

Exploring the acceptability of innovative technology: a pilot study  
using LENA with parents of young deaf children in the UK.

Abstract

Early intervention is widely recommended for children at risk of difficulties with speech, language and communication. Evidence for effective practice remains limited due in part to inherent difficulties in defining complex interventions and measuring change.

The innovative Language Environment Analysis (LENA) system has exciting potential for early intervention and for evaluating outcomes. LENA is used widely in the United States; however there is little to guide the introduction of this new technology in the UK.

Successful implementation of new technology is predicted by its perceived acceptability and usefulness. This qualitative pilot study aimed to explore the acceptability of LENA for UK families with a young deaf child. Four families used LENA to record for one day. They received and discussed LENA feedback reports with a specialist Speech and Language Therapist. Using qualitative methodology with

a pragmatic epistemology, semi-structured interviews were conducted and the data explored using Thematic Analysis. Three families were positive about using LENA; they identified benefits of the feedback, suggested important factors for future use and would recommend it to other families. One family chose not to complete the recording. Key to acceptability is parental understanding of LENA's purpose and the need for a trusted professional to facilitate interpretation and change. LENA is acceptable for some UK families with a young deaf child suggesting there is potential for successful implementation. Further study to explore LENA's usefulness is recommended.

#### Key Words

Early Intervention, LENA, Communication, Children, Families, Deaf, Technology, Outcomes

## I Introduction

Hearing is essential for the development of spoken language; permanent hearing loss (defined as an average of more than 40 dB HL over 0.5, 1, 2 and 4 kHz) affects about 900 children born each year in the UK and has long-term implications, not only for speech, language and communication, but also for social interaction, educational attainment, employment opportunities and quality of life (Davis et al., 1997; Stacey et al., 2006). Early diagnosis of hearing loss followed by prompt intervention is recommended to minimise the risk of speech, language and communication difficulties and to maximise spoken language potential (Davis et al., 1997; Pimperton and Kennedy, 2012).

The introduction of the universal Newborn Hearing Screening programme has made early diagnosis routine and most babies are diagnosed and aided within a few weeks of life (NHS Newborn Hearing Screening Programme, 2016). Early support services, such as Speech and Language Therapists (SLTs) and Teachers of the Deaf (ToDs) now have the opportunity to become involved during this time of important developmental change to influence outcomes for the

child. There is an expectation that with early and appropriate intervention, listening and spoken language development is attainable for many children with hearing loss (Yoshinaga-Itano, 2003).

Demonstrating the effectiveness of interventions such as these is essential to justify their value to those commissioning services.

However, these complex interventions present methodological challenges both in terms of their definition and in capturing their outcomes; consequently, there is limited evidence for the most effective practice. To address this, Dunst and Trivette (2009) suggest evaluating the “desired outcomes” of intervention rather than the intervention itself. A desired outcome of early intervention with young deaf children is change in those factors, which are thought to be beneficial to communication development. A measure of these *beneficial factors* may be an appropriate method of demonstrating the effectiveness of an intervention.

#### 1 Beneficial factors for spoken language development

Spoken language outcomes are significantly affected by factors such as maternal level of education, socio-economic status and degree of hearing loss (Hart and Risley, 1995); clearly, these are beyond the

control of clinicians. However, several other key factors are widely held to be important and form the basis of many early communication interventions. They include

*Achieving adequate audibility:* Although hearing loss may be diagnosed early, achieving optimal hearing for speech is still not straightforward. Factors such as noisy listening environments and inconsistent use of hearing technology impair the child's exposure to language (Van Dam et al., 2012).

*Quantity of language* spoken to the child: The amount of language spoken by parents to their hearing children from birth to three years has been shown to partially predict their IQ, language abilities and academic achievement at ages 9 and 10 years (Hart and Risley, 1995).

*Active parent-child interaction:* The importance of parent-child communication for language development has been widely demonstrated. For many children with hearing loss however, reduced responsiveness as well as poor linguistic ability can create conversational breakdown, which reduces both adult-child interaction and the quantity of linguistic input (Van Dam et al., 2012).

*Intervention and support to facilitate language development:* Parents are typically the biggest influence in their baby's life; current clinical guidelines recommend working through parents as the most appropriate approach with young deaf children (Muse et al., 2013; Royal College of Speech and Language Therapists, 2009).

## 2 Language Environment Analysis system (LENA)

The Language Environment Analysis (LENA) system is a recent technological innovation, which potentially provides a way to demonstrate these described "beneficial factors" to parents as a basis for intervention and to capture the "desired outcomes". LENA enables exploration of the child's natural language environment by capturing a daylong recording of the speech and environmental sounds occurring throughout the day (LENA, 2015). The child wears a small recording device, the Digital Language Processor (DLP), which is held securely on his/her chest in the pocket of a T-shirt specially designed to minimise acoustic interference. The resulting audio file is subsequently processed and analysed by specialist software providing simple graphs of key measures. These measures include a breakdown

of the *Audio Environment* and counts of *Adult Words*, *Child Vocalisations* and *Conversational Turns*. These primary LENA measures reflect the key beneficial factors described above:

Achieving Audibility: Uniquely, LENA captures the daily Audio Environment of the child in terms of meaningful and distant speech, silence and background noise, including TV and electronic sound.

Quantity of input: Adult Word Count counts the number of adult words spoken that are audible to the child.

Active parent-child interaction: Conversational Turns demonstrate the number of spoken alternations between adult and child.

Intervention: Clinicians use the LENA information to support parents/carers in making changes to facilitate their child's communication development.

In the USA, LENA is already used for both research and clinical practice with deaf children, for example Aragon and Yoshinaga-Itano (2012). Conversely, in the UK there is little awareness of LENA and limited published information to guide its introduction. Whilst audio and video recording are common in UK practice, LENA's unique recording and feedback system makes it a very different approach for

parents. The introduction and effective implementation of any new technology or intervention requires that it should be seen as “acceptable” (Holden and Karsh, 2010); whilst there is no consensus on the *definition* of or for a *measure* of acceptability, the Medical Research Council guidance (Craig et al., 2008) also describes the need for acceptability to be established during the development of new complex interventions. Levels of acceptability for using LENA are difficult to ascertain from current literature; although drop-out rates are reported in some studies, these seem to be related to non-LENA issues, such as family re-location (Suskind et al., 2013). Future use of LENA with young deaf children in the UK initially rests on whether it is perceived as acceptable by their parents and the professionals who work with them. Additionally, introduction of LENA technology in the UK requires consideration of important issues, such as cost and NHS information governance. Consequently, in order to make recommendations about potential implementation, there is firstly a need to explore its acceptability with UK families.

### 3 Aims of this study



This pilot study was undertaken to begin to address this issue by asking the research question: Is LENA acceptable to parents of young children with hearing loss in the UK?

Key objectives of the study were to

- Investigate parental interest in and concerns around using LENA through a focus group.
- Provide parents with the experience of using LENA with their child and explore their views using individual semi-structured interviews.
- Determine if further study is justified and make recommendations regarding appropriate development and future implementation.

## II Method

This pilot study was designed to begin to understand whether using LENA is acceptable to parents of young children with hearing loss. In order to explore their individual experiences and views, a qualitative methodology using pragmatic epistemology was selected.

The study consisted of three stages

- 1) Focus group: to introduce LENA, explore parents' initial impressions, concerns and interest.
- 2) A LENA "trial"
- 3) Semi-structured qualitative interview

All aspects of the study were conducted by the researcher/first author, who is also a specialist Speech and Language Therapist with extensive experience of working with deaf children and their families; this was explained to participants.

Having reviewed and discussed all aspects of the study protocol with the researcher, the University of Nottingham Medical School Ethics Committee was satisfied that it fully addressed all ethical requirements and granted approval.

## 1 Participants

The study used purposive sampling and the inclusion criteria of families with a child under the age of 24 months with a permanent

sensori-neural hearing loss (SNHL) of greater than 40dB. All forms of hearing technology (hearing aid(s), cochlear implant(s) and bone conduction hearing device(s)) and communication mode were included. Potential participants were approached through an existing local parents group run by The Ear Foundation, a Nottingham-based voluntary sector organisation bridging the gap between clinic-based hearing technology services and their use in daily life. Details of participants are presented in Table 1.

Table 1 about here.

## 2 Focus group

Parents received a written invitation to participate; this invitation introduced LENA and the purpose and format of the focus group. Four families attended this parents group regularly and all consented to participate in the focus group. The researcher was known to only one family, having conducted an initial assessment with them during the previous 12 months. The focus group was designed to explore the families' initial responses to LENA and their ideas for and concerns

about using it. During the focus group, they were shown a brief video explaining the background to LENA and given opportunity for hands-on experience of the Digital Language Processor and LENA T-shirts. The researcher used a schedule of two open-ended questions, "What are your initial thoughts about this?" and "Is this something you would be interested in using with your child?" followed up with opportunity to ask questions and prompts such as "Can you tell me more about that?" to facilitate group discussion. Subsequently, the families were invited to participate in a "LENA trial" and provided with Research Volunteer Information sheets. All four families provided consent to participate in this next stage of the study.

## 2 LENA "trial"

Using LENA with families consisted of three steps: Record, Return, Review.

### Record

The families were provided with a pack containing the Digital Language Processor (DLP) and instructions for its use. They also chose one of the LENA T-shirts in a size suitable for their child. As

described, these tops have a specifically designed pocket on the chest, which provides minimal acoustic interference and safely holds the DLP in a suitable position to record sounds around the child. The researcher explained the instructions and answered any questions. The researcher's phone number was provided in case of additional queries.

The researcher reminded and reassured families that the recording would be uploaded contemporaneously to the LENA software for computer analysis; this would *never* involve a person listening to the recording. If at any time during the day they felt uncomfortable, they should simply remove the DLP, switch it off and the recording would be deleted.

The family recorded a whole day of their choosing by switching on the DLP in the morning, securing it inside the T-shirt pocket and leaving it to record all day. They were advised to remove the DLP during bath time and also during periods of sleeping or when the child was in a harness or car seat to ensure child safety; placing the DLP near to the child allowed it to continue recording at these times.

Return

The researcher collected the DLP at an agreed time and location after the recording day and a date was booked for the Review session. The DLP was connected to a password-protected computer in a secure location and the audio file of the recording uploaded to the LENA software for automatic analysis. The DLP was then free to be used by other participants. Processing takes several hours; once completed, "reports" of the data were available to be printed and shared with the family in the Review session.

### Review

Several levels of analysis are possible with LENA; only the Core Reports were used in this study. These include:

*Adult Words:* the total number of adult words spoken near or to the child.

*Conversational Turns:* the number of adult-child conversational interactions.

*Audio environment:* showing the mix of audio components in the child's environment, which includes Meaningful Speech ("live", close and clear vocalisations from adults, the child and other children), Distant (speech that is overlapping or further away from the child),

TV and electronic sounds (including radio and tablets), Noise (for example, toys rattling) and Silence.

*Child Vocalisations*: speech sounds produced by the child, which may include canonical syllables (such as “baba” “dada”), proto-phones (such as squeals or raspberries) and words. They do not include cries or vegetative sounds (such as sneezing).

LENA reports are simple, colourful graphs displaying a breakdown of these results across different time frames (see Figures 1 and 2); for this study, the Hourly display was used. From the time the DLP is switched on in the morning until turned off at night, each hour of the day is displayed as a vertical bar representing the total for that measure, for example, the total number of Adult words spoken during that hour. The Audio environment bar is broken into the components described above, for example, one vertical bar may consist of 30% silence, 10% TV and electronic, 5% Noise, 25% Distant and 30% Meaningful speech.

Figures 1 and 2 about here

During a Review session, these reports are shared with parents, each of the measures are explained and discussion is facilitated around the findings, exploring areas of interest, for example considering specific times of the day when conversational turns are relatively high or when TV noise is particularly low.

### 3 Parental interview

For this study, the individual semi-structured interview was conducted during the Review session, using a pre-determined schedule in part based on the focus group findings. The interview was carried out in two parts: pre- and post-sharing of the reports. The first part covered issues such as quality of information received prior to use, confidence using LENA, their choice of recording day. The second part following the review of reports asked about the experience of receiving the reports and thoughts about future LENA use. In three families only the mother was present for the review and interview (P1,3, 4); for P2, both mother and father participated.

### 4 Data analysis



Individual interview data was transcribed and analysed inductively by the researcher using Thematic Analysis (Braun & Clarke, 2006).

### III Results

During the focus group, all the participants expressed a high level of interest in using LENA; whilst this may be anticipated as a first response to the exciting technology, for most of these parents the interest was maintained after having hands-on experience, suggesting that they perceived LENA as acceptable.

Participants received verbal explanation as well as written and hands-on instructions for using LENA, which engendered confidence in using the device; for all the parents, using the LENA DLP was easier than they had anticipated. Despite their original concerns the clothing was reported as acceptable. Three parents were concerned the DLP could be switched off accidentally or that their child could remove it from the vest; neither of these events occurred.

All participants mentioned the recording process and how it made them feel. For three participants, they acknowledged an initial feeling of awareness, but that this passed, for example:

"I was expecting to be constantly aware that it was there, but no you forget all about it pretty quickly." (P1)

The parent who had anticipated that she would feel conscious of the recording and be unable to act naturally, reported that in fact it wasn't a problem at all.

Despite reassurance that they would not be listened to, handing over a recording of your day creates some sense of vulnerability. Whilst all participants accepted the assurance that this recording would not be listened to; it was still referred to by them all, for example, "I was singing then [...] I hope you didn't listen to that!" (P4)

Trust in the person dealing with the recording seemed to help participants in this study;

"I mean it's having the trust in the person who's doing it...but if that information's got to go anywhere else...if it's a stranger we'd probably think a bit different." (P2)

In other words, a known professional may be more trusted than an unknown researcher (Suskind et al., 2013).

All the mothers commented that using the DLP was or would have been easier when they were alone with the child and related this directly to the recording process, feeling more aware of their adult interactions being recorded than of those with the child.

One of the four families (P2) felt so uncomfortable with being recorded that they chose to remove the DLP and discontinue recording, commenting:

"I just didn't like it at all."

"It's like being spied on."

"It's just the thought of being in your own home and you can't talk normal knowing you're getting recorded."

These parents were concerned not only about perceived intrusion into their own conversations, but also the potential impact on other people in the house. This was not an issue for other participants.

Most participants allowed the DLP to record the full 16 hours. Some participants suggested that it might be more acceptable to use LENA for less than a day, perhaps during an intervention session in which

parents want to try out a new strategy to see how their child responds.

A proposed benefit of LENA's daylong recording is its ability to reflect natural communication in everyday life. However, choosing a "good day" to record was an issue for all families. A good day seemed to be one in which they could best demonstrate positive behaviours and strategies, for example plenty of individual contact with their child and situations in which their child was likely to be most vocal. For each family, this "good day" turned out to be different than they had planned and three families wanted another opportunity to record.

Underpinning some of the issues of acceptability seems to be that of the understanding and involvement of *both* parents. For three families, only one parent received the introductory LENA information and provided consent (P1,2,3). One suggested that:

"Maybe it'd be best to get more information first before you sign a contract and tell your partner or husband" and "It boils down to how

both people feel about it, you know under the same roof.” (P2, Mother)

This parent also pointed out:

“cos I went to all those groups every week, to all those sessions so you learn a lot more from the sessions [...] (he) never went so he was only hearing off me.” This reflects common everyday practice of professionals providing home visits with only one parent present.

The families all expressed some level of anxiety before receiving the feedback reports, which seemed to be related to the novelty of the tool, but also to concerns about their own competence, for example, “Am I doing enough?” (P1)

The process of sharing the reports facilitated *active parental involvement*, engaging parents in several ways:

- Asking questions: “Do you think there’s enough meaningful speech there?” (P1)
- Considering the impact of the linguistic and audio environment: “There’s more background noise than anything isn’t there...its cos we were out then.”(P4)

- Reflecting on their own behaviours: "I talk to him a lot at these times." (P3)
- Discussing their child's development openly: "I just want to know the truth.... cos if it were really low then I'd just be like let's do what we can to help the situation." (P1)
- Demonstrating their current knowledge: "I try to keep the TV off so I'm glad that's showing on there...when the TV is on I really do notice it if I'm doing anything like talking, I really don't get a response from him at all." (P1)

Parents found the visual reports accessible,

"Yeh I'm not smart that way with maths but I did understand the bar chart...how much there is in a bar just says it all doesn't it?" (P3)

"I think it's useful cos you're used to percentiles from the growth charts and things." (P1)

Parents spontaneously added their own meaning to the reports, for example making links between the time of the recording, what would have been happening at that time and noticing aspects of their child's behaviour,

“10 till 11, that’s why there’s a lot going on then ...he was quite vocal, singing and copying them, yeh that’s probably why.” (P4)

Most parents thought it would be useful to repeat the LENA process, for example to observe progress and check if it was being maintained, observe different environments, such as nursery or to provide “evidence” for audiological decisions by using the reports to supplement audiological findings and parental report.

Themes identified from the thematic analysis are presented in Table 2.

Table 2 about here

#### IV Discussion

As previously described, establishing acceptability levels from the existing literature is difficult; although drop-out rates are reported in some studies, these seem to be related to non-LENA issues, such as family re-location (Suskind et al., 2012). There is little discussion around the issues of intrusion, recording and privacy, which were

encountered in this pilot study; these concerns were significant enough for one family out of four to refuse.

Practical changes may address these concerns; improving participant information, requesting consent from both parents, providing home visits to actively involve all primary carers and the option of using LENA in a limited way, such as for targeted recordings. However, the family in this study reported that there was little that could be offered to improve their aversion to LENA and it may be that for some families LENA will never be acceptable.

Concerns around “achieving” a good day may reflect parents’ anxiety about not “doing enough” for their child. In UK culture, parenting is a highly moral issue and the perception of being judged on your skills as a parent, presents a risk to compliance and implementation. The opportunity to carry out several recordings and the assurance that any recording may be repeated if parents are unhappy with it may help address this issue. Reports from well-respected users of LENA in the US also substantiate the assertion that acceptability is improved through repeated use; feedback reports demonstrating positive



change over time seem to be a powerful incentive (Suskind et al., 2012). Whilst using LENA as a “one-off” experience for this study was interesting, further study into its usefulness should reflect the more likely clinical practice of repeated use.

Sharing LENA reports generated active parent involvement; nevertheless, parents strongly expressed the need for help with interpretation to add meaning, relevance and application for their individual family. This indicates that dialogue between parent and professional is still required to facilitate discussion, help parents interpret and act upon LENA findings. Additionally, for the participants, having a known professional seemed to provide an important element of trust, which has implications for acceptable implementation. Suskind et al. (2013) also found that parents wanted reassurance that they could repeat the recording if they were unhappy with it in any way; this sense of having total *control* seemed to improve their acceptance.

LENA did not fulfil all parental expectations, for example, some hoped for feedback on their child’s quality of speech. LENA has additional

functions, which may provide this “missing” information requested by parents; however only the core LENA reports were used in this study. Additionally, some of the unfulfilled expectation directly reflects the one-off nature of LENA use in this pilot study and again demonstrates the need to investigate acceptance and utility in a more extended application, which better reflects likely use.

#### V Conclusions & Implications

Early diagnosis and intervention are widely recommended to maximize the spoken language potential of deaf babies. Limited evidence for best practice highlights the difficulties of evaluating such complex interventions; however delivering effective interventions and demonstrating their value is vital in modern healthcare when resources are stretched.

The LENA system provides a possible solution to this dilemma; LENA shows change in the important factors beneficial to communication development as a basis for intervention and to demonstrate outcomes.

Although relatively unknown in the UK, promising initial findings from this qualitative pilot study suggest that UK parents consider LENA to be acceptable, an important first step in developing a complex intervention. Acceptability seemed to be primarily affected by parental understanding of LENA's purpose, concerns of privacy and perceived appraisal of parenting skills.

Successful implementation of any new technology is predicted not only by acceptability but also by *perceived usefulness*; findings on usefulness were restricted by the single LENA use in this study.

Further study is underway to explore repeated LENA use, which is more typical of clinical practice.

LENA's innovative system has exciting potential for both UK research and clinical practice with a broad range of children, not only those with hearing loss.

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### Conflict of Interest Statement

The Authors declare that there is no conflict of interest.

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Table 1: Participant information

Participant ID	P1	P2	P3	P4
Hearing loss	Bilateral severe/ profound SNHL	Bilateral profound SNHL	Bilateral profound SNHL	Bilateral severe SNHL
Hearing technology used	Bilateral hearing aids	Bilateral hearing aids	Bilateral cochlear implants	Bilateral hearing aids
Parent/s attending the local parents group	Mother	Mother	Mother	Mother Father

Table 2

Theme 1: Using the new technology	
Sub-theme	Sample quote (participant ID)
"It was pretty straightforward to use"	<p>It was absolutely fine, it was really easy to use, no problems at all. (P1)</p> <p>It was quite easy, easy to do and easy to read the instructions [...] I put it on [child], that was easy and everything. (P2, Mother)</p> <p>I felt like I had to keep checking [...] but it was fine so yeh not a problem, not a problem at all. (P3)</p> <p>I'd thought he'd be fiddling with it to see what it was but no...as soon as I put the vest on he was fine, he didn't touch it at all, I was surprised over that actually.(P4)</p>
Being recorded	Some people don't like it do they? Maybe

	<p>feels like it's all a bit staged. Doesn't bother me really [...] I was quite confident that nobody was going to be listening to it.(P1)</p> <p>I think you couldn't have a conversation [...] straight away I didn't like it. I think everybody's different, obviously (mother) feels different to the way I reacted...she thought it was a good idea. I'm just one of those people definitely you know...I won't like it. It doesn't matter how many ways you explain it the answer would still be no. (P2, father)</p> <p>it was just more the uncomfortable bit of thinking that someone's listening to your conversation and it made us uncomfortable as well...if I was in on my own with [child] it probably would have been different.(P2, mother)</p>
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	<p>When you've got your partner here you talk to I probably would have felt a little bit conscious of what WE were talking about. (P3)</p> <p>It was fine actually, not as bad as what I thought cos I was expecting to be constantly aware that it was there but no you forget all about it pretty quickly. (P4)</p>
A good day	<p>I don't know what the results will be like; it wasn't that typical a day. (P1)</p> <p>It probably wasn't the best day to do it actually [...] we were out a lot of the day so...I wish I'd done it the day before. [...] we was in most of the day that day playing and he had a really good day that day.(P4)</p>

Understanding	<p>It boils down to how both people feel about it you know under the same roof. Maybe it'd be best to get more information first before you sign a contract and tell your partner" (P2, mother)</p> <p>Cos I went to all those groups every week[...] he never went so e was only hearing off me. (P2, mother)</p>
Theme 2: The reports	
Anticipation & Future use	<p>Seeing the results is quite nerve wracking!(P1)</p> <p>I just want to do it again! (P1)</p> <p>Am I doing enough? (P4)</p>
Feedback: <ul style="list-style-type: none"> <li>• Visual feedback &amp; numbers</li> <li>• Active parental involvement</li> </ul>	<p>Yeh I talk to him a lot at those times. I try to keep the TV off so I'm glad that's showing on there [...] when the TV is on I really do notice it if I'm talking, I really don't get a response from him at all" (P1)</p>

<ul style="list-style-type: none"> <li>• Role of the feedback provider</li> </ul>	<p>I did understand the bar chart[...] how much there is in a bar just says it all doesn't it? (P3)</p> <p>Well I mean I see it differently now [...] I mean I'm surprised he is vocalising a lot. I'm pleased it was better than what I was expecting. (P4)</p>
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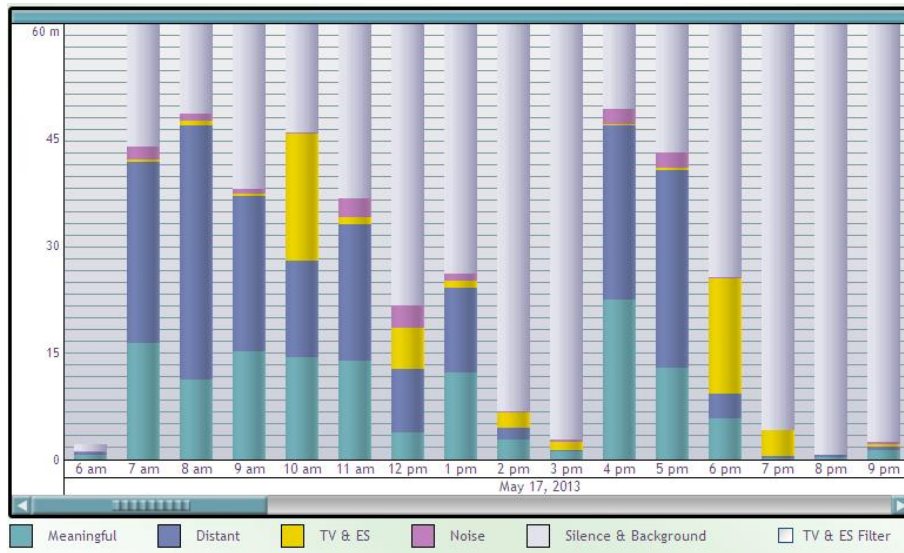


Figure 1: LENA Audio Environment view



Figure 2: LENA Composite View