

# Talking to Toddlers: Drawing on Mothers' Perceptions of Using Wearable and Mobile Technology in the Home

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**Abstract. Background.** Mother-child interactions often give rise to opportunities for early language learning in the context of everyday life. Persuasive technology has the potential to influence maternal language behaviours in the home and promote mothers' active engagement in the development of their children's communication skills. **Aim.** This paper explored maternal perceptions regarding the use of a language tracking wearable (Language Environment Analysis; LENA) device and a parent education smartphone application in an 8-week trial with their young children. **Methods.** Mother/child dyads were enrolled in a feasibility trial designed to obtain objective auditory and linguistic data from each child's naturalistic settings (Control Condition), provide feedback to mothers about their child's home language environment (LENA Feedback Condition), and to explore effectiveness of an app designed to promote meaningful parent/child interactions during daily routines (LENA Feedback and App Condition). **Results and Discussion.** The majority of mothers (80%) who participated in the trial reported a preference for using the mobile app and/or LENA technology again. Maternal responses during this pilot informed the design of an ongoing, prospective language intervention study for parents and their young children with significant hearing loss.

**Keywords.** Wearable technology, smartphone app, maternal language behaviour, user experience, child language environment

## 1. Introduction

During the first few years of life, children undergo a sensitive language acquisition period characterised by the rapid development in communication and linguistic skills [1].

For children with normal hearing, pre-school language experiences/milestones predict trajectories of later language and educational outcomes [1, 2]. In the case of children with hearing loss, disparities in oral language experiences, as compared to their typically hearing peers, may place them at risk of delays in spoken language development [2].

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In the design of interventions to address language delays, the role of the adult caregiver is often emphasised in therapy [2]. Adult caregivers, specifically mothers, naturally spend a substantial amount of time with children and are recognised as the primary contributors of spoken language input, in terms of quantity and content that children receive during the early critical years [2, 3]. Adults generally have little conscious awareness regarding the quantity of talk provided to children [2]. Efforts by early intervention professionals (i.e. speech pathologists) are typically channelled into enhancing partnerships with parents and promoting active parental engagement [4]; that is, parental behaviours which promote meaningful learning and optimal outcomes through purposeful interactions with children [5]. Two interventions warrant attention. Firstly, in parent-directed language interventions, the provision of verbal feedback is used by speech pathologists to enhance parental input to the child [2]. Secondly, therapy may focus on enriching the child's immediate environment; reducing noise, reducing speech in noise, and increasing speech directed to the child. Having a tool which provides measurable feedback on these two factors and the ability to monitor progress over time may potentially complement and increase effectiveness of behavioural interventions [2].

### *1.1. Language ENvironment Analysis (LENA) Technology*

Access to the Language Environment Analysis (LENA) system has enabled parents and speech pathologists to view quantified data about a child's overall audio and speech environment [6]. The hardware component of LENA technology is a small, wearable recording device placed in the front pocket of a child's clothing. Recordings are processed by the LENA software which generates frequency counts including *communicative interaction* data (quantity of adult words spoken to the child, number of turns taken between adult and child, and amount of speech-like sounds the child produces) and *environmental* data (close range speech, electronic media, distant speech, background noise and silence) [7]. Providing parents with LENA-generated feedback can facilitate active parental engagement by opening a dialogue between speech pathologists and parents about a child's home language environment.

### *1.2. Mobile App Technology*

Beecher and Buzhardt [4] proposed mobile applications as another technology-assisted strategy for increasing parental engagement. There has been an increased general acceptance of mobile technology as a feature of everyday life and a notable surge in the adoption of mobile devices across diverse populations [4]. Mobile applications, as virtual platforms, have the potential to provide increased access to information, which can be used to persuade and educate [8]. The continual evolution of app development now includes persuasive design features which can modify the behaviours of users [8]. Dialogue support has been identified as a human-computer persuasive design element which uses feedback as a way of interacting with the user [8]. Feedback to the user includes prompts, suggestions and reminders [8]. Additionally, the use of symbolic visual rewards displayed on the app upon completion of a task or goal has also been found to be a typical feature employed to influence user behaviour [8].

### 1.3. Aim of Pilot Study

Wearable speech recognition technology and the promise of mHealth (mobile technology) offer potential intervention benefits to parents outside of the clinical environment. Nonetheless, the successful implementation of any novel technology is in part, predicted by the users' experience and perceived notion of utility [9]. Failure to address usability factors could hinder the adoption of novel technology, and could result in dissatisfied users, decreased effectiveness and/or high churn rate [10]. Research is required which ensures that technologies are suitably designed and targeted to the end-users' needs before being implemented in clinical interventions [10].

A key objective of this feasibility study was to provide mothers with the experience of using LENA technology and a mobile app with their children, and to explore their first-hand opinions upon completion of the trial. This paper is focused on exploring participating mothers' perceptions of the pilot with the aim of informing future iterations of using wearable and mobile technology in home-based language intervention research.

## 2. Method

Participants (5 mother and child dyads) were recruited for an 8-week feasibility trial. All participating mothers were smartphone users who spoke English at home and did not require an interpreter. Child participants were aged between 11 months to 2 years (Mean age=1.28 years; SD=0.45), had normal hearing and no additional special needs.

Mother/child dyads completed an assessment and briefing session at the start and end of the trial. Formal child assessments included a receptive and expressive language test and a cognitive developmental screener. Mothers completed measures of vocabulary and cognitive ability. A 10-minute mother-child play sample was also video-recorded at the start and end of the trial. Parent-report questionnaires were used to collect demographic information, child communication development details, ratings of parental competency and knowledge, as well as written views on the technologies used in the study. This paper used an inductive content analysis approach to explore maternal written comments about the use of LENA technology and the mobile app.

Mothers were given the option of completing either a day-long recording of up to 16 hours per week, or to record for up to 16 hours over 2 consecutive days in a week. Participant awareness of when the recordings were taking place was inevitable, hence the latter option was proposed as a strategy to neutralise the possibility of the Hawthorne effect by promoting acclimatisation to the LENA recordings. Participants were also asked to complete a time-use Daily Activities Diary (DAD) for each recording day which informed the interpretation of LENA data and feedback provided to mothers. None of the LENA recordings were completed on days when the children were in day care as exploring the potential of implementing interventions in the home environment was central to this study.

### 2.1. Pilot Trial Conditions

The use of the LENA system and mobile app was trialled with participants using a repeated-measures study design. A baseline LENA recording was taken at the start of the trial (week 1) and a follow-up recording was taken at the end of the trial (week 8).

Each mother-child pair completed all 3 study conditions (2 experimental conditions and 1 control condition) between weeks 2 to 7 as described below:

*Control Condition.* Participants completed 2 weekly 16-hour long LENA recordings and filled in a Daily Activities Diary (DAD) describing types of activities they were involved in, people who were around and settings which they were in on the days of recording.

*LENA Feedback Condition.* Participants completed 2 weekly LENA recordings and DADs as per the control condition, after each week. An individualised visual language environment feedback report based on the dyad's most recent LENA recording was provided to the mothers. Mothers also had either a face-to-face or over the phone verbal discussion about each week's report with the study researcher lasting approximately 15-30 minutes. The feedback provided to mothers outlined key LENA targeted language counts displayed in the form of graphs (number of adult words, conversational turns and child vocalisations per hour) and a snapshot of the child's overall audio environment.

*LENA Feedback and Use of Mobile App Condition.* In addition to the weekly recordings and providence of LENA feedback (as outlined in the previous condition), mothers were asked to download the mobile app and incorporate short, parent-child interaction activities as suggested by the app into their daily routine for 2 weeks.

### 3. Results

#### 3.1. Participant Characteristics

All 5 participating mothers had normal hearing and were aged between 37 and 41 years (Mean age=39; SD=1.58). All mothers reported that they were the primary caregivers of their children and spent an average of 136 hours per week (SD=29.9; Range= 104-168) with their child. All families were intact, with two adult parents living in the home. The average relative socio-economic advantage decile (1=areas of least advantage, 10= areas of greatest advantage) for participants was 7.6 (SD= 1.81; Range= 5-10) as defined by SEIFA (Socio-Economic Indexes for Areas) 2011 census data using household postcode. Participant demographic and family characteristics are summarised in Table 1.

**Table 1.** Participant demographic and family characteristics.

Mother/child dyad	Mother's age (years)	Child's age (months)	Mothers' highest level of educational attainment	Work/study load	Time spent with child (hours per week)	SEIFA decile
P1	38	12	Postgraduate degree	Mat. leave	168	8
P2	41	11	Bachelor's degree	Full-time	104	5
P3	37	13	Diploma/vocational certification	Self-employed	168	8
P4	40	15	Bachelor's degree	Full-time	120	7
P5	39	24	Postgraduate degree	Part-time	120	10

### 3.2. Maternal Perceptions on the Use of LENA Wearable Technology and the Mobile App

The role of feedback and perceived usefulness were recurring themes (Table 2) which emerged from mothers' written responses to the open-ended questions at the end of the trial, "What did you like about the use of the LENA system/mobile app?" and "What would you change about the use of the LENA system/mobile app in this study?"

*Feedback.* Visual representations of LENA data were a salient part of feedback which added to the positive experience. Mothers' commented on the perceived impact after viewing LENA feedback information on their own communicative behaviours which indicated engagement with persuasive technology. Badges which were part of the mobile app's reward system as feedback to the users for completing suggested daily activities were viewed as an excessive feature which could be omitted.

*Perceived usefulness.* Changes to simplify the LENA recording process (i.e. recording over one day instead of two), altering the size of the LENA device and catering to mothers' information needs by having a short video demonstration to accompany the app activities would help address negative experiences reported by the mothers about the use of the technologies in the trial. A majority of mothers expressed positive sentiments about the ease of use for both the wearable LENA recorder and the mobile app. They reported that the app interface was user-centric and suggested app activities were practical and easy to implement with their children.

**Table 2.** Positive and negative responses on the use of LENA and mobile technology based on maternal perceptions after the trial.

Themes	Sub-themes	Description	Sample quote(s)
<b><u>Receiving Feedback</u></b>			
<b>Feedback (Positive)</b>	Visual value	Accessibility of LENA graphs	"Feedback (objective- based on actual recordings) to visualise amount of talk and vocalisations"
	Influence on parental communication behaviour	Engagement with LENA feedback	"Helped me understand the spoken patterns of the day. Showed me just how important/valuable reading is!"
<b>Feedback (Negative)</b>	Unnecessary features	Mobile app reward system	"Found the badges unnecessary."
<b><u>Perceived Usefulness</u></b>			
<b>Usefulness (Positive)</b>	Simplicity/ Ease of use	Wearable LENA device	"Simple, still able to do what we would normally do."
	User-centric	Mobile app dialogue support	"Daily reminders to use the app, ability to return to a favourite activity and completed activities."
	Practical Application	Mobile app primary task support	"Simple easy but interesting activities help our child enjoy communicating with us."

Themes	Sub-themes	Description	Sample quote(s)
Usefulness (Negative)	Process design	LENA recording procedure	"Didn't find Day 2 recordings particularly useful. If possible, have only 1 long recording per week."
	Information needs	Mobile app primary task support	"A short video showing the tips ie. with a caregiver and child."
	Hardware limitation	Wearable LENA device	"Device should be smaller."

At the end of the 8-week trial, 4 of the 5 mothers expressed interest in using the mobile app again, and 3 participating mothers reported that they would use both the LENA system and mobile app again in the future. Participant 1 also commented post-trial: "I have placed the app on my phone home screen."

#### 4. Discussion

This paper investigated the maternal perceptions of incorporating modern technologies into daily mother/child language interaction. Usability and feasibility are key contributors to the success of any parent engagement initiative using technology [4]. The feasibility of the approach was supported as the participating children tolerated the use of the LENA recorder and all 5 mother-child participants who enrolled for the study completed the 8-week trial successfully. The use of wearable LENA and mHealth tools were evaluated based on user perspectives, although limited to mothers who had participated, upon completion of the trial. Access to objective information about language behaviours, ease of recording, as well as having a user-centric app experience facilitated mothers' positive perceptions on the value of LENA feedback and perceived usefulness of the technologies.

Completing a 16-hour recording over two consecutive days during the pilot was implemented as a strategy to control for the Hawthorne effect on maternal language behaviours. It was however, highlighted in the comments made that completing one long day of recording was preferred over two consecutive recording days. Allowing for controlled flexibility in LENA recording procedures is likely to promote participant adherence and retention, which are vital elements in successful prospective trial research. This pilot also adopted a repeated measures study design which allows each mother/child dyad to act as their own baseline and for the comparison of measurements across conditions. Analysis of objective measurements of language data is ongoing and will be reported on in a subsequent publication.

Findings of this pilot demonstrated that participants were willing to use the technologies again in the future although, due to the small subject size characterised by more well-educated and socio-economically advantaged participants, this observation might not be generalisable. The ensuing study has addressed this issue by commencing recruitment on a broader Australian cohort from different early intervention sites dispersed across states and geographic regions. Maternal (user) perceptions of the pilot were considered when developing the methodology for a 12-week trial, which is currently underway, exploring mother's input to children who have significant hearing loss.

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