 hours):</u></p> <p>During home visits, the researcher modelled and coached the participant on quantitative and qualitative language strategies to enhance the child's language environment, identified as being appropriate and meaningful</p>

	based on LENA analysis, the family's daily routine and the child's current language level.
Week 5	<p>The researcher gave the same written instructions, DLP and t-shirt/vest to the participant and advised them to complete the second LENA recording on a day similar to the first recording.</p> <p>Two Early Years professionals independently completed the adapted SPISE questionnaire and rated the participant using the Involvement Rating Scale (Moeller, 2000).</p> <p>The researcher collected the DLP post-recording and uploaded the second recording onto the LENA software for quantitative analysis.</p>
Session 6	<p><u>End of block visit (approx. 1 hour):</u></p> <p>The researcher visited the participant to feedback the results of the second LENA recording and conduct a semi-structured interview to investigate the participant's opinions regarding LENA and the intervention process. This also included completing the adapted SPISE questionnaire.</p>

### 3.7. Reflexivity

When implementing qualitative research that requires analysis and interpretation by the researcher, their involvement in the study and the way in which it may influence results must be acknowledged. Consequently:

The researcher is an Early Interventionist working with families of preschool deaf children. Her main role is to support families practically and emotionally following the diagnosis of a HL in their child, specifically providing guidance and recommendations on how to enhance their child's speech and language development. Outcomes for deaf children in the area are historically low, deemed at least in part due to the low levels of engagement and involvement of families in their child's intervention. Consequently, the researcher has been interested in identifying new intervention approaches that may increase parental interest in their child's development, thus improving outcomes.

## 4. Results

### 4.1. Quantitative Analysis

#### 4.1.1. Maternal Self-Efficacy and Involvement

##### 4.1.1.1. Maternal Self-Efficacy (MSE)

Regarding the questionnaires completed by the participants (MSE (Participant)) and by professionals (MSE (Professional)), all participants increased their MSE score from pre- to post-intervention.

**Table 4.1 Parent and professional maternal self-efficacy scores pre- and post-intervention (averages for P1-P14 only)**

Participant	Maternal Self-Efficacy: Participant responses (%)			Maternal Self-Efficacy: Professional responses (%)		
	Pre-Intervention	Post-Intervention	Difference	Pre-Intervention	Post-Intervention	Difference
P1	45	85	40	50	67	17
P2	48	88	40	61	71	11
P3	68	95	27	64	71	8
P4	61	92	32	58	73	15
P5	65	88	23	64	82	18
P6	71	92	21	56	64	8
P7	65	91	26	68	82	14
P8	73	89	17	71	88	17
P9	73	92	20	61	68	8
P10	73	92	20	71	88	17
P11	58	88	30	52	67	15
P12	74	85	11	61	74	14
P13	67	79	12	39	45	6
P14	47	58	11	58	68	11
P15	48			55		
P16	41			36		
P17	29			32		
P18	48			36		
P19	47			53		
P20	71			62		
<b>Average</b>	<b>63</b>	<b>87</b>	<b>24</b>	<b>59</b>	<b>72</b>	<b>13</b>

Pre-intervention, the mean MSE (Parent) score (for P1-14 who completed the intervention) was 63% (range 29%-74%). Post-intervention, this was 87% (range 58%-95%), an increase of 23% (range 11%-40%).

The mean MSE (Professional) score pre-intervention was 59% (range 32%-71%). Post-intervention, this was 72% (range 45%-88%) an increase of 13% (range 6%-18%). Although the professionals detected an improvement in MSE, it was less than that perceived by the participants themselves.

Of P15-20 who declined to continue with the intervention, five achieved a MSE (Professional) and MSE (Parent) score below the mean for participants who finished the intervention. The exception was P20, who had one of the highest pre-intervention MSE (Parent) scores of all 20 participants.

#### **4.1.1.2. Involvement**

No discrepancies in scores were identified between the two professionals who rated the participants for involvement.

**Table 4.2 Parent involvement rating as perceived by two Early Years professionals (averages for P1-P14 only)**

Participant	Involvement Rating (/5)	
	Pre-Intervention	Post-Intervention
P1	3	4
P2	3	3
P3	3	4
P4	3	4
P5	5	5
P6	3	3
P7	3	3
P8	5	5
P9	4	4
P10	4	4
P11	3	3
P12	3	4
P13	2	2
P14	2	3
P15	2	
P16	2	
P17	2	
P18	2	
P19	3	
P20	3	
<b>Average</b>	<b>3</b>	<b>4</b>

Of the 14 participants who completed the intervention, nine showed no change in involvement rating from the pre- to post-intervention phases. Four participants (P3, P4, P12) improved from category 3 ('average') to 4 ('good participation'). P14 improved from category 2 ('below average') to 3 ('average'). See Appendix D for category descriptions.

Of the nine participants who showed no improvement, two (P5, P8) had a pre-intervention rating of 5, meaning they were already showing 'ideal participation' and could not improve. Two participants (P9, P10) were rated as 4 ('good participation') pre-intervention and therefore had little room for improvement.

Three of these four participants (P8, P9, P10) achieved the highest scores in MSE (Parent) questionnaire both pre- and post-intervention.

All six participants who declined to use LENA had lower involvement ratings; four (P15-18) were rated category 2 ('below average') the lowest score given for all participants. Only two participants who completed the intervention were scored similarly. P15-17 also had amongst the lowest MSE scores of all participants. The remaining two participants (P19, P20) had a rating of category 3 ('average').

#### **4.1.2. Word Counts and Language Environments**

The LENA Natural Language Study (Gilkerson & Richards, 2008) collected data on the language environments of 329 typically-developing, English-speaking children. In 2017, the reference set increased to 375 children (Gilkerson, Richards et al, 2017). These studies led to the development of norms for AWC, CVC and CTC at each month of age from two to 48-months. Although this study involved deaf children from a variety of linguistic backgrounds, comparison to typically-developing children is useful to monitor progress. Equally, because an EI aim is to support early language development in the same trajectory as hearing peers, comparison of the two is helpful to inform practice.

#### 4.1.2.1. Adult Word Count (AWC)

All participants showed an increase in their AVC from pre- to post-intervention.

Table 4.3 LENA adult word count pre- and post-intervention

Participant	Adult Word Count						
	Pre- Intervention	Percentile Rank	Post- Intervention	Percentile Rank	Difference	%difference	%ile difference
P1	9417	24	12367	42	2950	31	18
P2	17604	89	21564	95	3960	22	6
P3	3551	1	13935	67	10384	292	66
P4	8510	36	17721	89	9211	108	53
P5	13988	67	20068	95	6080	43	28
P6	3136	1	14794	74	11658	372	73
P7	12100	50	15097	76	2997	25	26
P8	7416	5	13650	47	6234	84	42
P9	4271	3	13312	61	9041	212	58
P10	12252	51	22972	98	10720	87	47
P11	20164	98	25556	99	5392	27	1
P12	18345	91	35919	99	17574	96	8
P13	1064	1	5468	1	4404	414	0
P14	11675	38	15598	57	3923	34	19
<b>Average</b>	<b>10250</b>	<b>40</b>	<b>17716</b>	<b>71</b>	<b>7466</b>	<b>73</b>	<b>32</b>

Pre-intervention, the mean AWC was 10250 (range 1064–20164). Post-intervention, this was 17716 (range 5468–35919), an increase of 7466 (range 2950–17574) or 73% (range 22%-414%). Although it might be expected that those participants who had a higher pre-intervention AWC would make a smaller increase post-intervention, some were still able to increase their AWC by a significant amount (e.g. P12 nearly doubled their AWC from pre- to post-intervention, despite having one of the highest pre-intervention AWC). However, others with a high pre-intervention AWC had a more modest increase (e.g. P11). All participants with a lower pre-intervention AWC (i.e. under 5000 words) showed a significant increase post-intervention (e.g. P3, P6, P13), despite this not always being reflected in the percentile rank. P13 is notable in that although there was no change in percentile rank post-intervention, AWC increased by 414% (over 4000 words).

#### 4.1.2.2. Child Vocalisation Count (CVC)

Table 4.4 LENA child vocalisation count pre- and post-intervention

Participant	Child Vocalisation Count						
	Pre- Intervention	Percentile Rank	Post- Intervention	Percentile Rank	Difference	% difference	%ile difference
P1	1043	8	4215	69	3172	304	61
P2	1885	73	2004	83	119	6	10
P3	722	9	4300	74	3578	496	65
P4	1686	31	3875	68	2189	130	37
P5	2766	68	3933	89	1167	42	21
P6	2014	47	3228	64	1214	60	17
P7	2131	49	1951	41	-180	-8	-8
P8	1924	1	2702	58	778	40	57
P9	572	1	1364	40	792	138	39
P10	1443	47	1985	67	542	38	20
P11	4920	78	5672	85	752	15	7
P12	2365	57	5106	97	2741	116	40
P13	376	1	1396	13	1020	271	12
P14	973	1	2050	38	1077	111	37
<b>Average</b>	<b>1773</b>	<b>34</b>	<b>3127</b>	<b>63</b>	<b>1354</b>	<b>76</b>	<b>30</b>

Pre-intervention, the mean CVC was 1773 (range 376–4920). Post-intervention this increased by 76% (range -8%–+496%) to 3127 (range 1364–5672). All but one participant increased their CVC post-intervention. Post-intervention, P7 had 180 fewer child vocalisations than in the initial recording (-8%). Despite four participants (P8, P9, P13, P14) achieving scores equating to the first percentile pre-intervention (suggesting a severe delay for their chronological age compared to normally-hearing peers), none remained in the first percentile post-intervention.

Five participants (P3, P4, P9, P12, P13) increased both their AWC and CVC significantly post-intervention. P6, P8 and P10 significantly increased the AWC but had a smaller increase (relatively) in CVC. Vice versa, P1 and P14 showed a relatively smaller increase in AWC but a larger increase in CVC. P2, P5 and P11 had a relatively modest increase in both AWC and CVC compared to other participants, although there was still an increase in both areas.

### 4.1.2.3. Conversational Turn Count (CTC)

All participants increased their CTC post-intervention.

Table 4.5 LENA Conversational turn count pre- and post-intervention

Participant	Conversational Turn Count						
	Pre-Intervention	Percentile Rank	Post-Intervention	Percentile Rank	Difference	%difference	%ile difference
P1	282	16	578	59	296	105	43
P2	361	54	426	69	65	18	15
P3	121	4	698	72	577	477	68
P4	490	50	908	84	418	85	34
P5	744	80	932	92	188	25	12
P6	199	7	569	59	370	186	52
P7	446	41	584	61	138	31	20
P8	343	18	612	60	269	78	42
P9	122	15	335	40	213	175	25
P10	548	80	654	91	106	19	11
P11	1527	99	1781	99	254	17	0
P12	809	85	1776	99	967	120	14
P13	57	1	308	23	251	440	22
P14	342	21	806	73	464	136	52
<b>Average</b>	<b>457</b>	<b>41</b>	<b>783</b>	<b>70</b>	<b>327</b>	<b>72</b>	<b>29</b>

Pre-intervention, the mean CTC was 457 (range 57–1527). Post-intervention, this was 783 (range 308-1781), an increase of 327 (range 65–967) or 72% (range 17%-477%).

There was variability regarding the relationship between pre- and post-intervention CTC. P11 and P12 had the highest pre- and post-intervention CTCs of all 14 participants. Despite achieving similar post-intervention CTCs (a difference of just five conversational turns), P11 increased their pre-intervention CTC by 120%, compared to 17% for P12. However, P12 was one of the few participants who showed an increase in AWC, CVC and CTC and MSE and involvement rating. P13 had the lowest pre- and post-intervention CTC of the cohort; despite increasing the pre-intervention CTC by 440%, the actual CTC remained relatively low for the child’s chronological age. In contrast, P3 had the second lowest pre-intervention CTC but demonstrated the second highest

increase of all 14 participants post-intervention (an increase of 68 percentile points). Despite P7 showing a reduced CVC post-intervention, the CTC still increased, suggesting a larger number of the vocalisations produced by the child were associated with meaningful interaction.

#### 4.1.2.4. Language Environments

LENA software assigns one of five acoustic categories to the data (see table 4.6). These categories are reported as a percentage of sound over the whole day/hour/five-minute period.

**Table 4.6 Descriptions of acoustic categories (Charron, Fitzpatrick et al, 2016)**

Meaningful Speech	Percentage of time a child is exposed to distinguishable speech during the recording period (typically above 35dBHL)
Distant Speech	Percentage of time a child is exposed to speech produced from more than six feet away or more. Over-lapping speech in child and adult conversations produced during the recording is included in this category on the basis that the adult's speech is not available to the child during this period
Television	Percentage of time a child is exposed to television/electronic devices during the recording period
Noise	Percentage of time that rattles, bumps and other non-human signals are captured during the recording period
Silence and background	Percentage of time that a child is exposed to silence, quiet or vegetative sounds (e.g. burping, coughing) during the recording period

**Table 4.7 Percentage of speech recorded by LENA pre- and post-intervention**

Participant	Speech produced (%)		
	Pre-Intervention	Post-Intervention	Difference
P1	61	72	11
P2	59	70	11
P3	49	73	24
P4	71	70	-1
P5	25	68	43
P6	39	52	13
P7	61	58	-3
P8	46	65	19
P9	44	60	16
P10	38	59	21
P11	51	84	33
P12	47	70	23
P13	67	79	12
P14	66	65	-1
<b>Average</b>	<b>52</b>	<b>68</b>	<b>16</b>

Pre-intervention, an average of 52% speech was detected overall (range 25%-71%) compared to 68% post-intervention (range 52%-79%). This corresponds with earlier findings of an overall average increase in AWC and CVC from pre- to post-intervention. On average, there is a 16% increase in the amount of speech produced (range -3%+43%) during the second recording. When the average length of the pre- and post-intervention recordings is calculated, this equates to the children being exposed to one hour 56 minutes of additional speech.

P4, P7 and P14 produced less speech during the post-intervention recording than the pre-intervention recording by 1%, 3% and 1% respectively. Although a reduction in the overall amount of speech is not the intended outcome of the intervention, these figures should be considered in the context of the amount of time they equate to “in real life”- namely, seven minutes (1%) and 22 minutes (3%) of an average 12-hour day. Variation of this amount could be understandable in the context of busy family life. Although P7 had an 8%

reduction in CVC post-intervention, there was an increased in AWC in the second recording, counter-acting the reduction in CVC somewhat. P4 and P14 both increased the AWC and CVC post-intervention; a reduction in the amount of speech detected by the recorder is therefore unexpected. However, when analysing the recordings to feedback to families, the researcher detected some chunks of time where adult or child speech had been recorded as “TV” which may explain this perceived reduction in “speech” time.

Although the results indicate an overall increase in the amount of speech produced by the participants, given the nature of this study, of interest is the percentage of time allocated to the “meaningful” and “distant” speech categories. This provides further information into the environments in which the AWC, CVC and CTC were produced.

**Table 4.8 Proportion of LENA distant and LENA meaningful speech produced pre- and post-intervention**

Participant	Pre-Intervention (%)		Post-Intervention (%)	
	Distant	Meaningful	Distant	Meaningful
P1	79	21	38	63
P2	63	37	63	37
P3	37	63	41	59
P4	65	35	71	29
P5	60	40	43	57
P6	72	28	62	38
P7	62	38	62	38
P8	76	24	58	42
P9	66	34	63	37
P10	61	39	51	49
P11	22	78	35	65
P12	47	53	39	61
P13	58	42	52	48
P14	48	52	57	43
<b>Average</b>	<b>58</b>	<b>42</b>	<b>53</b>	<b>48</b>

Overall, eight of the 14 participants (P1, P5, P6, P8, P9, P10, P12, P13) increased the proportion of meaningful speech produced compared to the initial

recording. Two participants (P2, P7) produced the same proportion of meaningful speech pre- and post-intervention. Four participants (P3, P4, P11, P14) produced more distant speech post-intervention, contrary to the intervention aims. Overall, although the mean percentage of meaningful speech produced increased post-intervention, more distant speech was produced by participants. However, it is important to note that the only category used by the LENA software for analysing AWC, CTC and CVC is the data identified as “meaningful” (Mulla, 2011). All participants produced a higher AWC and CTC post-intervention as discussed above, suggesting that the adult speech produced post-intervention was of a higher quality than that produced pre-intervention.

P1 had the biggest increase in meaningful speech post-intervention and the second highest proportion of meaningful speech of all 14 post-intervention recordings. P11 had the highest proportion of meaningful speech post-intervention but actually produced less meaningful speech than in their initial recording. P6 and P7 produced the same proportion of meaningful and distant speech post-intervention; however, whereas P7 showed no change from the pre-intervention results, P6 produced 10% more meaningful speech compared to the pre-intervention recording.

## 4.2. Qualitative Analysis

Analysis of the participant interviews revealed five overarching themes, described below.

### 4.2.1. Navigating the recording process

#### 4.2.1.1. Motivation for using LENA

Six participants cited intervention focused on the daily routine as a motivating factor for using LENA. For others, motivation came from being able to demonstrate the child's typical, spontaneous speech and language skills to the researcher outside an intervention session.

**Table 4.9 Participant quotes regarding their motivation for using LENA**

Motivation for using LENA	
P10	When you described it to me, about being focused on the daily routine...that sparked my interest because it's so different to anything anyone has suggested before. I thought if it's about our daily routine and daily things it might be easier for me to do more regularly.
P4	We've had conversations about the routine and teaching [my child] using the daily routine pretty much since he was born, haven't we, but this was actually....I don't know, bringing all that to life.
P13	I wanted to prove to you and everyone how much he is talking at home. Because I know you were worried so I wanted you to see.

#### 4.2.1.2. Initial anxiety about being recorded

Six participants reported feelings of anxiety or worry at the thought of being recorded, particularly regarding the researcher's perception of the content. However, none of these participants reported a change to the daily routine or interaction style because of this initial anxiety.

**Table 4.10 Participant quotes regarding their initial anxiety about being recorded**

Initial anxiety about being recorded	
P1	I was a bit nervous about the recording picking up what I was saying...it could have been awful if you just listened to me shout all day.
P10	I was a bit worried about the recording and being recorded all day like that....
P8	I suppose I was a bit worried about what you'd hear and maybe you'd think I wasn't doing lots of things right or how I should do it, you know.

### 4.2.1.3. Concern about being judged

Two participants (not those who reported anxiety about the recording- see 4.2.1.2) mentioned the possibility of being “judged”, highlighting the need for a positive relationship between the professional and the parent before embarking on such an intervention. However, their concern did not outweigh the potential benefits of completing the recording.

**Table 4.11 Participant quotes regarding concern about being judged by the professional**

<b>Parental concern about being judged</b>	
P4	You're kind of opening yourself up for judgement, aren't you?
P5	I think parents have got to put their faith in you, as a professional, to be doing these things to help the child. That you won't be judging them, whether the recording turns out to be really bad or really good.

### 4.2.1.4. The value of parent-to-parent support

For one participant, a deciding factor in her decision to use LENA was positive feedback from another parent. Opportunities to hear from families who have used LENA could foster positive feelings in families with concerns or reservations.

**Table 4.12 Participant quote regarding the value of parent-to-parent support**

<b>The value of parent-to-parent feedback</b>	
P1	I talked to [another child's] Mum about it and she thought it was great so I thought we'd give it a go...She was saying she felt the same initially but thought it really helped her.

### 4.2.1.5. Disagreement between family members

Two participants reported that family members had reservations about using LENA. Negotiation was required to ensure the entire family was happy to engage with the process. Confidence in the researcher disposing of the recording if requested was significant, highlighting the importance of parental trust in the professional (see 4.2.1.12).

**Table 4.13 Participant quotes regarding disagreement between family members**

<b>Disagreement between family members</b>	
P4	[My husband] was a bit more...weirded out, by the idea of being recorded all day, more than me anyway...we just talked about the reasons for and against it...and also I said that if we weren't happy with it I would just ask you to delete it.
P14	My Dad was asking why I wanted to let someone record us and that I should say no...

#### **4.2.1.6. Challenges/concerns related to equipment**

Four participants reported some initial worries about keeping the equipment safe. No physical damage to the DLPs was sustained while they were with the families. Three participants reported having to “convince” their child to wear the t-shirt provided for the DLP, similar to Charron and colleagues (2016), either for the first or second recording (but never both).

**Table 4.14 Participant quotes regarding challenges and concerns related to equipment**

<b>Challenges/concerns related to equipment</b>	
P11	I had to really battle with [my child] to get him to put the t-shirt on the first time.
P5	I was a bit worried that [the LENA DLP] was quite easy to take out of the t-shirt, so I was worried she'd break it or lose it if I took my eye off her.
P6	The second time was a problem. He didn't want to wear it so it really was quite difficult to get him to talk at all with it on. It was quite difficult. So I don't think the second one was as good as it could be.

#### **4.2.1.7. Change in routine because of recording**

Two participants reported changing their routine because of the recording, either for practical or sensitivity reasons. Professionals must discuss the recording day with families ahead of time to ensure it can reasonably fit into their daily routine.

**Table 4.15 Participant quotes regarding the change in routine because of the recording**

<b>Change in routine because of recording</b>	
P4	It changed what we did- because normally we'd go swimming on a Saturday but we didn't because it would be like, two hours of the recorder just sitting in a locker room. So we didn't do that.
P6	We didn't go to my sister-in-law's house because I didn't think it was fair...if they were to be picked up on the recording.

#### 4.2.1.8. Initial changes to parent-child interaction during the recording

Two participants reported feeling pressured to encourage their child to talk as much as possible at the beginning of the first recording day. This desire faded over the course of the day, similar to results from Smyth and Brinkman (2014). However, both participants increased their AWC, CVC and CTC post-intervention, suggesting the intervention was successful despite this potential performance-related increase in talk during the first recordings. Furthermore, as mentioned, an advantage of lengthy recordings in a natural environment as used in LENA is that it is vastly more difficult to sustain this performance-related increase for this length of time compared to 30-60 minute intervention sessions (see 3.5.1.4.).

**Table 4.16 Participant quotes regarding initial changes to parent-child interaction due to awareness of the recording**

Initial changes to parent-child interaction during the initial recording	
P9	I kept trying to get [my child] to talk in the first one so I was asking him loads of questions...after the first half an hour or so I calmed down a bit and then after that I was talking to him normally.
P5	I felt that I was under a bit of pressure to make her perform to begin with, .... to make her speak a lot. At the beginning [my husband] kept saying to me, "stop asking her questions", especially on the first recording... I think it faded because after a while I just go on with it.

#### 4.2.1.9. Reduced awareness of the recorder over time

Twelve participants reported they felt aware of the recorder initially but this reduced reasonably quickly, similar to results from Smyth and Brinkman (2014). Comments suggest that the business of the daily routine (because the recording took place in the home environment) significantly contributed to this.

**Table 4.17 Participant quotes regarding reducing awareness of the recorder over time**

<b>Reducing awareness of the recorder over time</b>	
P3	The day gets busy I just...forgot about it. Maybe you think about it for one minute but then you need to make breakfast and get to school and come home and do the cleaning and you can't sit and think about it all day. I think having it on all day makes you more likely to forget about it.
P11	A little bit but only for a very short time- I said to my husband that it was a bit strange to be recorded like that but after about 10 minutes I completely forgot about it.
P8	I forgot about it pretty quickly when I put it on.

#### **4.2.1.10. Anxiety about LENA results**

Some participants expressed anxiety related to LENA results rather than the recording itself. All these participants expressed a willingness to repeat the intervention in the future, suggesting this anxiety was short-term. The intervention was successful for all 14 participants, which may have influenced their willingness to do it again.

**Table 4.18 Participants quotes regarding anxiety about LENA results**

<b>Anxiety about LENA results</b>	
P1	I was a bit nervous actually, with the second recording, because I was nervous it wouldn't go well and the numbers [adult word count, conversational turn count etc] would go down and that would be quite...embarrassing.
P7	When you were coming over to show me the results, I was a bit nervous the results would be worse than I thought.

#### **4.2.1.11. Reduced confidence in results**

Of the 28 recordings implemented, three had inaccurate graphical results (adult speech displayed as TV/electronic noise). This highlights the importance of professionals obtaining consent to access the audio recording, not only to provide further insight into the participants' day and the amount and type of talk (see 4.2.2.1.) but also to confirm the results produced. The algorithms used are a developing model and LENA has not been validated in many of the languages involved in this study. Nevertheless, LENA can be a useful tool to support parental understanding of child language development. Although it was not possible to pinpoint what caused this inaccuracy, it may have been linked to

interference from the surroundings. Of the three participants affected (P4, P12, P14), only one reported an impact on their confidence in the results.

**Table 4.19 Participant quote regarding reduced confidence in LENA results**

<b>Reduced confidence in LENA results</b>	
P12	The recorder said it was super noisy and we just watched TV all day! So I don't understand that, that's not what happened at all. Yeh, which is kind of annoying because it made me feel...feel less confident about the results.

#### **4.2.1.12. Importance of parental trust in the professional**

Familiarity with and trust in the researcher were cited as factors which influenced the participants' attitudes to the recording, similar to results from Allen and colleagues (2017) and is critical for professionals considering using the technology with families. Two of the three participants who declined the intervention had been on the Early Years caseload for only two months, therefore having less opportunity to build rapport with relevant professionals (including the researcher) than other participants.

**Table 4.20 Participant quotes regarding the importance of trust in the professional**

<b>Importance of trust in the professional</b>	
P1	It's only you listening...and you've seen enough of me and [my child] for there not to be any surprises. I trust you not to judge me.
P4	[It didn't worry me] because I've known you for ages so I'm not that worried about you listening. If it was someone I don't know as well, that might have been different. But I do know you and [my child] knows you.
P10	I know you, as well, so that made a difference- if it was someone I didn't know I probably wouldn't have done it...Because for me, I knew I could trust you- I've known you long enough to know you as a person, as a professional.

#### **4.2.2. Parental understanding following the initial LENA results**

##### **4.2.2.1. Value of listening to audio clips**

Listening to the recording was instrumental in developing participant understanding of a variety of aspects of the intervention, including the difference between different types of LENA speech (see 4.2.2.2.) and the value of language strategies discussed during the intervention.

**Table 4.21 Participant quotes regarding increased understanding by listening to audio clips**

<b>Developing parental understanding by listening to audio clips</b>	
P3	...listening to clips [of the recording] was good to help me understand what we were talking about, to really make it clear to me.
P10	It was important...just to back up what you were saying. For example, that bit about the difference between meaningful and distant speech- to actually hear the difference and what it sounds like to [my child] when someone is talking to her from further away, that's quite helpful.
P4	...if you just have the graphs you can see the main things, like, "oh yes, when [my child] watches TV, he talks less and I talk less", but you can't see the positives can you? Like...you know the bits "when [my child] said this and you responded in this way, did you hear what happened after that?"- those bits you pointed out to me...I think I needed to hear those things to really understand why they were any good.

#### **4.2.2.2. Impact of understanding LENA distant and LENA meaningful speech**

Linked to 4.2.2.1., participants reported that the opportunity to hear the difference in segments identified as having a large proportion of "meaningful" and "distant" speech was helpful. Although the impact of overlapping speech, background noise and distance is explained to parents of CHL by a range of professionals, the opportunity to hear the difference was powerful (and arguably more effective) for these participants.

**Table 4.22 Participant quotes regarding the impact of understanding LENA distant and LENA meaningful speech**

<b>Impact of understanding LENA distant and LENA meaningful speech</b>	
P1	But then when you listen to it and you hear actually how it is when you're next to her and then when you're further away, obviously it's going to be harder for her to learn from it...I'll be talking to her and without thinking I'll wander into the kitchen. But now, I'll stop and go back and finish what I was saying.
P12	When you see it on the graph, and then you can hear the difference between them when you listen back, that's really good

#### **4.2.2.3. Importance of talking**

Some participants reported that their understanding of the importance of adult talk developed through the intervention. Again, although often discussed by Early Interventionists, LENA was instrumental in establishing participants

understanding of the link between exposure to talk and child language development.

**Table 4.23 Participant quotes regarding change in their understanding of the importance of talking**

<b>Developing parental understanding of the importance of talking</b>	
P6	I didn't really know [before] how important it is to talk.
P14	I think overall, it's made me really understand how important talking is and how much talking I actually do. And also, actually, that it's not that hard to talk more, once you know how.
P13	I suppose I hadn't really realised before how important that is. How important it is that children are listening to lots of talking and are chatting.

#### **4.2.2.4. Importance of interactive conversation**

Some participants commented on developing an understanding of the importance of conversation and how this differed from exposure to adult talk. The graphical representations of AWC and CTC separately were influential in increasing understanding in this area.

**Table 4.24 Participant quotes regarding change in the understanding of the importance of conversation**

<b>Developing parental understanding of the importance of interactive conversation</b>	
P7	I didn't realise how important conversation was and the difference that can make. So I was making a mistake and just talking all the time but I never really gave him time to respond.
P9	It's about the adult and the child talking together, not just the adult talking all the time.
P4	Like, the thing about the difference between exposing him to adult talk and actual conversation. I hadn't really thought about that before until I saw it [on the graph]. So now I'm trying to include him in conversation more.

#### **4.2.2.5. Amount of talk: perception versus reality**

Numerical and graphical results were instrumental in supporting some participants to appreciate the difference between their perception of the amount of adult talk used and the reality (see 4.2.4.7.). Intervention was successful in increasing the AWC, CVC and CTC, suggesting increasing participant awareness of the amount of talk was useful.

**Table 4.25 Participant quotes regarding the difference between their perception of the amount of talk undertaken in a typical day compared to reality**

<b>Perception .v. reality regarding amount of talk</b>	
P6	I thought I was talking to him a lot and I wasn't really.
P14	When I saw he was in the one percent for talking I was shocked and sad... I didn't know that [my child] was talking really quite little for his age before but now I do...I think overall, it's made me really understand...how much talking I actually do.
P2	I was so pleased with myself because I've been taking her to those groups at the children's centre. But I hadn't realised that actually I was hardly talking or playing with her while I was there. I was shocked, you know, because I was going to all that effort to take her there but actually it was pretty meaningless for her. When I saw that on the graph, I was...yeh I was shocked.

### **4.2.3. Practicalities/logistics of the intervention**

#### **4.2.3.1. Ease of use/acceptability of equipment**

Most participants found the equipment easy to use. Some reported that their children were initially interested in exploring the DLP, necessitating the use of parental distraction techniques, but this reduced over time. One participant reported their child was happy to have a “special” piece of technology. Only one participant had a practical issue with the DLP, in that she did not activate the recording after turning it on.

**Table 4.26 Participant quotes regarding ease and acceptability of the equipment**

<b>Ease of use and acceptability of equipment</b>	
P13	[My child] seemed to like explaining it to his brothers and showing them he had something special. So I think he was aware of it but not in a bad way, more in a...proud way.
P7	Yeh, looks good, looks small, almost like a mobile phone isn't it? And you just tuck it into the t-shirt so you don't really notice it. And the t-shirt just looks like a normal t-shirt so no one even knows he's wearing it really.
P11	I thought [it would be easy] but then it didn't actually record the first time...I should have remembered or read the instructions- I forgot you have to press down and hold the button to record.

#### **4.2.3.2. “Ideal” length of time between recordings**

Many participants reported that the time between the two recordings was quite short. From a research perspective, this was necessary to identify any

therapeutic benefit. Clinically it could be advantageous to implement the intervention over a more extended period (giving participants' opportunities to trial the recommendations in different environments) or to split the intervention into two separate blocks (one focusing on increasing the amount of talk and one on qualitative language strategies). Despite the relatively short time between recordings, there was still a clinically significant improvement in results.

**Table 4.27 Participant quotes regarding their “ideal” length of time between recordings**

<b>“Ideal” length between recordings</b>	
P5	This was quite close, wasn't it? Not much time between each. So maybe slightly longer. Maybe about three months or four months between them
P12	But for me maybe with a bit more time between them, because I felt this was a bit, um, rushed, a little bit. I'd like a bit more time next time. Maybe every five or six months or something.
P10	I think I would have liked a bit longer between recordings, I think it might have shown more of a difference. Maybe [every] four months?

#### **4.2.4. Benefits of LENA-based intervention**

##### **4.2.4.1. Bespoke intervention tailored to the family routine**

For most, a significant advantage of the intervention was its specific nature, tailored to the individual family's daily routine; strategies were deemed more functional and therefore easier to implement. This is valuable for all parents but particularly those who feel additional stress or anxiety about parenting a deaf child (as reported by two participants). LENA is therefore a unique therapeutic tool to produce personalised, family-centred therapy. However, arguable, for this, professionals require full access to the recording.

**Table 4.28 Participant quotes regarding the bespoke nature of the intervention, tailored to the family routine**

<b>Bespoke nature of the intervention</b>	
P5	...functional recommendations are a huge bonus, it makes it much easier for us to use in real life- and because of that, we do it more.
P6	I'm more likely to be able to [use these strategies compared to other interventions]. Because I can do this stuff as part of my normal day- not having to do something different.
P7	I've really liked how it is really personal to me.
P8	You...are really making an effort to find out what's normal for me, what's a typical day and how am I interacting with [my child] on a normal day. And then the suggestions you make after that are more personal to me. Not just stuff that professionals say to everyone. It's actually about what I can do in my day to make a difference. I really liked that.

#### **4.2.4.2. Change in participants perception of their role in intervention**

Because of the intervention, some participants reported feeling less reliant on professionals and having a better understanding of the critical role parents play in supporting their deaf child. This suggests increased parental understanding of the collaborative nature of EI.

**Table 4.29 Participant quotes regarding the change in the participants' perceptions of their role in the intervention**

<b>Parent perception of their role in intervention</b>	
P14	I feel a bit more that I know what I'm doing and that I can help him to make progress, I don't have to rely on you to do it.
P9	I think I see now that it doesn't have to be so fancy. I don't need to get special toys or this or that. Actually I can help him myself just by doing little things, you know. I suppose I feel less that I need to let everyone else make my son strong. I can help too.
P6	I think now I can see what I can do to help him every day and that it's important that I do. And that because I'm there with him everyday I'm probably the only person who can do that stuff with him.

#### **4.2.4.3. Parental confidence in supporting speech and language development post-intervention**

Nine participants reported an increase in their knowledge and confidence (i.e. MSE) in helping their child's speech and language development. For some, this was related to the bespoke nature of the intervention (see 4.2.4.1.); for others, it

was related to understanding what they were already doing to help and how to do it more often.

**Table 4.30 Participant quotes regarding parental confidence in supporting their child’s speech and language development following the intervention**

<b>Parental confidence in supporting speech and language development post-intervention</b>	
P11	I think I learnt a lot from it, particularly about what to do for [my child] specifically, not just children in general, to help him with his language...I know what I’m doing and what I should be doing.
P7	[I feel] like I’m a better mother. I know now what I was doing before that was good and I’m trying to do more of it...But for the parent, it can make you feel better about what you’re doing and help you feel more confident. And then I guess a more confident parent is better for the child too.
P6	I understand a bit more how well he’s doing...I have a better idea about what I can do to help [my child]. I feel better about it- I know how to help him more.

#### **4.2.4.4. Reduction in parental feelings of guilt post-intervention**

As a result of being able to combine language-promoting techniques into their daily routine, some participants commented on feeling “less guilty” compared to having to find time in their busy schedules to dedicate to therapy activities.

**Table 4.31 Participant quotes regarding reduced feelings of guilt post-intervention**

<b>Reduced feelings of guilt post-intervention</b>	
P3	It [using strategies developed from LENA involving the daily routine] can make you feel less guilty when you don’t have time to do a particular game or something with your child everyday.
P2	[Now] I don’t have to lie in bed at night thinking like I’ve failed [my child] because I haven’t spent an hour doing one to one activities with her.
P8	So before, um, I’d feel bad if I didn’t do a therapy activity one day with [my child] but actually there’s lots of opportunities during the day so it’s more...I don’t know, realistic

#### **4.2.4.5. Comparison to other therapy approaches**

Participants were overwhelmingly positive when comparing LENA to other therapeutic approaches. A significant benefit was the subtler recording equipment, used in the home, producing more natural recordings than approaches involving video-recordings. Some participants felt that LENA

intervention resulted in more “realistic” recommendations than more traditional, play-based therapies, which fostered confidence and positivity (see 4.2.4.4).

**Table 4.32 Participant quotes regarding comparisons between LENA intervention and other therapy approaches**

<b>Comparison to other therapy approaches</b>	
P2	I've found it far more realistic...You know, when everyone expects you to just spend every minute with your one child, and I've got three others to also think of and they all want me and everything...it's been the first time I feel a professional has taken that on board.
P13	For me this one was better because [my child] was more relaxed and we didn't talk only about play.... It's easier to forget about this one, isn't it? Because you just carry on with all the things you have to do and it goes out of your mind. But when someone is holding an iPad in your face, it's impossible to forget about it. And then because it's on all day it's get all the bits of the day that you don't capture on an iPad recording.
P14	I found it easier to do this one I think. Because it's at home, to start with, so that's easier. And it's more about what happens in the real life for me and [my child], which means then the things we [discussed] are easier for me to do.

#### **4.2.4.6. Unexpected outcomes of intervention**

For two participants, an unexpected result of the intervention was an increase in their child's HA use. Motivation for this came from listening to large quantities of their child's speech out of context through the recording, highlighting the impact of the HL on speech intelligibility. For another participant, discussions around behaviour management were a positive outcome of the intervention.

**Table 4.33 Participant quotes regarding unexpected outcomes of the intervention**

<b>Unexpected outcomes of the intervention</b>	
P13	Well it was when [nursery key worker] listened to the recording and she said that sometimes she couldn't understand [my child] when he was speaking. That made me think that maybe it is important he uses the hearing aids. Because if other people find it difficult to understand him maybe his speech isn't so clear.
P8	Actually it was quite powerful listening back, as I think that helped me understand just how...unclear his speech is. [That made me feel] really sad, I suppose- but it worked because it gave me the motivation to make sure his hearing aids are on all the time, didn't it!
P1	I had thought we were only going to be talking about her talking. But actually when we were going through it and we kept coming back to behaviour and the stuff you suggested was actually really helpful...

#### 4.2.4.7. The value of graphical/numerical feedback

For nearly all the participants, a significant advantage of LENA was the graphical and numerical feedback. This reportedly helped develop their understanding of the amount of language being used overall, times of the day they talked more or less, how they talked or interacted with their child and how this compares to other families of children the same age.

**Table 4.34 Participant quotes regarding the value of graphical and numerical feedback from LENA**

<b>The value of graphical/numerical feedback</b>	
P7	I feel like having a number and a graph, that helped me to really understand...The graph, you know, that really showed it clearly times we were talking more and times we were talking less. And that helped us then to [focus] more about the times we needed to work on, because it was really clear from the graph.
P5	It's very visual which really appealed to us both...it's a very...measurable way of looking at it. You really know where you stand.
P9	I think seeing it like that on a screen is quite powerful...The numbers were quite useful as well... It helped me to understand what we should be aiming for.

#### 4.2.4.8. Ease of increasing the amount of talk versus changing the quality of talk

Nearly all the participants felt it was easier to act on strategies related to increasing the amount of talk compared to the quality of language. In part, this was because the graphical/numerical feedback produced by LENA regarding the quantitative language environment was easier to understand and utilise and because strategies related to the amount of talk were applicable throughout the day.

**Table 4.35 Participant quotes regarding the ease of increasing the amount of talk compared to changing the quality of talk**

<b>Strategies related to graphical feedback .v. bespoke language strategies</b>	
P12	I thought it was quite a lot easier to remember the things that were related to the graphs. More than the things that were about the way we are speaking.
P11	It's easy to remember two things; talk more generally and talk more with [my child]. The other things, like the "talking ahead" and "leaving gaps" and stuff, that stuff is harder...I think I am doing it but I really have to remind myself- maybe it's because I still need more practice before I can do that on my own without thinking about it?
P5	The language types [strategies] are more tricky to remember. Not to remember but...to know when to use them. But the ones more related to the <i>amount</i> of talk, they are a bit easier for me.

## 4.2.5. Importance of the parent-professional dialogue

### 4.2.5.1. Benefits of face-to-face feedback

Eleven participants commented on the value of receiving face-to-face feedback from the researcher in supporting them to understand the results. Discussing the results together gave both parties the opportunity to reflect, feedback and share ideas.

**Table 4.36 Participant quotes regarding the benefits of face-to-face feedback**

<b>Benefits of face-to-face feedback</b>	
P10	For me, that opportunity to talk it through, that was really important... you need someone to explain it properly, and to be asked those questions that make you think about what you were doing in that particular snippet... a written report would be good as a summary [but] it's not the same as you sitting in front of me and demonstrating the strategies and talking to me about all the different times of day I can use those strategies to talk more and to talk more with [my child] to support her development.
P9	I think it's probably quite important to talk about [the results] together. [Because] how would I know what it meant, whether that was good or bad or normal...I don't think I'd know. But because we spoke about it you and explained it, it actually became quite a big thing for me.
P5	We definitely thought the feedback session was vital because it meant we really understood what we were seeing. [A screenshot or written report] would have basically been meaningless without that conversation...The feedback session is really important I think. I don't think we would have got so much from it if we hadn't had that.

#### 4.2.5.2. The value of modelling sessions

Most participants felt they benefited from the follow-up sessions (during which the researcher modelled specific language strategies). One participant suggested a “record-feedback-review” approach would have been suitable (see 4.2.5.5.).

**Table 4.37 Participant quotes regarding the value of the modelling sessions**

The value of modelling sessions (focusing on language strategies)	
P9	In the home visits after, you showed me how to do all the things we discussed, in real life. That's quite important for me, because I find it so much easier to do after I've actually seen it.
P8	I think the changes have probably, erm, come from talking about it and you showing me when and how to use the different strategies. Not just looking at the graph. Because it's not just a case of saying “talk more” or “talk less”, “talk nearer”, “leave a gap” is it, but actually <i>how</i> to do it, I think... The difference is actually seeing it, in real life, you know, rather than someone just saying, “go and do this”.
P13	I think, for me, it would have been better without the visits after the recording maybe. If I did the first recording and we just talked about the results and then waited a bit and did another recording. Because really I didn't think I needed the visits after that.

#### 4.2.5.4. Participant perception of “too much” adult talk

Some participants reported feeling that by increasing the AWC, they were subsequently reducing opportunities for child vocalisations. The balance between increasing the AWC and CTC will depend on the individual child's language level and characteristics, which must be flagged within the intervention.

**Table 4.38 Participant quotes regarding the perception of “too much” adult talk**

Perception of too “much” adult talk	
P11	The only problem now is that because so many people are trying to remember to talk to him more, I worry sometimes that he talks less because of it.
P7	It's quite difficult, isn't it- giving him lots of talk to listen to but also giving him time to speak. I'm not sure I've got it yet.
P9	I think the hardest thing has been finding a balance between not talking too much but still talking enough.

#### 4.2.5.5. Suggestions for improvements

By providing opportunities for participants to discuss and share ideas with the researcher, they could give suggestions for changes and improvements to the intervention process, so improving the experiences of families in the future.

**Table 4.39 Participant quotes regarding improvements to the intervention**

<b>Suggestions for improvements to intervention</b>	
P12	I would have liked to first work on how much we are speaking and to concentrate on that. And then later to work on how we are speaking. Almost like two separate blocks?
P11	Maybe it would be good to get a written report with the feedback from the recording so that we could look at it and show other people.
P5	But I wonder if maybe some people would only want the recording and the feedback, not the follow up sessions. Or maybe vice versa. So maybe having those options would be good.

## **5. Discussion**

This study aimed to investigate the use of LENA to influence the quantitative language environment and the impact of this intervention on MSE and PI. Key points identified from the quantitative and qualitative results will be summarised below. The first section will explore the use of LENA as an intervention tool to promote change in the family's environment. The second will examine the impact of the intervention on MSE and PI. The third will discuss areas to consider when using LENA to support language counselling and coaching. The fourth will investigate some of the practicalities to be considered by professionals. The final section will discuss some of the limitations of the study and next steps.

### **5.1. Language environments of children with a hearing loss**

#### **5.1.1. Using LENA to change the quantitative language environment**

The quantity of adult talk and adult-child interactions in the environment is a significant predictor of child language outcomes (Ambrose et al, 2016; Hurtado et al, 2008; Hart & Risley, 1995). This study demonstrates that not only does LENA allow researchers and clinicians access into the natural language environments of the children with whom they work, intervention involving LENA is effective in promoting change in the language environment of CHL from a variety of cultural and linguistic backgrounds. Post-intervention, participants produced an average of over 7000 additional adult words; some individuals increased their AWC by tens of thousands of words compared to their pre-intervention recording. CTC increased by hundreds of turns for most participants. Should these results be sustained over time, the children of the participants in this study will receive on average approximately 700 additional hours of language input a year from caregivers- a clinically significant amount. More talkative parents have children with better language levels (Walker et al, 1994). Language levels are associated with academic outcomes (Johnson, Beichtman & Brownlie, 2010), emotional well-being and behaviour (Bryan, Freer & Furlong, 2007) and employability (Elliott, 2011). Using LENA as an

intervention tool therefore has the potential to improve child outcomes significantly.

Thirteen participants were from low SES backgrounds. Parents from low SES backgrounds are known to produce significantly less adult talk than those from other backgrounds (Hart & Risley, 1995); the results may be different had the participants been from more of a mixed demographic. Regardless, all 14 families were able to significantly improve their language environments, demonstrating the potential power of the LENA system. The families involved in the LENA Natural Language Study (Gilkerson & Richards, 2017; 2008) that produced the LENA norms were from a range of SES backgrounds; consequently, comparison of the participants' results from this study to the norm remains valid.

### **5.1.2. Numerical feedback produced by LENA**

The numerical and graphical feedback produced by LENA was instrumental in developing parental understanding of their child's language environment (see 4.2.4.7.). For some, being able to compare their results to the norm (i.e. normally-hearing English speaking children) was instrumental.

AWC, CVC and CTC can be expressed by the raw value (or projected value for a 12-hour recording period) or percentile rank (see 4.1.2.). Although comparison to the norm is important to provide context to the results, it is essential that parents recognise and celebrate their achievements and improvements, particularly where clinicians are working to empower families and develop confidence in their knowledge and skills. On all but one occasion, participants whose results equalled the first percentile in the initial recording improved their percentile rank at the second recording. However, some participants who had a high percentile rank at the initial recording were able to produce significantly more adult words/conversational turns in the second recording but could not "improve" the percentile rank (e.g. P11- 99<sup>th</sup> percentile for CTC before intervention). If feedback following intervention focuses only on the change to the percentile rank, the discussion is not reflective nor celebrative of the change

that has occurred. P13, whose post-intervention AWC score remained in the first percentile, produced over 4000 additional adult words compared to the first recording day. Although this remains low for the child's chronological age, the change is significant but would be missed in a discussion that focuses only on percentile rank. Clinicians must discuss a family's results relative to their initial recording, as well as in the context of comparison to the norm. In this study, discussions with participants included reference to the raw values, percentile ranks and percentage change, giving participants a full understanding of their results.

## **5.2. Maternal Self-Efficacy and Parental Involvement**

### **5.2.1. Using quantitative linguistic feedback to improve MSE and PI**

All participants identified a change in their MSE levels following the intervention process. Questionnaires completed by professionals also recognised an improvement, although to a lesser extent than the participants. However, parent ratings hold more weight in the assessment of MSE as they are commenting on their own levels of self-efficacy; professionals are only able to report on their perceptions (DesJardin, 2004). Regardless, that professionals were able to identify a change in MSE is encouraging.

In their interviews, participants referred to changes in their confidence levels associated with better understanding of and belief in their ability to provide a supportive language environment for their children within their daily routine (see 4.2.4.3.). Knowledge and confidence are key components of self-efficacy beliefs (Hoover-Dempsey et al, 2005); these comments support the quantitative results highlighting greater MSE as a result of the intervention. Although DesJardin (2006) emphasises the importance of a "mentorship approach" (p291) to support the development of MSE, there have been few other specific suggestions of interventions that have been shown to improve MSE for parents of CHL. LENA-based intervention may be one such possibility.

Despite all participants showing a change in MSE, only four improved their involvement rating from pre- to post-intervention. However, qualitative results

indicate that many participants did experience a change in their involvement levels as a result of the intervention, regardless of their rating. Participants reported feeling less reliant on professionals to promote change and more able to influence their child themselves post-intervention (see 4.2.4.2.). Better parent understanding of the valuable role they play in their child's intervention and belief in their ability to contribute to their child's development has been shown to lead to greater engagement in intervention and subsequently lead to better child outcomes (Ingber, 2004).

### **5.3. Therapeutic considerations**

#### **5.3.1. Re-thinking language intervention: quantity before quality**

Although EIPs explain the importance of parents spending time talking to and interacting with their CHL, EI frequently focuses on the child's qualitative language environment. One reason for this is because research has long since identified differences in the qualitative language environment for CHL compared to CNH (e.g. Moeller & Schick, 2006), highlighting the importance of work targeting this area. Secondly, historically, before the invention of LENA, professionals were limited in their ability to gain an understanding of a child's natural quantitative language environment outside of intervention sessions. Attempts to elicit this information through discussion with or observation of parents could lead to the professional developing an inaccurate impression of the amount of language used during the daily routine. This could be due to the Hawthorne Effect (see 3.5.1.4.), meaning parents "perform" under the knowledge of being observed, or because the parent has an inaccurate, preconceived idea about how much language they use around their child.

LENA makes it possible for clinicians and parents to obtain information about a child's real-life natural language environment quickly and easily, meaning intervention targeting the quantity of adult language is more realistic and measurable. Given the research to show the influence of the quantity of adult language on child language (e.g. Hoff & Naigles, 2002; Hart & Risley, 1995; Walker et al, 1994), the results from this study serve as a reminder to clinicians

to reconsider the intervention trajectory; namely, to ensure there is a language environment rich in quantity before beginning to focus on quality. In this study, even participants who were providing their children with a relatively language-rich environment pre-intervention made significant improvements post-intervention. A focus on quantity is also important given comments from participants regarding how much easier it was to increase the amount of talk during the day compared to changing the quality of type of talk they used (see 4.2.4.8). Consequently, intervention targeting quantity is more likely to provide families with an early sense of success, thus building PSE, responsiveness and ultimately PI. Quantitative feedback was deemed more pertinent and functional for parents and formed the springboard from which they could begin to understand and make changes to the language environment.

EI programs highlight the importance of embedding language techniques into naturally occurring interactions with children through daily routines and activities (Fewell & Deutscher, 2004; Roper & Dunst, 2003; Dunst, 2000). Professionals working with families of CHL often try to demonstrate how to embed facilitative language techniques into everyday occurrences such as mealtimes and bedtimes routines (Woods, Kashinath & Goldstein, 2004). However, they often have to resort to simulating them in unnatural environments or request access to the daily routine as an observer, which may be neither practical or comfortable for the family, nor representative of “normal”. LENA gives EIPs access to these routine situations without the effects of observation, giving them an opportunity to ensure their suggestions can be fully integrated into the family’s normal life. This was recognised by participants as being critical to the success of the intervention (see 4.2.4.1.).

### **5.3.2. Targeting “speaking tactics”**

Eight participants increased the proportion of meaningful speech used during the recording day following intervention. Some participants highlighted a benefit of LENA intervention as the opportunity to hear the difference between “meaningful” and “distant” speech by listening back to the recording (see 4.2.2.1., 4.2.2.2.). An important component of the intervention is time spent

discussing “speaking tactics” (including practical strategies to reduce the distance between the adult and child and avoiding instances of vocal clashes) to ensure the language parents produce is accessible for the child. These strategies are important for all children but are vital for CHL who often have inconsistent or degraded access to speech and language (VanDam et al, 2012). Learning from and engaging in talk at a distance or where there are conflicting sources of sound will be considerably more difficult for these children. Furthermore, arguably CHL will find it more challenging engaging in conversations with an adult whose speech is perceived as “distant” to the child and are therefore more likely to disengage, meaning they have less opportunity to reap the benefits of adult-child conversation highlighted in the literature (Zimmerman et al, 2009).

### **5.3.3. Using LENA to illustrate discussions with parents**

The visual and quantitative results produced by LENA were instrumental in supporting parental understanding of factors that had been previously discussed by a variety of professionals (see 4.2.2.). Hearing or seeing the impact was more effective than simply “being told”. Using LENA with families relatively early following diagnosis may be useful in supporting parents to understand these areas as quickly as possible. Should participants not be comfortable using LENA, professionals need to consider other methods of communicating this message (e.g. sharing recordings from other families with their consent), although arguably, a significant factor in the success of the intervention was that each participant was able to relate the discussion to their own experiences and recording.

## **5.4. Practicalities: Promoting acceptability of the system**

Of the 22 parents approached to take part in this study, two refused outright. Three declined to use LENA due to concerns about being recorded but consented to involvement through the questionnaires and interview. A further two dropped-out due to difficulties convincing their children to wear the

equipment. Of the 15 participants who used the device, only one found it a negative experience and requested that the recording was deleted. Fourteen participants completed the intervention. Allen and colleagues (2017) had a similar response; three out of the four participants approached found the device to be acceptable. In a Canadian study, two out of seven families ultimately dropped-out, although this was reportedly due to issues around the timing of the recordings rather than the recordings themselves (Charron, Fitzpatrick et al, 2016). Of the five participants approached by Mulla (2011), four found LENA to be acceptable. Overall in these studies there is a participation rate of 70-80%. There are few references about drop-out rates in other LENA research, however, overall parents are more willing to use it than not. The qualitative results from this study show that the participants initial concerns about being recorded were largely unfounded and any anxiety or awareness faded quickly, similar to results from other studies (Allen et al, 2017; Smyth & Brinkman, 2014). Ultimately, participants who completed the intervention deemed it helpful and were mostly positive about the experience. This is critical given concerns from sceptical professionals who have reservations about introducing the system to families on their caseloads. However the equipment must be used sensitively. Given that in this study, two of the three participants who declined to use LENA were new to the EI caseload, it should perhaps only be introduced after the family has had time to build rapport and trust with the professional. This is a bespoke process which will vary from family to family, professional to professional. In both this study and Allen and colleagues' (2017), trust in the professional was highlighted as being imperative to the success of the intervention. This is particularly important when the professional is requesting to listen to the recording to provide qualitative information about the listening environment and the daily routine, as in this study.

Charron and colleagues (2016) found that all five children included in their study either always or occasionally reacted negatively to wearing the LENA t-shirt. One participant was ultimately excluded from Mulla's (2011) study as the child would not tolerate the LENA t-shirt provided. In this study two participants dropped-out of the intervention as they were unable to get their children to wear

the LENA t-shirt; other participants reported this was an initial concern, although it was ultimately unfounded. This could present a barrier to its use with young children. Where resources allow, families should be given the t-shirt in advance, giving the child the opportunity to become familiar with the t-shirt before the recording day.

One participant reported that a significant factor in her decision to proceed with the intervention was a report from another mother. Parent-to-parent support is a major influence of family, parent and child well-being (Henderson, Johnson & Moodie, 2014) and has the power to alter parent attitudes to intervention, as seen in this research. Opportunities to discuss personal experiences with LENA through playgroups, coffee mornings, discussion sessions, etc could be important for increasing reluctant parents' confidence in the system and understanding of the advantages it brings.

## **5.5. Limitations and next steps**

The Involvement Rating Scale (Moeller, 2000) was less sensitive to change than the MSE component of the SPISE. Although there were justified reasons for choosing not to use the Involvement component of the SPISE (see 3.5.3.), with hindsight, it may have been a more appropriate and valid measure of PI. Although self-report measures are not without criticism, particularly regarding the reliability of the responses given, a self-report involvement measure targeted to parents of CHL may have produced more insight into the participants' views regarding their involvement in the intervention rather than relying on professionals' impressions alone.

LENA has since been validated in several tonal and non-tonal languages including Spanish (Weisleder & Fernald, 2013), French (Canault, Le Normand et al, 2015), Mandarin (Gilkerson, Zhang et al, 2015), Korean (Pae, Yoon et al, 2016), Dutch (Berends, 2015) and Vietnamese (Ganek & Eriks-Brophy, 2017). It has not been validated in many of the languages used by participants in this study, potentially raising questions about the reliability of the results produced. The algorithms used by LENA to identify the AWC, CWC and CTC were

developed and normed on a database of speech samples collected from American-English families (Xu et al, 2008). However, it is suggested that an automated, algorithm-driven system using American-English phonological models should be able to be applied to language environments of children from a variety of geographical, cultural and linguistic backgrounds (Gilkerson et al, 2015). This is because LENA measures are derived from segmentation of the audio stream by identifying “who spoke when”, rather than recognising individual words. Consequently, the system is not necessarily language dependent and is in principle applicable across languages and cultures (Gilkerson et al, 2015). Secondly, as mentioned previously, recordings of at least 12 hours were requested, as errors are deemed less likely to be significant in a more substantial data set (Warren et al, 2010). Finally, this study involved a within-subject design; each family was measured twice using LENA. The results of the second recording were compared to the first, rather than to another family or group. Any irregularities in the coding of the audio stream as a result of the language used would be present in both recordings, therefore minimising the impact of this variable.

Of the 22 families approached, only 14 ultimately took part in the duration of the study. A larger cohort would provide more reliability from a research perspective. However, a smaller number of participants was required to provide high quality, effective intervention in the time-frame provided and was appropriate for a study of this type involving mixed methods comparative case studies. Furthermore, it is not clear whether the changes in the language environment or the improved MSE levels will be sustained over time. Further investigation and follow-up is required.

Finally, as part of the study, the six participants who declined to use LENA or dropped-out part way through the process (either related to difficulties with the equipment or discomfort with the recording process) were also interviewed to investigate their views and opinions regarding LENA. Although a full analysis of these transcripts was beyond the scope of this study, further investigation and examination of their comments would provide professionals with insight into the barriers that exist for families regarding this equipment.

## 6. Conclusion

This study has shown that LENA is an effective intervention tool that can be used by clinicians to promote a positive change in the quantitative language environment for CHL and their families. In this study, parents of CHL from a variety of cultural and linguistic backgrounds were able to increase the quantitative language environment surrounding their child, often by significant amounts. Parents themselves were able to recognise and appreciate the significance of this change and improved MSE levels were identified in both the quantitative and qualitative results. Although professional observations of PI using Moeller's (2000) Involvement Rating Scale suggested less change in this variable, participants were able to identify a change in their perception of their role in EI and reduced dependency on outside professionals, suggesting their understanding of the collaborative nature of intervention has developed. Given the research demonstrating the link between PI and MSE, it is possible that this improvement in MSE levels could lead to more active involvement in intervention in the future, although it remains to be seen whether the improved language environment and MSE levels are sustained over time.

There is a huge body of evidence supporting the need for EIPs to target the quality of adult language and adult-child interactions for CHL; a number of intervention approaches have been developed for this purpose. However, LENA gives professionals the tools required to focus on and reliably measure the quantity of adult language and interactions that occur daily in the child's natural language environment. Only after the presence of language in the child's environment has been established and confirmed can the quality of language become the focus of intervention.

From a reflexivity perspective, following this process, this researcher can sympathise with professionals who may have anxieties about introducing LENA to the families with whom they work. The parent-professional relationship is delicate and must be handled with the utmost of care. This researcher was hugely sceptical about using LENA with families on her caseload. However, the results of this study have been surprising and have led to the researcher re-evaluating her preconceived notions about the families on her caseload

generally, their understanding and grasp of therapeutic concepts targeted previously and what is effective in promoting change. As a result of this study, LENA will now be introduced as soon as families are deemed ready and will be used as the foundation on which intervention can work to improve both the quantitative and qualitative language environments for these children.

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# Appendices

## Appendix A: Ethical Approval Documents



SOCIAL SCIENCES, ARTS AND HUMANITIES ECDA

### ETHICS APPROVAL NOTIFICATION

**TO** Abi Ma'ayan  
**CC** Dr Imran Mulla  
**FROM** Dr Timothy H Parke, Social Sciences, Arts and Humanities ECDA Vice  
Chairman  
**DATE** 13/10/17

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Protocol number: EDU/PGT/CP/03276

Title of study: An investigation into the use of quantitative linguistic feedback with parents of preschool children with a hearing loss

Your application for ethics approval has been accepted and approved by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

This approval is valid:

From: 13/10/17

To: 01/01/18

Additional workers: no additional workers named

**Please note:**

**If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and your completed consent paperwork to this ECDA once your study is complete. You are also required to complete and submit an EC7 Protocol Monitoring Form if you are a member of staff.**

Approval applies specifically to the research study/methodology and timings as detailed in your Form EC1A. Should you amend any aspect of your research, or wish to apply for an extension to your study, you will need your supervisor's approval (if you are a student) and must complete and submit form EC2. In cases where the amendments to the original study are deemed to be substantial, a new Form EC1A may need to be completed prior to the study being undertaken.

Should adverse circumstances arise during this study such as physical reaction/harm, mental/emotional harm, intrusion of privacy or breach of confidentiality this must be reported to the approving Committee immediately. Failure to report adverse circumstance/s would be considered misconduct.

Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Students must include this Approval Notification with their submission.

EDU/PGT/CP/03276 UNIVERSITY OF HERTFORDSHIRE  
ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS  
(‘ETHICS COMMITTEE’)  
FORM EC4  
CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS  
FOR USE WHERE THE PROPOSED PARTICIPANTS ARE MINORS, OR ARE OTHERWISE  
UNABLE TO GIVE INFORMED CONSENT ON THEIR OWN BEHALF

I, the undersigned *[please give your name here, in BLOCK CAPITALS]*

.....

of *[please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

.....

hereby freely give approval for *[please give name of participant here, in BLOCK CAPITALS]*

.....

to take part in the study entitled *[insert name of study here]*

An investigation into the use of quantitative linguistic feedback with parents of preschool children with a hearing loss

(UH Protocol number EDU/PGT/CP/03276)

**1** I confirm that I have been given a Participant Information Sheet (a copy of which is attached to this form) giving particulars of the study, including its aim(s), methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, how the information collected will be stored and for how long, and any plans for follow-up studies that might involve further approaches to participants. I have also been informed of how my personal information on this form will be stored and for how long. I have been given details of his/her involvement in the study. I have been told that in the event of any significant change to the aim(s) or design of the study I will be informed, and asked to renew my consent for him/her to participate in it.

**2** I have been assured that consent to access to my child’s data may be withdrawn at any time without disadvantage to him/her or to myself, or having to give a reason.

**3** In giving my consent to participate in this study, I understand that my child’s data will be accessed.

**4** I have been told how my child’s data will be handled: how it will be kept secure, who will have access to it, and how it will or may be used.

**5** I understand that in the event that his/her participation in this study may reveal findings that could indicate that he/she might require medical advice, I will be informed and advised to consult his/her GP. If, during the study, evidence comes to light that he/she may have a pre-existing medical condition that may put others at risk, I understand that the University

will refer him/her to the appropriate authorities and that he/she will not be allowed to take any further part in the study.

**6** I understand that if there is any revelation of unlawful activity or any indication of non-medical circumstances that would or has put others at risk, the University may refer the matter to the appropriate authorities.

**7** I have been told that I may at some time in the future be contacted again in connection with this or another study.

**8** I declare that I am an appropriate person to give consent on his/her behalf, and that I am aware of my responsibility for protecting his/her interests.

Signature of person giving consent

.....Date.....

Relationship to participant

.....

Signature of (principal) investigator



.....Date.....

Name of (principal) investigator [in BLOCK CAPITALS please] ABI MA'AYAN

**UNIVERSITY OF HERTFORDSHIRE**

**ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS**

**(‘ETHICS COMMITTEE’)**

**FORM EC3**

**CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS**

I, the undersigned *[please give your name here, in BLOCK CAPITALS]*

.....  
*of [please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

.....  
hereby freely agree to take part in the study entitled *[insert name of study here]*

An investigation into the use of quantitative linguistic feedback with parents of preschool children with a hearing loss

(UH Protocol number EDU/PGT/CP/03276)

**1** I confirm that I have been given a Participant Information Sheet (a copy of which is attached to this form) giving particulars of the study, including its aim(s), methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, how the information collected will be stored and for how long, and any plans for follow-up studies that might involve further approaches to participants. I have also been informed of how my personal information on this form will be stored and for how long. I have been given details of my involvement in the study. I have been told that in the event of any significant change to the aim(s) or design of the study I will be informed, and asked to renew my consent to participate in it.

**2** I have been assured that I may withdraw my consent for access to the data at any time without disadvantage or having to give a reason.

**3** In giving my consent to participate in this study, I understand that my data will be accessed and I have been informed of how/whether this data will be transmitted/displayed.

**4** I have been told how information relating to me (data obtained in the course of the study, and data provided by me about myself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used.

**5** I understand that my participation in this study may reveal findings that could indicate that I might require medical advice. In that event, I will be informed and advised to consult my GP. If, during the study, evidence comes to light that I may have a pre-existing medical condition that may put others at risk, I understand that the University will refer me to the appropriate authorities and that I will not be allowed to take any further part in the study.

**6** I understand that if there is any revelation of unlawful activity or any indication of non-medical circumstances that would or has put others at risk, the University may refer the matter to the appropriate authorities.

7 I have been told that I may at some time in the future be contacted again in connection with this or another study.

Signature of participant.....Date.....

Signature of (principal) investigator  Date

Name of (principal) investigator *[in BLOCK CAPITALS please]*

ABI MA'AYAN

**UNIVERSITY OF HERTFORDSHIRE**

**ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS  
(‘ETHICS COMMITTEE’)**

**FORM EC6: PARTICIPANT INFORMATION SHEET**

**1 Title of study**

An investigation into the use of quantitative linguistic feedback with parents of preschool children with a hearing loss

**2 Introduction**

You are being invited to take part in a study that involves access to your child’s data. Before you decide whether to do so, it is important that you understand the study that is being undertaken and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask us anything that is not clear or for any further information you would like to help you make your decision. Please do take your time to decide whether or not you wish to take part. The University’s regulations governing the conduct of studies involving human participants can be accessed via this link:

<http://sitem.herts.ac.uk/secreg/upr/RE01.htm>

Thank you for reading this.

**3 What is the purpose of this study?**

Analysis of your child’s data aims to identify whether the use of quantitative feedback about the environment leads to a change in the environment over time. It also aims to investigate whether any change in the language environment is linked to a change in parents’ perceptions of their skills and understanding of the strategies and techniques discussed during intervention sessions.

**4 Do I have to take part?**

It is completely up to you whether or not you decide to give consent to your child’s data being involved in the analysis. By agreeing to take part, you are consenting to your child’s data being analysed to identify any patterns. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw your consent to access your child’s data at any stage without giving a reason. A decision to withdraw your

consent to your child's data at any time, or a decision not to take part at all, will not affect any treatment/care that you may receive from the researcher or the service.

**5 Are there any age or other restrictions that may prevent me from participating?**

To participate you must have a child aged 0-4 who has a diagnosed hearing loss and have been referred to the local Sensory Service. Your child must be using or developing spoken language to communicate and have no other diagnosed additional needs. You do not have to use English in the home but be able to engage in conversation with the researcher in English during visits.

**6 How long will my part in the study take?**

If you decide to take part in the study, the data you have provided previously will be used by the researcher. You will not have to provide any additional information.

**7 What will happen to me if I take part?**

By agreeing to take part, the data previously obtained during your child's intervention will be analysed using qualitative and quantitative methods. You will not have to do anything additionally.

**8 What are the possible disadvantages, risks or side effects of taking part?**

There are no risks of side effects of taking part in this study.

**9 What are the possible benefits of taking part?**

By agreeing for your data to be used in the study, there is potential for the service to identify new and more effective ways of working with families with young children with a hearing loss. This will benefit both yourself and other families in the area.

**10 How will my taking part in this study be kept confidential?**

All data is stored anonymously using an identifier number in place of your child's name. All data is stored on a laptop with a security password. The laptop is kept in a secure locker. Only the researcher and the researcher's manager have access to this locker. Completed consent forms will be scanned and saved in the researcher's personal area on the service's electronic system.

11 **Will the data be required for use in further studies?**

- 11.1 You are consenting to the possible re-use or further analysis of the data in future ethically-approved studies; the data will be anonymised and will only be used in studies undertaken within the University of Hertfordshire.

13 **Who has reviewed this study?**

This study has been reviewed by:

- 13.1 The University of Hertfordshire Social Sciences, Arts and Humanities Ethics Committee with Delegated Authority

The UH protocol number is EDU/PGT/CP/03276

15 **Factors that might put others at risk**

Please note that if, during the study, any medical conditions or non-medical circumstances such as unlawful activity become apparent that might or had put others at risk, the University may refer the matter to the appropriate authorities.

16 **Who can I contact if I have any questions?**

If you would like further information or would like to discuss any details personally, please get in touch with me, in writing, by phone or by email:

Abi Ma'ayan

07773255226

[abigail.maayan@newham.gov.uk](mailto:abigail.maayan@newham.gov.uk)

**Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University's Secretary and Registrar.**

**Thank you very much for reading this information and giving consideration to taking part in this study.**

**Appendix B: Adapted SPISE (Parent Version) (DesJardin, 2004)**

Please answer the following questions based on your feelings about your ability to support your child's development (1 = not at all, 6 = very much)

1. To what extent do you know how to help your child develop sounds?

1	2	3	4	5	6
---	---	---	---	---	---

2. To what extent do you know how to help your child develop words?

1	2	3	4	5	6
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3. To what extent do you know about and are able to do speech and language activities and strategies with your child at home on a daily basis?

1	2	3	4	5	6
---	---	---	---	---	---

4. To what extent do you feel you can positively support your child's listening development?

1	2	3	4	5	6
---	---	---	---	---	---

5. To what extent do you feel you can positively affect your child's speech and language development?

1	2	3	4	5	6
---	---	---	---	---	---

6. To what extent do you feel you can positively affect your child's overall early development (e.g. physical development, thinking skills etc)?

1	2	3	4	5	6
---	---	---	---	---	---

7. How comfortable are you in doing listening and language activities with your child?

1	2	3	4	5	6
---	---	---	---	---	---

8. How confident are you in doing listening and language activities with your child?

1	2	3	4	5	6
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### **Appendix C: Adapted SPISE (Professional Version)**

Please answer the following questions based on how your perceptions of the above parent (1 = not at all, 6 = very much)

1. To what extent do you feel this parent knows how to help their child develop sounds?

1	2	3	4	5	6
---	---	---	---	---	---

2. To what extent do you feel this parent knows how to help their child develop words?

1	2	3	4	5	6
---	---	---	---	---	---

3. To what extent do you feel this parent knows about and is able to do speech and language activities and strategies with their child at home on a daily basis?

1	2	3	4	5	6
---	---	---	---	---	---

4. How much do you feel this parents feels they can positively support their child's listening development?

1	2	3	4	5	6
---	---	---	---	---	---

5. How much do you feel this parent feels they can positively affect their child's speech and language development?

1	2	3	4	5	6
---	---	---	---	---	---

6. How much do you feel this parent feels they can positively affect their child's overall early development (e.g. physical development, thinking skills etc)?

1	2	3	4	5	6
---	---	---	---	---	---

7. How comfortable do you think this parents feels doing listening and language activities with their child?

1	2	3	4	5	6
---	---	---	---	---	---

8. How confident do you think this parents feels doing listening and language activities with their child?

1	2	3	4	5	6
---	---	---	---	---	---

## **Appendix D: Involvement Rating Scale (Moeller, 2000)**

<p><b>Rating 5- Ideal:</b> Family;</p> <ul style="list-style-type: none"><li>- seems to have made a good adjustment to the child's deafness</li><li>- is able to put the child's disability in perspective within the family</li><li>- actively engage in sessions</li><li>- attend sessions and meetings regularly and pursue information on their own</li><li>- serve as effective advocates for their child</li><li>- are highly effective conversational partners with the child and serve as strong and constant language models</li><li>- are capable of applying techniques of language expansion</li><li>- extended family members are involved and supportive</li></ul>
<p><b>Rating 4- Good:</b> Family:</p> <ul style="list-style-type: none"><li>- members make better than average adjustment to the child's deafness</li><li>- take an active role (not the lead) in intervention</li><li>- serve as good language models for the child and make an effort to carry over techniques at home</li><li>- have fairly good facility in techniques for language stimulation</li><li>- make efforts to involve extended family members</li></ul>
<p><b>Rating 3- Average:</b> Family:</p> <ul style="list-style-type: none"><li>- makes efforts to understand and cope with the child's diagnosis</li><li>- participate in most sessions/meetings</li><li>- busy schedules and family stresses may limit opportunities for carryover of what is learned</li><li>- may find management of the child challenging</li><li>- rely primarily on professional guidance</li><li>- attempts to advocate but may be misdirected in their efforts</li><li>- selected family members may carry more than their share of responsibility for the child's communicative needs</li><li>- are willing to use language expansion techniques but need ongoing support and direction</li></ul>
<p><b>Rating 2- Below average:</b> Family:</p> <ul style="list-style-type: none"><li>- struggles in accept of the child's diagnosis</li><li>- may be inconsistent in attendance and participation</li><li>- inconsistent in managing the hearing aids and keeping them on the child outside of school/nursery</li><li>- may have some significant life stressors that interfere with consistent carryover at home</li><li>- management of the child presents daily challenges to the family</li><li>- communicative interactions with the child are basic</li></ul>
<p><b>Rating 1- Limited:</b> Family:</p> <ul style="list-style-type: none"><li>- faces significant life stresses that may take precedence over the child's needs</li><li>- has limited understanding of deafness and its consequences for the child</li><li>- participation may be sporadic or less than effective</li><li>- parent/child communication is limited to very basic needs</li></ul>

## **Appendix E: Interview Schedule**

**Introduction:** Thank you for taking the time to meet with me today. I am now meeting with parents who have taken part in the intervention to get a better understanding of your thoughts and opinions of the LENA system and the intervention process, including any suggestions of changes or improvements you may have. With this information I hope to have a better understanding of how to meet the needs of children on the early years caseloads in the future.

**Procedure:** I am going to ask you a series of questions to guide our conversation but please feel free to talk about your experiences and add any information you feel is important or relevant and please feel free to ask questions.

### **Questions:**

1. What are your thoughts on your child's language development?
  - What do you think are your child's strengths and weaknesses?
  - How easy do you find it to support your child's language development?
  - Do you have any worries regarding your child's language development?
  
2. What was your understanding of the study and what we were aiming to do?
  - Clarify if necessary.
  - What is your understanding of why this is important?
  
3. What is your understanding of the LENA?
  - What did you expect it to do?
  - What is your understanding of how it works?
  - (If not already discussed above): What is your understanding of how we wanted to use it support your child?
  
4. What did you think of the LENA and the t-shirt that went with it?
  - Did you have any concerns about your child wearing it?
  - Did your child wearing the t-shirt influence what you did that day- e.g. who you saw, where you went?
  
5. What were your initial thoughts when asked to use the LENA/take part in this study?
  - Any concerns?
  - Positive feelings?
  - What did you hope using the LENA would achieve?

6. Did you discuss using the LENA with other members of your household?
  - Did they have any concerns? Did you agree on using it with your child?
7. How did you feel on the recording day? How do you think your child felt?
  - Did any issues come up that you hadn't expected?
  - Were any previous concerns (e.g. possible intrusiveness, awareness of the being recorded?) founded?
8. How easy did you find it to use the device?
9. Having used the LENA, what would you say are the advantages and disadvantages of using it?
  - What would you say to another family who had the same concerns as you initially about using the LENA?
10. Do you think the recording(s) were representative of a typical day for you and your child?
  - If not, why not?
11. How do you feel using the LENA compares to other interventions you've experienced before, such as video feedback?
12. How easy did you find it to incorporate the strategies discussed into your daily routine after the initial recording?
  - What would have made it easier?
  - Has using the LENA changed the way you perceive your role in your child's intervention at all? If so, in what way?
13. Would you consider using the LENA again in the future to support your child's language development?
  - How do you think the LENA could be used with families of children with a hearing loss?

I'd like to thank you for your time today and for taking part in this intervention. The information you've provided has been really helpful in supporting us to move the service forward and identify new ways of working with families. Do you have any questions for me that you'd like to ask?

