Talk2MeMore: Pilot Study Report

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August 2018

Summary of Key Findings

In total, data recorded by 35 parent-child dyads who had meaningfully engaged with the app for more than one session was available for analysis. The retention rate for the complete study period (i.e. eight weeks) was 23% (n=8). The sample represented a diverse range of parent education levels and income levels. The most popular activities engaged during sessions were reading, playing and everyday activities.

Demographic Variations in the Language Environment

Some variety was observed in the activities engaged during sessions throughout the study period depending on parents' education levels. Significant differences in the language environments at baseline were only recorded with respect to education level in relation to the number of sentences per session. A significant relationship was also identified between the number of sentences per session and education level and between number of questions per hour and education level. No other significant differences were identified at baseline.

Caregiver Behaviour and Confidence Change

The rate of response to the post-study questionnaire was poor (n=5). Accordingly, while the responses collected pre- and post-study are presented in the report below, it is recommended that conclusions are not drawn with respect to caregiver behaviour or confidence change based on responses to the post-study questionnaire, due to the significant difference between these sample sizes for comparison purposes. Similarly, analysis of the quantitative language variables at three points throughout the study are also presented below. However, due to the very low retention rate reported above, the sample size at Time 1 (baseline; N=35) is considerably higher than that at Time 3 (end of study; N=8). Therefore it is not possible to meaningfully interpret the results presented below with respect to caregiver behaviour and confidence change in the overall sample.

'Study Completion Sample'

In order to better explore any changes in the quantitative language variables across the study period, data pertaining to the eight participants who successfully completed the full study period (i.e. 40 sessions) were analysed separately. The demographic characteristics of this smaller sample was also mixed, similarly to the overall sample. Some significant differences were observed in the quantitative language variables with respect to education level. However, due to the very small sample size and multiple issues with the data (highlighted further below), it is not possible to meaningfully interpret these differences.

Participant Feedback

Qualitative feedback from participants is generally positive overall, with some suggestions for improvement of the app in future.

Challenges and Recommendations

A number of challenges faced throughout the study period are identified and discussed, together with recommendations for similar research in future. These challenges included participant retention; quality of self-reported demographic information; data limitations; and a lack of experimental control.

Introduction/Background to Study

In 2017, a partnership was formed between the Early Learning Initiative/National College of Ireland and Talk2MeMore, the organisation responsible for the development and provision of an app by the same name. The Talk2MeMore app ("the app") uses mobile technology to analyse the type of language used by parents when engaging with the app and provides feedback and guidance to parents on maximising the impact of the language exposure they are providing on their child's language development.

Literature Review

The Early Language Environment

The acquisition of language ability is a major achievement of the early developmental period and such acquisition in the first four years of life has a significant impact on later functioning in a range of domains including emotional and behavioural functioning and educational attainment (Clegg et al., 2015).

In the context of their children's language development, parents have a significant role to play. The early learning environment that parents and caregivers provide for their children has been demonstrated to have a significant impact on children's later language development (Rodriguez & Tamis-LeMonda, 2011). In particular, the extent to which children receive "language nutrition" – through talking, reading or interacting – during the critical first three years of life provides valuable scaffolding for future language development (Zauche et al., 2016).

Both the quantity and quality of language input have been identified as developmentally influential. Initially, the sheer volume of language heard by children was identified as critical in their language development (Huttenlocher, 1998). However, recent research has moved to attribute language development to other aspects of language exposure, suggesting that, for instance, lexical diversity of words heard by the child and active participation in conversational turn-taking with an adult play an equally significant – if not greater - role as the mere quantity of adult-spoken words the child is exposed to (Jones & Rowland, 2017; Romeo et al., 2018; Zimmerman et al., 2009).

This diversity in lexical input and the individual differences in caregiver speech and language activities have been demonstrated to impact on the acquisition of corresponding differences in the child's language knowledge and speech patterns and in their vocabulary growth (Huttenlocher et al., 2017; Pan, Rowe, Singer & Snow, 2005). Given that these individual caregiver differences play an important role in the child's language acquisition, factors that influence this caregiver language diversity are likely

to also play a significant role. In the context of this study, research exploring the lexical diversity of parents from varying socio-economic backgrounds is particularly relevant.

The Word Gap

Children develop and learn in widely varying circumstances, dictated by the wide variations in their home, learning and wider socio-cultural environments. While the importance of language exposure or language "nutrition" in early life is well-established, the effects of variation in the quantity and quality of this language exposure have also been explored. Building on the seminal study by Hart and Risley (1995) - which identified that children from welfare families may have heard approximately 30 million less words by the age of 4 years than those from professional families – a significant body of "word gap" research has developed in recent decades (see, for instance, Betancourt, Brodsky & Hurt, 2015). This body of research has examined the mechanism of this language difference between low and higher income families, making various suggestions for policymakers and educators in how best to 'bridge' this gap (Avineri et al., 2016; Hindman et al., 2016; Snell et al., 2015).

In terms of what accounts for this word gap, prior research has identified a number of aspects of the early language environment which may differ across socioeconomic settings, leading to differential outcomes in terms of language development. As highlighted above, parents have been shown to play a significant role in creating this environment. Parents from lower socio-economic groups have been shown to talk less with their children than their more advantaged peers and do not use as great a variety of words or syntactic complexity, with corresponding impact on the diversity and range of their children's language acquisition (Hart & Risley, 1995; Hoff-Ginsberg, 1991, 1992, 1998; Hoff, 2003).

Exploring Language Exposure: The Challenge of Ecological Validity

Whether they explore language exposure, language acquisition or the efficacy of interventions aimed at increasing language development, many studies in this field over the past number of decades have struggled with common methodological challenges. In the case of language exposure research, in particular, much research to date has relied on data collected through in-person observations or recordings which requires time-intensive transcription and analysis by the researcher. Such methodological challenges have, in past studies, limited the potential sample size and length of recordings, even in the case of seminal studies involving naturalistic observation, such as that carried out by Hart & Risley (1995) (Gilkerson et al., 2017). Technology developed in recent years has lessened this burden and created new and more efficient methods of collecting data pertaining to language exposure. In particular, tools such as the Language Environment Analysis (LENA) system offer a wearable audio recorder combined with automated vocal analysis software (LENA Research

Foundation, 2014). Such technology, although not without its limitations, has been validated and used as a method of data collection for a range of studies exploring language acquisition to date (Ganek & Eriks-Brophy, 2017; Greenwood et al., 2018).

Intervention

Given this body of evidence, it is unsurprising that a number of interventions have been developed which aim to support parents to, in turn, support their children's language development. The methodology of such interventions varies and includes those delivered through home visiting programmes, in primary care settings and through mobile health mechanisms (Leung et al., 2018; Leung, Leffel & Suskind, 2018; Suskind et al, 2016; McClure et al., 2018). Many of these interventions do, however, share a common aim – to use quantitative feedback to increase parental knowledge of their children's language development and the practices that encourage such development, with a view to inducing caregiver behaviour change which enriches the early language environment of their children.

The recent development of innovative technologies which can monitor and provide detailed feedback on caregiver language input provides a positive opportunity for further intervention. Such technology allows a more ecologically valid means of assessing and encouraging the quantity and diversity of words spoken by parents to their children in the real-life setting of the home environment. Interventions providing this type of feedback have demonstrated significant increase in participant children's language ability (Gilkerson, Richards & Topping, 2017). Preliminary findings also suggest that such educational interventions, delivered using quantitative linguistic feedback on the effect of the caregiver's language output has the potential to enhance the child's language environment – a very valuable outcome in the context of their broader language development (Suskind et al., 2013).

Research Questions

This pilot study has several aims. Firstly, the language analysis data provided by the app, together with demographic information collected on the participants, will be used to explore variations in the language environments of a cross-section of Irish homes. This will extend the existing 'Word Gap' research and explore language environments in an Irish context for the first time. This data will secondarily be used to assess whether the quantitative feedback provided to caregivers through their engagement with the app leads to behavioural changes which will enhance the home language environment. As highlighted above, a range of educational interventions which aim to increase parental knowledge of their children's development have been shown to be successful in achieving similar aims to date. Finally, a pre-study and post-study questionnaire will be used to determine whether

engagement with the app has increased caregiver confidence levels in supporting their child's language development.

Accordingly, the main research questions are:

1   Do family demographic factors predict the language environments children are exposed to?
2   Does the provision of feedback through an app elicit caregiver behavioural change in terms of how and how often they engage with their child?
3   Does the provision of feedback through an app elicit increased caregiver confidence levels in engaging and supporting their child's development?

Ethical Considerations

Ethical approval was obtained from the National College of Ireland Ethics Committee in November 2017. Due consideration was given to the following ethical considerations:

Privacy of the participant families

The data collection method used in this study involves recording participant caregivers, in their homes, during their interactions with their children. Accordingly, the protection of the privacy of participant families was a critical component of the application for ethical approval and something that remained a consideration throughout the study period. The following steps were taken to safeguard the privacy of participants:

- During registration, a uniquely identifiable number was generated to act as the identifier for all user-specific artefacts in the Talk2MeMore platform. This acted to anonymise the participant's data.
- With the exception of the participant's Username and Contact Number, all other data was stored on the Talk2MeMore database, hosted on a secure cloud-based service provider using international standard security protocols.
- The participant's Username and Contact Number were stored in a separate, secure location. This information was linked to the unique identifier for each participant and access to this information was limited to the Talk2MeMore research team and only made available in the event of a child or caregiver being at risk of harm.
- No personal data was shared with any third parties.

- Talk2MeMore prepared and adopted industry standard best practices to minimise the risk of exposure, with full details of measures in place contained in the Talk2MeMore Cybersecurity Policy.

Throughout the recruitment process, concerns around privacy protection were voiced by a number of potential participants. All potential participants were assured of the steps outlined above which would be taken to protect their privacy, should they proceed with the study.

Child protection

In accordance with Children First: National Guidance for the Protection and Welfare of Children, it was recognised that some potential ethical issues may arise in relation to child protection. Specifically, there was the potential for child emotional abuse to be observed in the home, through the data generated by the app (i.e. positive/negative language used by the parent with the child). In the instance that the language heard by the child was consistently 0% positive over a 2-week period, this could be considered an indicator of psychological and/or emotional abuse. Accordingly, a child safeguarding statement was developed, in line with the Children First Act 2015 and in consultation with a representative of Túsla. A Designated Liaison Person was assigned for both organisations (NCI and Talk2MeMore).

Methodology

The study commenced in November 2017 and data collection ceased in June 2018.

Study Procedure

Caregivers who were interested in taking part in the study were asked to follow a number of steps in order to participate.

1. **Completing the Consent Form and Questionnaire**
Caregivers who took part in the study were required to read and sign the study consent form. They also completed a questionnaire asking about their communication with their child and their confidence in talking, reading and playing with their child.

2. **Installing the App and Registering Personal Details**
Support was provided by either an ELI Home Visitor or a member of the Talk2MeMore technical team to install the app to their smartphone and register their details. The basic personal information asked during the registration process included their name, email address, child's first

name, child's age, child's gender, number of children they have, phone number and the parent's own level of education.

3. Using the App

Participants were asked to use the app for at least 30 minutes a day, for at least five days a week, over an eight week period (see below). When a caregiver decided to engage with the app, they turned it on to start the voice recording while they engaged with their child.

At the end of each session, participants were provided with quantitative feedback on the language their child was exposed to during the session, together with targets and suggestions on ways in which they can improve their child's language environment. Participants also received a daily update for the duration of the study period, providing additional advice and content related to increasing their child's language exposure such as links to instructional videos, book suggestions and activity ideas.

Participant Recruitment

During the study, participants were recruited through a number of pathways including through social media; direct contact with preschools and early years' services; and through home visiting programmes. Participants were considered suitable for the study if English was their first language; they had access to Wi-Fi/network connectivity at least once every 48 hours; and they owned a smartphone with an Android operating system.

A number of challenges surrounded participant recruitment. Firstly, the nature of the app – which records vocal parent-child interactions in the home environment – is one which presented concerns from some potential participants with respect to privacy. As highlighted above, this was an ethical concern which was given full consideration and the measures taken by the study to ensure protection of participant privacy was clearly communicated at all stages of the recruitment process with a view to assuaging this concern.

In the case of participants who were recruited through home visiting programmes, the home visitors themselves played a key role in increasing recruitment levels. However, feedback from those involved in these programmes suggests there was a degree of reluctance by home visitors to introduce or suggest participation in the study to some of the families they work with. This may have been for a number of reasons, with anecdotal feedback suggesting home visitors did not wish to impose what they viewed as an additional burden on families who may already be dealing with a number of additional stressors and challenges.

Data Collection

Demographic Information
Demographic information about the participant families, including parental age, education level, income level, marital status and child age and gender, was collected as part of the registration process.

Caregiver Confidence
Caregiver confidence was measured before and after the study using a questionnaire containing ten Likert-style questions which measured levels of caregiver confidence in supporting their children's language development.

Caregiver Behaviour Change
The pre and post-study questionnaires also contained a number of Likert-style questions which explored the caregivers' perceptions and behaviour regarding their child's language environment.

Language Analysis

When switched on and engaged during active sessions, the Talk2MeMore app collected quantitative data pertaining to language exposure using the following metrics:

- **Word Count:** The number of words transcribed for the user session

- **Volume of Positive Language:** The level of positive language observed during the user session

- **Question Count:** The number of questions asked during the session, indicating turn-taking

- **Language Complexity:** The style of language being spoken and sentence complexity

Results

Retention & Engagement

In total, 65 parents returned completed consent forms with a view to taking part in the study. However, active sessions of engagement with the app were recorded for only 39 of these parents. There were a number of reasons expressed for disengagement with the study at this early stage, including technological literacy challenges surrounding the onboarding process; parents realising that their

phone did not support the app; or changes in personal circumstances which made it impossible for parents to dedicate time to the study.

A total of 764 sessions were recorded throughout the pilot study period. Of these sessions, the average session length was 16 minutes with the maximum length of a recorded session being 102 minutes. Of the total of 39 participants, three engaged with the app for only one session. The longest period of engagement with the app during the study was 79 days (approximately 11 weeks), with the average period of engagement being 34 days (approximately 5 weeks). The average number of sessions recorded each week across the participants overall was 6.58. The participant who engaged most frequently with the app recorded an average of 16 sessions each week.

Description of Sample

Caregivers

In total, 39 caregivers actively engaged with the app. Of these caregivers, those who recorded a single session of less than one minute duration were excluded from the final dataset. The remaining 35 caregivers ranged in age from 12 to 43 years (M = 35.23, SD = 5.52). Approximately 80% of caregivers (n=28) were married while the remaining 20% (n=7) were single. The sample contained a mix of income levels represented by homemakers (n=13), full-time paid employees (n=17), part-time paid employees (n=3) and those who are either unemployed or unable to work (n=2).

The caregivers also demonstrated a diverse range of education levels, from those who had obtained Junior Certificate (n=1), Leaving Certificate (n=1), diploma (n=5), primary third level degree (n=11) and postgraduate qualification (n=9). Approximately 23% of participants identified as having only primary school level education (n=8). Given that this sample is intended to be representative of the wider population, this finding is somewhat surprising and is believed to be attributable to participant error during the registration process as 'Primary School' is the first available option on the drop-down list in this section of registration.

Caregiver Education Level (N=35)

- Primary School
- Junior Certificate
- Leaving Certificate
- Diploma
- Primary Third Level Degree
- Postgraduate Qualification
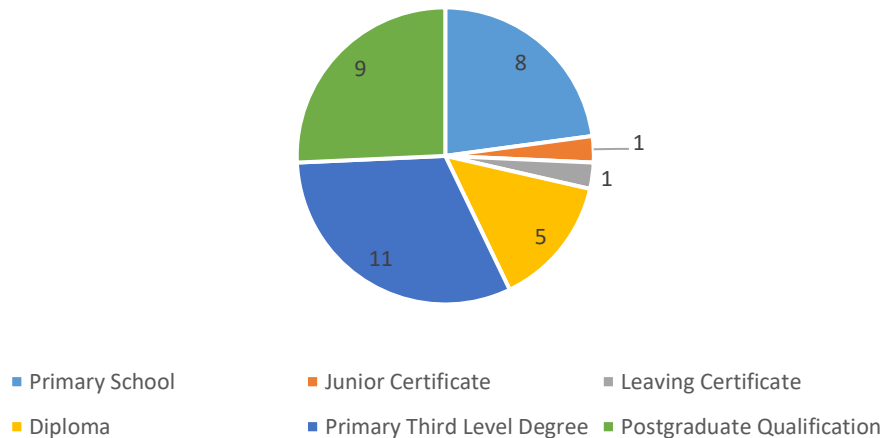
Children

The child sample involved in the study consisted of 28 boys and 11 girls who ranged in age from one month to 49 months (M = 20.43, SD = 13.12). The sample consisted of children who were the only child in their family, to those with up to three siblings. The average number of children in the participant families was 1.31 (SD = .68).

Session Engagement

The type of engagement that was demonstrated by participants with the app during sessions was also explored with respect to the activities engaged during the sessions and the time of day at which sessions took place.

Frequency of Activities

At the end of each session, participants were asked to indicate what activity or activities they were engaging in while recording the session with their child. The options are as follows, with participants able to select up to five options for each session:

- Reading
- Playing
- Everyday Activities
- Singing
- House Chores
- Watching TV
- Other

The frequency of activities recorded during sessions across the full study period are presented below.

Frequency of Activities During Session (N=1040)

Frequency of Activities During Session (N=1040)
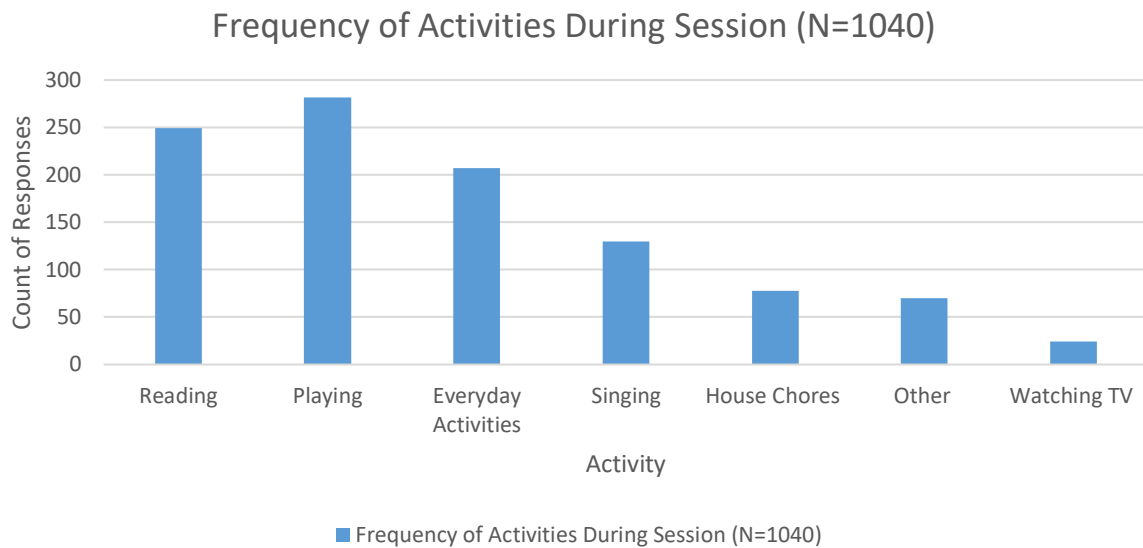
As can be seen above, reading, playing and everyday activities were the most popular activities engaged during the sessions throughout the study period. This is a positive finding in the context of the quality of the children's language environment, in which naturalistic activities, such as reading, play and everyday activities, have been shown to support language development. The benefits of parent-child shared book reading for preschool children's emerging language skills are well recorded in the research literature (Farrant & Zubrick, 2013; Reese, Sparks & Leyva, 2010; Zauche et al., 2016). Furthermore, periods during which parents read to their child have been shown to yield higher adult word counts and conversational turns than non-reading periods, for both high and low education level parents (Gilkerson, Richards & Topping, 2017). Play is another activity which – when engaged between adult and child – has been demonstrated as valuable in scaffolding child language acquisition (Wasik & Jacobi-Vessels, 2016; Weisberg et al., 2013).

Any variations in the activities engaged by parents during sessions were explored in the context of parent income and education levels. Although engagement in certain activities were comparable between homemakers and employed parents, there was significant variation in parent engagement in reading depending on level of education.

Activities Engaged by Parent Income Level
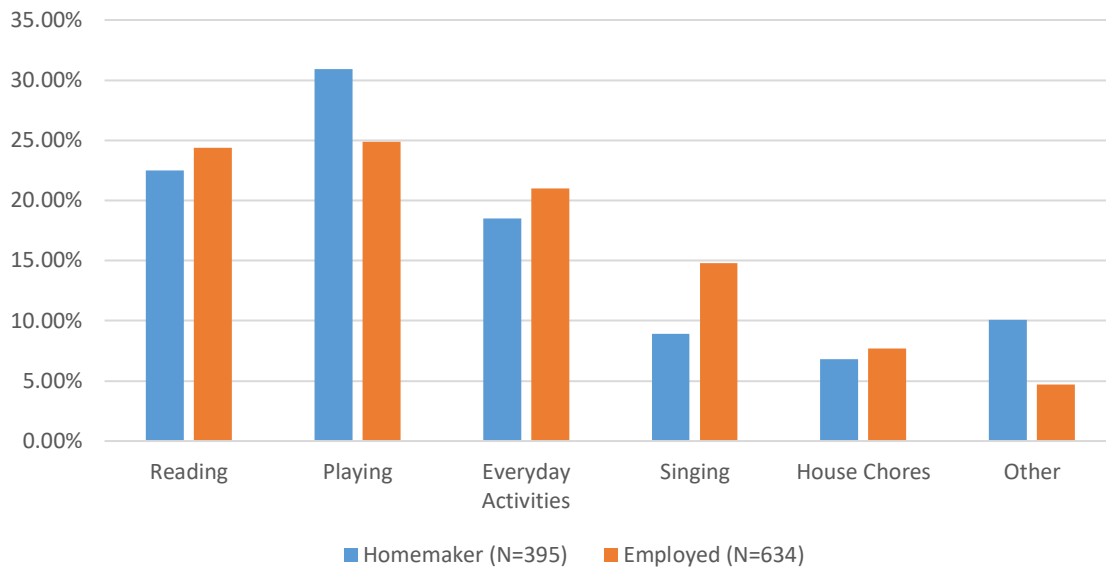
As seen below, of the 492 activities recorded at the end of sessions by parents with postgraduate level education, 38.7% of responses related to reading. Comparably, reading formed 17.7% of recorded session activities by third level parents (N=492 recorded activities) and 15.3% of recorded session activities by parents with primary or secondary level education (N=215 recorded activities). This finding is supported by a body of research which links parental educational level to both the quality of the home learning environment and the developmental and academic outcomes of children (Burchinal et al., 2002; Kalil et al., 2012; Myrberg & Rosen, 2009). Another observable difference between the differing parental education levels is in the frequency of selecting 'Other' activities as an option at the end of sessions. As can be seen below, parents with up to secondary level education selected 'Other' activities approximately four times more than parents with third level or postgraduate education. This is an interesting observation although, with no further information available as to what these 'other' activities consisted of, it is not possible to gain further insight into this difference (see Recommendation 4 below).

Activities Engaged by Parent Education Level

Legend:
- ■ Primary/Secondary Level Education (N=215)
- ■ Third Level Education (N=492)
- ■ Postgraduate Education (N=285)
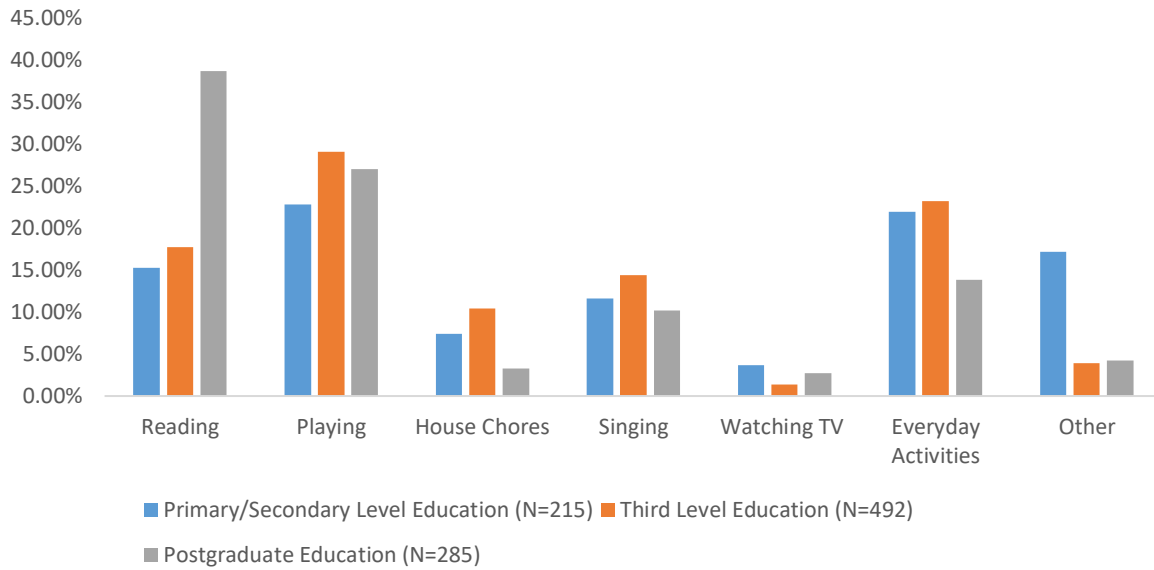
Time of Session Engagement

Parents engaged with the app at varying times of day with the highest frequency of sessions recorded between 20.00 and 21.00 (see figure below).
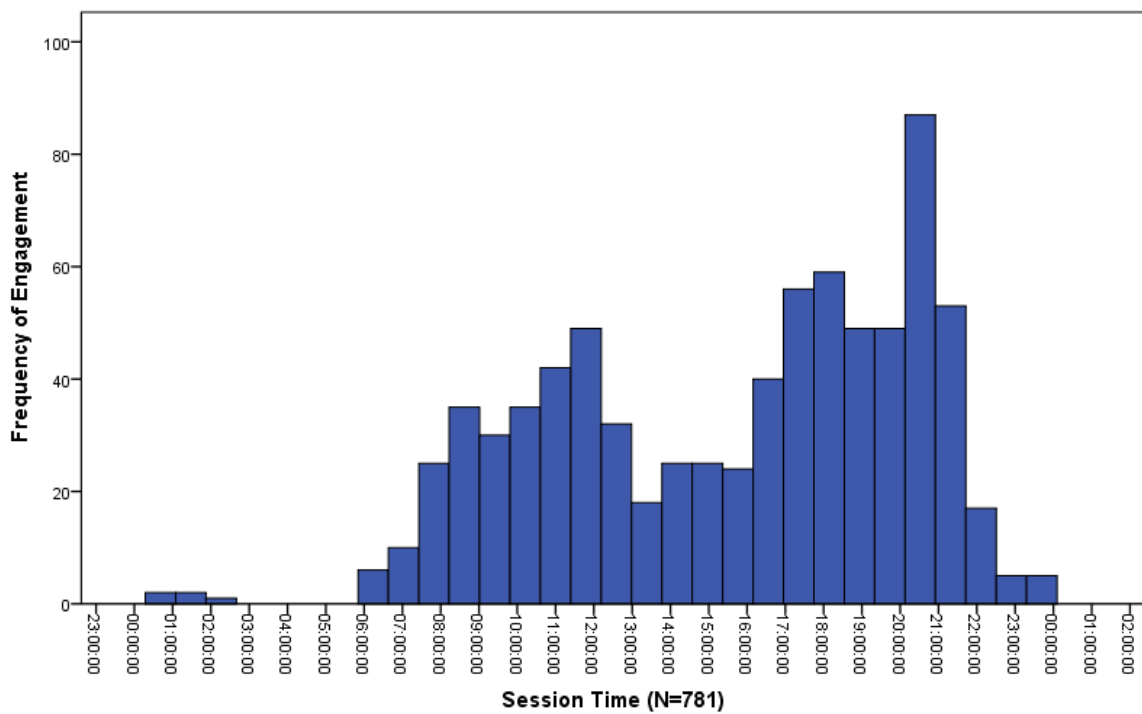
Baseline Language Exposure

Baseline Demographics

In order to obtain an accurate baseline measure of participant families' language environments – and to account for technological challenges or participant error during the first session recording – the average of each participant's first three sessions was obtained with respect to all of the dependent variables, together with demographic data on each participant. Participants who had engaged with the app less than three times were excluded. Accordingly, baseline data was available for 31 participants.

Demographic information for the baseline sample are presented in the tables below.

Variable	Minimum	Maximum	Mean	Standard Deviation
Parent Age (Years)	12*	43	35.68	5.68
Child Age (Months)	0	49	20.32	13.1
Number of Children	1	4	1.35	.71

Variable	Category	Frequency
Income Level	Home Maker	12
	Full-time Paid Employment	15
	Part-time Paid Employment	2
	Unemployed	1
	Unable to work due to illness/disability	1
Education Level	Up to Secondary Level	9
	Third Level Education	14
	Postgraduate Education	8
Marital Status	Single (Never Married)	6
	Married (Not Separated)	25

### Baseline Quantitative Language Variations

Nonparametric statistics were used as the baseline data did not display normal distribution. A variety of tests were used to determine any variation in the dependent variables (i.e. word count, question count, words per hour, questions per hour, number of sentences and lexical diversity (as measured by the count of adverbs, nouns and verbs in each session)) across the demographic data. A series of correlations indicated that no significant relationship existed between any of the dependent variables

and any of the demographic variables. Looking to differences between the demographic groups with respect to the dependent variables, a series of independent-samples Kruskal-Wallis H tests indicated a significant difference in relation to number of sentences per session with respect to education level only ($x^2(2)$ = 6.91, p = .032). Looking to the differences between the three education levels (up to Secondary Level, Third Level and Postgraduate Level), the highest average number of sentences per session at baseline were recorded by caregivers with third level education (n = 14, M = 19.71), followed by those with postgraduate education (n = 8, M = 16.75). The average number of sentences per session recorded at baseline by parents with up to secondary level education was 9.56 (n=9).

A series of Spearman's correlations also indicated a relationship between the number of sentences per session and education level (r_s = .361, p =.046) and between number of questions per hour per session and income level (r_s = -.374, p =.038). No significant relationship was identified between any of the other variables.

Baseline Session Activities

The activities selected by participants at the end of their first three sessions were combined to give an indication of the types of activities engaged at baseline. Participants were able to select up to four activities in which they engaged during each recording session. Across the 31 participants who recorded a minimum of three sessions, a total of 114 activities were selected during these first three sessions. The most popular activities during the baseline sessions are presented below.

Activities Engaged During Baseline Sessions (N=114)
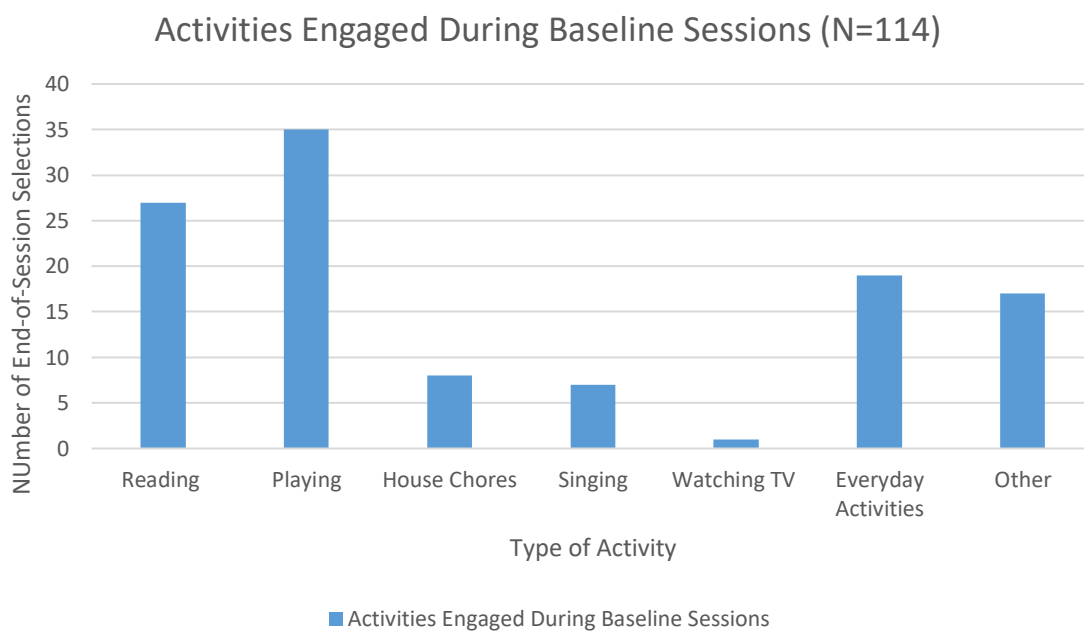
Caregiver Behaviour Change

Caregiver behaviour change was assessed using two different forms of data collection. Firstly, responses provided by participants to a pre-study questionnaire exploring their behaviour in relation to their child's language environment were compared to responses to identical questions in a post-study questionnaire.

Pre- and Post-Study Questionnaire

In total, 22 completed pre-study questionnaires and five post-study questionnaires were received. Accordingly, pre-post comparison and an assessment of caregiver-reported behaviour change could only be carried out in relation to five participants. This represents a very small sample size and, accordingly, the results below should be interpreted with caution and should not be taken to represent the level of behaviour change which occurred throughout the full sample.

Responses were given on a Likert-style scale with participants asked to indicate their level of agreement with a number of questions about their behaviour with respect to their child's language development. In total, 20% of parents (n=1) indicated increased agreement with the statement "an adult/caregiver talks directly with my child for more than two hours per day". A further 40% of parents (n=2) demonstrated decreased agreement with this statement and the remaining 40% of parents (n=2) demonstrated no change in their agreement with this statement. In relation to the amount of time their child spends interacting with technology, 80% of parents (n=4) indicated no change in their agreement with the statement "my child spends more time each day interacting with another person than watching TV/using tablet/phone". The remaining 20% (n=1) indicated decreased agreement with this statement.

Similarly, 60% of parents (n=3) indicated no change in the extent to which they talk to their child during daily routines (e.g. when cooking, feeding, giving a bath) and the remaining 40% of parents (n=2) indicated a decrease in this behaviour, based on their level of agreement with the statement "I usually talk to my child during daily routines". Taken collectively, these results indicate that a small minority of parents demonstrated positive behaviour change following the study, as compared to their behaviour before the study. However, given the very small sample size available in this regard, these results should be interpreted with caution. It should also be noted that all parents (n=5) responded positively at the pre-study stage to all of these statements, indicating some level of agreement.

Language Analysis

To explore whether any change was exhibited in the dependent variables over the study period, they were examined at three time-points, the first being the first session recorded by the participants. As

participants were asked to engage with the study for five days a week over an eight-week period, the final time-point represented data recorded during the 40th session. The mid-study time point represented data recorded at the 20th session. Due to variation in the number and length of sessions between participants, the sample size between each time-point is quite different and this should be considered when interpreting the results below.

Variation in the quantity of words the children were exposed to throughout the study period was explored using the word count per session (or, in the case of the baseline measure, the average word count of the first three sessions) and the number of words per hour in the session.

As can be seen below, the quantity of words in the language environment does appear to have exhibited some level of change across the study period. The variability in the sample sizes below and in the length of each session must again be taken into consideration when interpreting this finding. Furthermore, limitations in the manner in which this data was collected (further explored below) mean that it is impossible to determine the quantity of words spoken by the parent, compared to those spoken by the child or other background voices. Accordingly, it is not possible to conclude whether the results below indicate a change in caregiver behaviour.
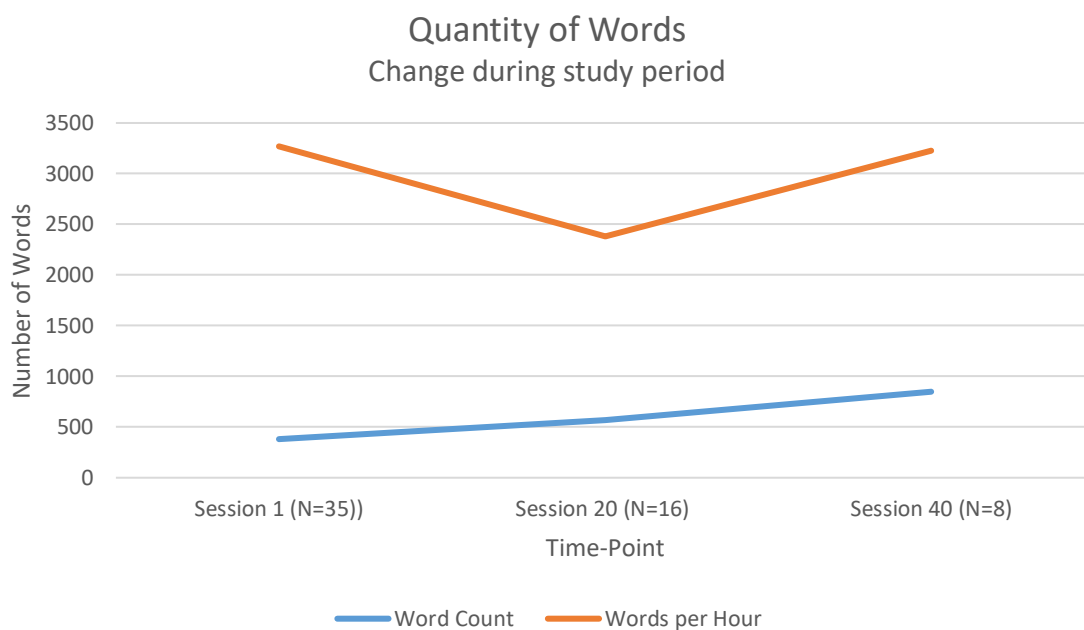

The level of conversational turn-taking was explored using the count of questions in each session and the number of questions asked per hour. Again, limitations in the data and the small and varying sample size across the three time-points should be taken into consideration when interpreting the below results, which do not suggest significant increases in turn-taking.

Conversational Turn-taking
Change during study period
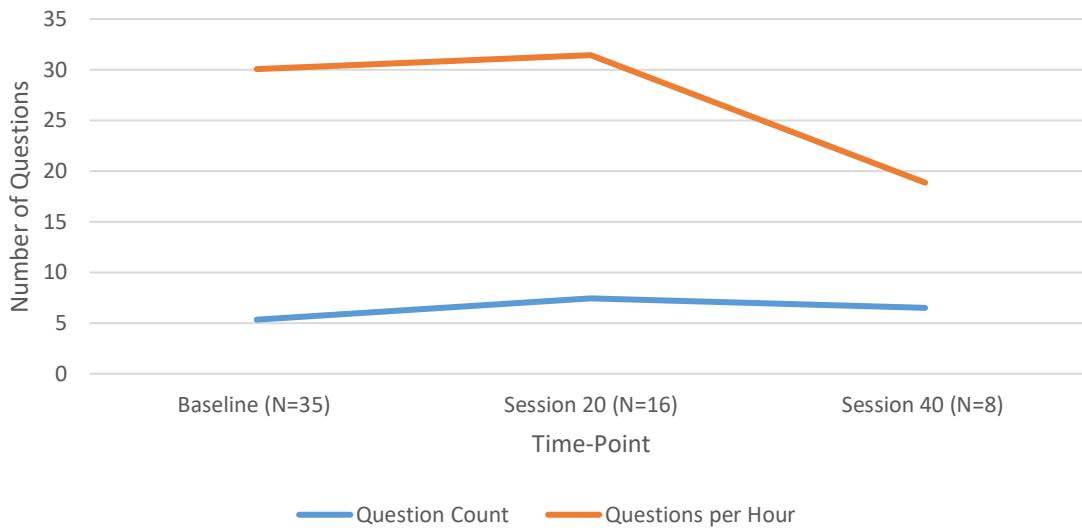
The activities recorded at baseline were also compared to the frequency of activities recorded during the final three sessions recorded by each participant. This comparison is presented at the chart below.

Activities at Time 1 and Time 2
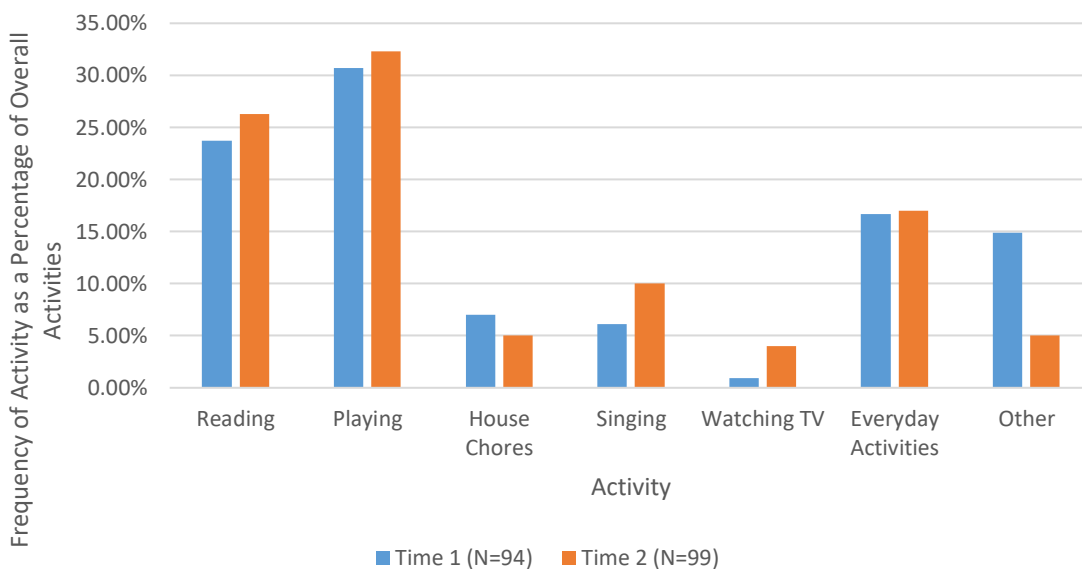
The positivity of the sentiment of language used during the study was also explored (see below). Again, the size of the sample and the limitations in the data should be considered when interpreting what

appears to be a reduction in the percentage of positive sentences recorded during sessions across the study period.

Positive Sentiment
Change during study period
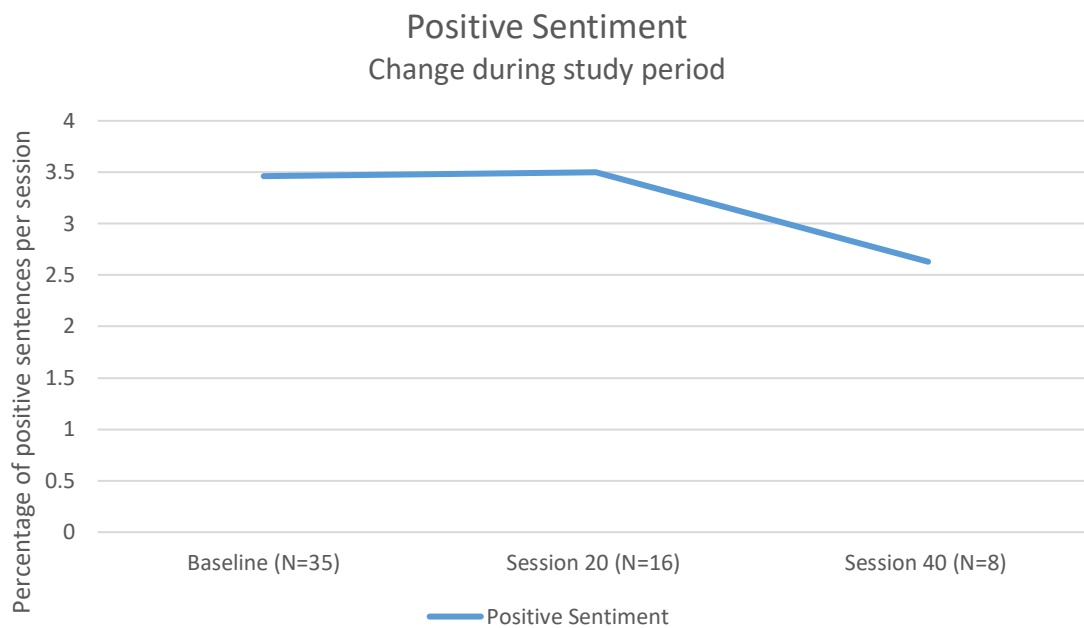
Study Completion Sample

Following the above analyses, it was determined that a total of eight participants completed the full study period (i.e. at least 40 sessions). The demographic characteristics and language environments of these eight participants were explored separately.

Description of Study Completion Sample

Caregivers

In total, eight caregivers actively engaged with and completed the intervention as recommended. Parent participants ranged in age from 31 to 43 years (M = 36.79, SD =3.17). Of these "completers", a total of seven (90%) of caregivers were married while the remaining 10% (n=1) was single. The sample contained a mix of income levels represented by homemakers (n=4; 50%), full-time paid employees (n=3, 37.5%) and part-time paid employees (n=1; 12.5%). These caregivers also demonstrated a diverse range of education levels. Two participants (25%) identified as having only primary school level education, three participants identified as having obtained a primary third level degree (37.5%) and a further three participants report having obtained postgraduate qualifications (37.5).

Children

The child sample consisted of a total of five males (62.5%), three females (37.5%) who ranged in age from 1 month to 38 months (*M* = 18.25, *SD* =12.99). This sample of "completers" was comprised of children who were the only child in their family (n=6), children with one sibling (n=1) and children with two siblings (n=1). The average number of children in the participant families was 1.38 (*SD* = .74).

Demographic information for the baseline sample are presented in the tables below.

Variable	Minimum	Maximum	Mean	Standard Deviation
Parent Age (Years)	31*	43	36.79	3.17
Child Age (Months)	1	38	18.25	12.99
Number of Children	1	3	1.38	.74

Variable	Category	Frequency
Income Level	Home Maker	4
	Full-time Paid Employment	3
	Part-time Paid Employment	1
	Unemployed	0
	Unable to work due to illness/disability	0
Education Level	Primary Education	2
	Third Level Education	3
	Postgraduate Education	3
Marital Status	Single (Never Married)	1
	Married (Not Separated)	6

The Language Environment

Baseline language environment was measured using data recorded in Session 1 (T1). Data recorded at a mid-way point (Session 20; T2) and final session (Session 40) functioned as an indication of progress and post-intervention (T3). Analyses of participant measures of all of the dependent variables, together with demographic data on each participant (i.e. caregiver NFQ level, education level and income level) were conducted.

Nonparametric statistics were used as the baseline data did not display normal distribution. The Friedman Test was used to explore differences in the sample as a whole across time. The Kruskal-Wallis Test was used to analyse all dependent variables (i.e. the quantitative language variables of word count,

words per hour, question count, questions per hour, sentence count) according to demographic categories.

The results of the Friedman Test indicate there are no significant differences in the average dependent variables across demographic categories. The results of the Friedman Test indicate there are no significant differences in the average word count in a session across the three time periods (p = .88). Comparing the Mean Ranks for the three sets of scores it appears there was an initial increase followed by a decrease in the average word count over time. This pattern is observed across all remaining dependent variables.

Kruskal-Wallis H tests and Independent samples Mann Whitney U Tests indicated no significant difference in the dependent variables across categories of income, education level, marital status, number of children or child gender. A series of Spearman's rho correlations indicated a negative correlation/relationship between baseline education level and engagement in reading (r_s = -.757, p =.03) and positive correlation between education level and baseline sentence length (seven words).

A series of Spearman's rho correlations indicated a borderline positive correlation/relationship between education level and sentence length (six words) recorded at Session 20 (r_s = .708, p =.049).

No other significant relationships were identified.

Caregiver Confidence

Caregiver confidence was assessed at the beginning of the study using the aforementioned Pre-Study Questionnaire and after the study using the Post-Study Questionnaire. As mentioned above, pre- and post-study questionnaires are available for comparison with respect to five participants only. In total, 60% of parents (n=3) demonstrated an increase in their agreement with the statements "I know how children learn new words"; "I know what to do to help my own child learn new words"; and "I feel confident that I can help my child's language development". All parents who responded to the post-study questionnaire indicated in an increase in their agreement with the statement "I know where to look, or who to ask, to get information on how to help my child learn new words". 80% of parents (n=4) indicated increase agreement with the statement "I feel confident that I use the right strategies to help my child to learn new words". Read together, these results suggest an overall increase in caregiver confidence at the end of the study as compared to confidence at the beginning of the study. However, caution must again be noted in interpreting these results, given the small sample size available here.

Participant Feedback

As part of the post-study questionnaire, participants were asked to provide feedback on their experience of engaging with the Talk2MeMore app. As mentioned above, a total of five completed post-study questionnaires were returned. In total, 80% of the five parents who responded to the post-study questionnaire agreed or strongly agreed that using the app was useful for them and for their child; that they learned new strategies that can support their child's language development; and that they have changed how much they talk to their child as a result of the study. All five participants who responded post-study indicated that they have the confidence to use the knowledge they gained from the app in their life. Full results are presented below:

Question	Agreed/Strongly Agreed	Disagreed/Strongly Disagreed	Neutral Response
Using the app was useful for me	80% (n=4)	-	20% (n=1)
Using the app was useful for my child	80% (n=4)	20% (n=1)	-
The programme duration (8 weeks) was too long	-	60% (n=3)	40% (n=2)
The programme duration (8 weeks) was too short	20% (n=1)	20% (n=1)	60% (n=3)
I have the confidence to use the knowledge I gained from the app in my life	100% (n=5)	-	-
I have learnt new strategies that can support my child's language development	80% (n=4)	-	20% (n=1)
I changed how much I talk to my child as a results of this study	80% (n=4)	20% (n=1)	

Participants also provided qualitative feedback about their experience of using the app. Comments from participants in this respect are outlined below.

Question	Feedback
From your experience of this app, what would you	*I found the app really useful however I found that the app picked up a lot of background noise, so even when we weren't speaking the app was registering that we were. This meant it was very hard to see results in Sentence Length.*

suggest would have improved the app?	*The screen cannot be locked when using the app so it attracts the child's attention to the phone unfortunately. It is hard when using the app if you are playing because you put the phone down but when playing you can't move away and if you do the app can't hear you. Possibly feedback could be given halfway through the programme at the 4 week stage. The tables after each session showing the amount of verbs, nouns etc the child hears. Could this be geared for the age of the child so you are getting more specific feedback for your child?* *Every time I click 'Let's Talk', the app thinks it's my first time. Confused by, for example, stats on March 21st – my word count in 15 minutes was 11,000. Per hour shows 5,526. Target was 706. But I see nothing on progress chart for that data.* *It was really buggy. It crashed during recording frequently and didn't always give me a reading on the number of words heard.* *Ios software as that is the phone I have. Maybe reminders when you log in what to work on specifically.*
From your experience of this app, what was most useful about the app?	*It was great to see the analysis each day and improvements that I was making for my daughter* *The daily updates and information to read to help my child progress were very useful* *I loved the tips and articles. Loved seeing results and progress* *The daily hints* *The data, in particular sentence length*
From your experience of this app, what was least useful about the app?	*As mentioned above, it was a little frustrating that the sentence length did not register correctly. On days when I really put in the effort to speak shorter sentences, it still showed majority 10 word sentences* *Tring to turn on the record wasn't very handy. When you're busy with small children a few less steps to pressing record could be helpful* *The target % of verbs, nouns, adjectives, adverbs of exactly 25% seems unattainable. Seems like hard to make sentences like that.* *The daily progress – when it did give me a number of words heard, it was hard to tell how accurate it was. The range was huge (from 2 digits to 4)*

Challenges & Recommendations

As mentioned throughout the above report, a number of challenges were faced throughout this study which have limited the ability to fully interpret or draw conclusions from the results presented above. These challenges are presented below, together with recommendations for future research which employs Talk2MeMore.

Challenge 1: Participant Retention

Significant participant attrition was observed throughout the study period. Looking to those participants who successfully recorded the recommended 40 sessions, the retention rate for the study was just 23% (n=8), compared to the number of participants who engaged in at least one session (n=35).

Comparably, the Parent Child Home Programme – an intervention with similar aims to Talk2MeMore (i.e. improving the home language environment) but very different methodology (i.e. twice weekly home visits by a trained paraprofessional) – has had an average programme retention rate of 82% over the last two years. This difference highlights the difficulties inherent in maintaining parent engagement in technology-based interventions, as compared to those with more traditional methods of delivery.

Recommendations

A review of the research in this area suggests that greater engagement and more positive outcomes may be achieved through a more "blended" intervention approach rather than using "stand-alone" technology-based programmes (Hall & Bierman, 2015). Although weekly email contact was made with participants throughout the study period to promote engagement, the high attrition rate suggests that this approach was not sufficient. Future studies exploring the efficacy of the app should perhaps follow a more structured and effective support protocol incorporating, for instance, regular phone or face-to-face supports.

The issue of participant retention will particularly need to be addressed in any future roll-out of the intervention amongst populations containing high levels of parents with lower levels of education,

as research suggests that such categories of parent are more difficult to retain to early interventions and parenting programmes are less likely to engage (Axford et al., 2012; Hackworth et al., 2018).

Challenge 2: Quality of Self-Report Demographic Information

As highlighted above, the data collected on participants' self-reported demographic characteristics highlighted some potential methodological challenges. In particular, participant error is understood to have arisen on at least one occasion in relation to reporting parent age (where one participant identified inaccurately as being aged 12 years) and in relation to parent-reported education level (where an unprecedented number of parents selected 'primary school education' as being their highest level of education).

Given the relatively small sample size involved in this study, there is higher potential for such errors to significantly impact on the study's findings, particularly in relation to demographic variation.

Recommendations

Rather than allowing participants to self-report on demographic information through the app's registration process, it is suggested that more accurate demographic information may be gathered by a researcher, through an initial participant interview, conducted face-to-face or over the phone.

An additional recommendation in relation to the gathering of demographic information is to facilitate the provision of information about the gender of the parent engaging with the app, either during participant set-up or at the beginning of each session to allow for further and more detailed exploration of caregiver behaviour change.

Challenge 3: Data Limitations

A number of limitations with respect to the data collected were identified.

Quantitative Language Analysis

A key limitation of the data collected by the app is the inability of the technology to distinguish between the parent, child or background voices. This limitation has a significant impact on the ability of the data to address one of the primary research questions i.e. the extent of *caregiver* behaviour

change. A more detailed breakdown of the quantitative language variables, accounting for the different voices recorded as part of a session, would allow for more detailed exploration of the language environment.

Qualitative Sentiment Analysis

Data pertaining to the app's analysis of the sentiment (positive or negative) of language recorded was explored by the research team and the following limitations were identified:

- The sentiment analysis does not appear capable of taking into account the context of the language used. Accordingly, some words and sentences were categorised as being negative where, in context, they arguably represent a positive parent-child interaction. For instance, lines from the popular *Gruffalo* series of children's books ("gruffalo crumble crumble"; "gruffalo he has terrible and terrible claws and terrible") were categorised as negative language when, arguably, such content should not be included in an analysis of the sentiment of the *parental* language.

- The quality and accuracy of the app's transcription functionality also appears to be limited. The qualitative data provided in relation to sentiment analysis contains excerpts from sentences which seem, in many cases, to be nonsensical. While this is an understandable technical limitation which is undoubtedly impacted by external factors such as background noise or proximity to the recording device, it does call into question the quality of the data collected by the app in this respect. Accordingly, the reliability of this data and any findings drawn from it must be interpreted with significant caution.

Recommendations

While it is appreciated that the above challenges represent technological limitations of the app which may not be easily addressed, clearer guidelines to parents in their use of the app may facilitate the collection of more reliable and accurate data. For instance, while parents may be told to minimise background noise during a session recording, one of the session activities available as an option at the end of each session is 'Watching TV'. This gives a mixed message to parents as it suggests that having a television on in the background is an acceptable activity to be engaged in during session recording. Rather, it should be made clear that having a television/radio on in the background has the potential to introduce other voices which will impact on the quality of the language analysis and should therefore be restricted in the environment during recordings.

Furthermore, although it is understandable from an ethical perspective that full transcripts of the sessions recorded by participants be unavailable to the research team, it is recommended that future

handling of this ethical consideration allow for access by the research team to such recordings. This would allow researchers to gain valuable insight into the context of quantitative and qualitative data provided by the app and would assist in validating such data. Greater validity in the data produced would allow for more meaningful and reliable interpretations of any results drawn from this data.

One additional note in this respect is that differences were observed in the activity engagement between parents of varying education levels. Specifically, parents with up to secondary level education selected 'Other' activities at the end of their sessions approximately four times more than parents with third level or postgraduate education. It would be interesting to explore this finding further, however no further information is available on what these 'Other' activities consist of. Introducing the ability for parents to provide more details on the 'Other' activity they are engaged in would allow for some level of qualitative analysis and might give more insight where similar findings are observed in future similar studies.

Challenge 4: Experimental Control

A number of aspects of the study's procedures lacked sufficient experimental control, which called into question the credibility and reliability of the data collected.

In particular, the number and length of sessions recorded by each participant varied significantly. This impacted on the distribution patterns of the data and restricted the sample size considerably at time points subsequent to the baseline. Although clear guidelines were provided to participants around the desired number and duration of sessions to be recorded as part of their participation in the study, and the additional measures they would be required to complete (i.e. pre- and post-study questionnaire), very few participants subsequently provided data that met the requirements of the study to effectively answer its research questions.

Recommendations

It is appreciated that by allowing parents to engage with the app free from the supervision of a researcher, in their own homes and at a time that is convenient to them, this study benefitted from a degree of ecological validity that would otherwise not be achieved. However, this ecological validity has led to significant compromise on the amount of control available to the research team over the

experimental environment and procedure. Greater control in this respect is essential to rectifying some of the data limitations highlighted above. This control may, for instance, take the form of monitored sessions, recorded in the presence of a researcher. Depending on the size of the sample and the number of sessions recorded, random sampling may be sufficient in this respect.

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