Impact of Maternal Smartphone Use on Language Output

by

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Abstract

Smartphones have not been critically assessed to the same extent as television to determine their potential impact on infant language development. Twenty-eight mother-infant dyads (*Female* = 17, *Male* = 11) 6 to 9 months-old (N = 13, M = 7.46 months, SD = 1.05) or 12 to 15 months-old (N = 15, M = 12.8 months, SD = 0.77) were recorded for 4 hours using the Language Environment Analysis device while maternal smartphone usage was tracked using a third-party application (*RealizD* or *QualityTime*). Previous research indicates that social media is frequently used by mothers for interpersonal support (Duggan et al., 2015), therefore it was critical to determine how these types of applications might impact infant language development. Mothers with 6 to 9 month-old infants used their smartphones about the same as mothers with 12 to 15 month-old infants. Maternal smartphone usage did not relate to the amount of language when analyzed across the whole 4 hours but correlated with less language heard by infants when examined at the 5-minute level in the 12 to 15 month age group. Finally, maternal social media use was not associated with decreases in the language heard by infants in the study. These results suggest that social media specific smartphone usage had minimal impact on the amount of language infants heard. While maternal smartphone usage impacted the amount of language heard by infants at the 5-minute level, age was the most important determinant in how often a mother spoke to her infant.

Keywords: smartphone, social media, infant language development, maternal speech, LENA

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List of Appendices

Impact of Maternal Smartphone Use on Language Output

An important component of infant language development is a healthy learning environment. Frequency of speech is a well-documented factor contributing to language acquisition (Diessel, 2007; Rowe, 2012), and research has shown that the more caregivers speak to infants, the better their linguistic outcomes are at 3-years-old (Hart & Risley, 1995). Reviews conducted on infant linguistic development research show that the effects of language learning are apparent even among preverbal infants (Soderstrom, 2007; Kuhl, 2010). For example, infants' preference for maternal speech is theorized to begin during the third trimester as fetuses become responsive to sound in utero (Busnel & Granier-Deferre, 1983; DeCasper & Spence, 1986; Mastropieri & Turkewitz, 1999). Current studies also indicate that infants are beginning to understand labels for common objects as young as 6 to 9 months-old (Tincoff & Jusczyk, 1999; Bergelson & Swingley, 2012). Conversational exposure is critical to helping young children develop better language skills. For example, when Huttenlocher et al., (1991) used audio and video recording to monitor play sessions between infants and their mothers, they discovered that vocabulary acquisition was related to the amount of speech mothers used during playtime. Additionally, conversational exchange has been linked to greater linguistic functioning in the minds of 4 to 6 year-old children across various levels of socioeconomic status (Romeo et al., 2018).

The home environment and quality of speech being used impacts language outcomes for infants across several stages of development (Ramírez-Esparza et al., 2014; Rowe, 2012). The variation of linguistic input also becomes increasingly important between the ages of 1 and 3 and a half years old (Huttenlocher et al., 2010). These studies indicate that caregiver-infant communication is extremely important to an infant's language development. Parent-infant conversations have been linked to improved language skills (Zimmerman et al., 2009; Goldstein

& Schwade, 2008; Warlaumont et al., 2014), which shows that it is important for parents to speak to their infants. Furthermore, parent-infant interactions have been found to be a better predictor of early language skills than reports of home literacy activities among infants 14-, 24-, and 36-month-olds (Dodici et al., 2003).

Maternal responsiveness is particularly important since most speech young children hear comes from female adults (Bergelson et al., 2019). For instance, maternal responsiveness is related to vocabulary development in the second year of life when infants begin to produce their first words (Tamis-LeMonda et al., 1998). The extent to which a mother is verbally responsive influences their infants' language development (Tamis-LeMonda et al., 2001), but distractions caused by smartphone usage may lead to a disruption in this relationship.

Importance of Social Interaction

Research on smartphones is still developing, however there is a robust literature that documents the distracting influences of other kinds of media, particularly television, on caregiver behaviour. For instance, when infant-directed video was used during playtime in a laboratory-controlled experiment, parents were less likely to talk to and play with their infants than when it was turned off (Courage et al., 2010). Furthermore, mothers who use electronic devices while breastfeeding have a decreased quality of interpersonal interaction with their infant (Ventura et. al., 2019). When mothers are not using a smartphone themselves, their child may be using it instead. A questionnaire-based study discovered that while some mothers think infants are capable of learning from smartphones, others believe it can be detrimental to their future development (Lee & Education, 2013). But is there evidence that infants can learn from video input alone (Chau, 2014)? This feature is readily available on child-centered applications which claim to teach language skills (e.g., Applications like *First Words for Baby;* Version 2.5).

The short answer seems to be “no”. Kuhl et al. (2003) had native Mandarin speakers read books and play with 9 month-old American infants in 12 sessions during a 4-to-5-week period; these infants were then compared with a control group who heard English during the 12 sessions. When later tested on their discrimination abilities between Mandarin and English, they found that the experimental group performed significantly better than the controls. Comparatively, when infants listened to the same language materials presented using audio-recordings or television, the experimental and control groups had similar performance outcomes indicating that interaction is an important factor to infant language learning (Kuhl et al., 2003). These findings are further supported by research determining that toddlers are unable to learn a novel word when using edited video clips, such as those from the *Teletubbies* children’s program (Krcmer et al., 2007). Even older children have difficulty learning from video-mediated events. For example, 4 and 5-year old children display weaker memory recall for scenes that are filmed versus scenes that are observed through a windowpane (Kirkorian, 2018).

It seems evident from the previously cited studies that children find it difficult to learn from screens alone and caregivers are less sensitive when their smartphone is in use. Although these studies did not examine smartphone applications specifically, they have determined that disruption from digital devices negatively impacts the amount of caregiver-child interaction. A continued lack of social interaction could impact children who are attempting to learn speech. Therefore, being mindful of activities that could negatively impact mother-infant interaction was a necessary component in the present study. Research has shown that increased smartphone usage leads to distraction among caregivers (McDaniel, 2019) so it is critical to determine if maternal smartphone usage impacts the amount of language infants hear.

Maternal Responsiveness

When mothers respond to communication efforts made by their infant, they help to scaffold future learning in their linguistic skills and conversational abilities. A longitudinal study by Tamis-LeMonda et al., (2001) discovered that maternal responsiveness was related to 5 early linguistic milestones: first imitations, first words, 50 expressive words, combined speech, and use of the past tense. They discovered that mothers' active responsiveness was positively correlated with reaching the predicted timings of each listed milestone. Another study found that when mothers gave contingent verbal feedback to their infants' speech, the infants subsequently changed their babbling to match the new phonetic patterns being introduced by their mothers (Goldstein & Schwade, 2008). Infants who babble also encourage further attention and social interactions from their mothers (Albert et al., 2018), indicating a strong two-way relationship. That is, both maternal responsiveness and communicative efforts by the infant are important predictors of linguistic development (Paavola et al., 2005).

When mothers respond to language efforts made by their infant, they often adapt their speech to help future learning. These contingent responses to infant vocalizations help map words to referent objects, which aids in future vocabulary development (Tamis-LeMonda et al., 2014). Mothers also tend to use longer and more complex vocalizations as their infants get older (Stern et al., 2008). Current research shows that parents are more likely to respond to speech related vocalizations than non-speech related vocalizations made by infants (Elmlinger et. al., 2019). This finding supports the reasoning of the social feedback loop: infants begin to produce language by babbling, but caregivers are more likely to respond to utterances that sound similar to their own speech. These verbal responses help to teach the infant their native language as well as which noises capture their parents' attention the most. While both the parent-infant pair are contributing to the conversation, the loop relies on the caregiver providing a contingent response (Warlaumont et al., 2014; Goldstein & Schwade, 2008).

Mothers typically maintain this healthy relationship by paying close attention to their infants' vocalizations (Tamis-LeMonda et al., 2001). By responding contingently to their infant, caregivers can encourage future language development (Elmlinger et. al., 2019). However, disruptions in this feedback loop could be problematic for infant language development. A possible cause of this disruption are smartphones; these devices are used by parents to communicate with one another as well as gain support remotely (Duggan et al., 2015). While smartphones can be an asset to parents, research has determined that increased smartphone usage leads to reduced caregiver responsiveness towards children (McDaniel, 2019). It is important to note that most of the studies previously cited were conducted with older children rather than infants.

Smartphones

Versatility of Communication

The rise of smartphones has pushed alternate forms of communication to the wayside; most significantly, the landline has become virtually obsolete in certain populations (Rennhoff & Routon, 2016). Smartphones allow the user to customize how they wish to interact with the other person while communicating (e.g., Skype and FaceTime are highly interactive in comparison to texting and emailing). However, increased smartphone usage can lead to disruptions in the interactions that occur between caregivers and their children (McDaniel, 2019). McDaniel named this trend *technoference*; it describes how different types of readily available technology (e.g., laptops, tablets, smartphones, etc.) have the potential to interfere with parent-child relationships (2015). When technology disrupts family interactions, mothers are more likely to report problems with their spouse (McDaniel et. al., 2018) and report feeling depressed (Newsham et. al., 2020). *Technoference* is also associated with behavioural problems among young children

(McDaniel & Radesky, 2018) and negative affect among infants (Stockdale et. al., 2020), however the directionality of these results still needs to be examined.

While smartphone usage has continued to increase, landline usage has subsequently decreased (Rennhoff & Routon, 2016). Conversations using landlines are limited to direct calls where both parties must communicate with one another vocally. Conversely, smartphone communication is very flexible (Turnbull, 2010). There are a multitude of ways to contact someone (e.g., call, text, email, SMS, etc.); therefore, the individual being contacted does not need to be available for a phone conversation to communicate effectively (Amstutz, 2017). These new forms of communication have a multitude of benefits for caregivers: infants do not need to be left unattended, loved ones can be contacted with ease, and it requires less effort to maintain interpersonal relationships (Turnbull, 2010). However, these gains should be examined critically in terms of how they impact parent-child communication (Abels et al., 2018).

Smartphones are rarely used for traditional phone calls. In fact, the two most common reasons Americans reach for their smartphones are to send text messages and to take pictures (Smith, 2011). This pattern is not unique to millennials; individuals 18 to 68 years-old consider texting to be a more suitable form of communication than phone calls (Forgays, Hyman, & Schreiber, 2014). However, texting and most activities performed using a smartphone do not provide any auditory input. It was important to determine how overall smartphone usage (e.g., texting, internet searches, phone calls, social media, etc.) impacted the infant language environment since research shows that many parents think about their smartphone at some point while caring for their child (Hiniker et al., 2015).

Relationships & Responsiveness

Emerging evidence points to a variety of negative influences from smartphones on caregiver behaviour, including a negative impact on the quality of family interactions (Hiniker et. al., 2016). The presence of a smartphone has been found to diminish the positive effects of interpersonal interaction (Dwyer et. al., 2018) and restricts relationship satisfaction between parents (McDaniel & Coyne, 2016; McDaniel et. al., 2018). Current research also indicates that mobile device use is common among parents caring for young children (Beamish, 2019) and patterns of increased mobile device use have been seen to have an impact on the development of social skills among eight year-old children (Zayia, 2020). For example, parents who use their smartphones frequently also report feeling less socially connected to their children when they are spending time with them (Kushlev & Dunn, 2019). These mobile devices reduce the amount of positive parent-child interactions and often lead to interpersonal family problems (McDaniel, 2019; Kildare & Middlemiss, 2017).

Abels et al. (2018) observed less sensitivity to children's attempts at gaining attention when a caregiver's smartphone was in use; all participants had children up to five years-old and were observed while visiting a playground or pediatric center. They discovered that activities like reading a magazine can impede a parent's ability to pay attention, but smartphone usage has the most significant effect on the contingency of caregiver responses. Another recent study has determined it is easier for children to gain attention when their parents are occupied with non-digital activities such as reading compared to digital activities like texting (Lemish et. al., 2020). Although interviews with caregivers have shown that they often feel guilty for using their smartphone when their child is present (Radesky et. al., 2016), smartphone ownership is becoming increasingly common in the United States (Pew Research Center, 2019). Furthermore, when caregivers believe their smartphone usage is problematic, they also report behavioural

difficulties among their children (McDaniel & Radesky, 2018). In other words, when parents use their smartphones frequently, they often perceive their children as more difficult.

The digital disruptions smartphones provide have also been linked to negative temperament among infants (Myruski et al., 2018) and behavioral issues among young children (McDaniel & Radesky, 2018). For instance, mothers of children five to six years-old who use their smartphones frequently during mealtimes are more likely to report behavioural issues (Radesky et. al., 2018). Radesky et al. (2014) unobtrusively took field notes documenting how 55 caregivers with one or more school-aged children interacted during mealtimes at a fast-food restaurant; 40 caregivers used their cellular devices with varying degrees of absorption during the observational period. They discovered that caregivers who were highly absorbed with their smartphones often reacted abruptly compared to caregivers who were not preoccupied during this period. These results are further supported by an observational study conducted in an Australian playground where over 75% of parents used their smartphone at least once while supervising children zero to five years-old (Mangan et al., 2018).

Past studies illustrate that smartphones have the potential to impact contingent responses among parents of young children (Beamish, 2019) and lead to caregivers being less sensitive to their infant's bids for attention (Khourochvili, 2017). Overall, the quality of conversation is diminished when a smartphone is present (Przbylski & Weinstein, 2013). This is a critical finding since studies suggest that the immediacy of responses to infant vocalizations can predict future linguistic development (Tamis-LeMonda et. al., 2014; Pretzer et. al., 2018). One observational study comparing American and Israeli parents discovered that increased smartphone use led to inattentiveness towards children two to six years-old (Elias et. al., 2020). Recent large-scale reviews have also found that smartphone use is linked to reduced caregiver responsiveness (McDaniel, 2019) and less sensitivity towards children zero to five years-old

(Braune-Krickau et. al., 2021). There is increasing evidence that prolonged maternal smartphone use leads to decreased responsiveness (Wolfers et. al., 2020).

It was anticipated that mothers of older infants (i.e., 12 to 15 months old) would use their smartphones to a lesser extent than mothers of younger infants (i.e., 6 to 9 months old). There are no studies which have examined if maternal smartphone usage changes according to infant age, but there is credibility in this notion. Infant-directed maternal speech becomes more complex as children get older and gain better comprehension skills (Genovese et al., 2020); therefore, it is unlikely that mothers are using their smartphone as often due to the increased effort required to form these more intricate vocalizations. For example, infants begin to say their first words around 12 months of age (Ramírez-Esparza et al., 2014), while infants 6 to 9 months old are typically still at the babbling stage (Goldstein & Schwade, 2008). Additionally, infants who are 12 to 15 months old are usually beginning to take their first steps which causes them to interact more often with their caregivers and make more efforts to gain their mother's attention (Clearfield et. al., 2008). Since mothers are sensitive to their children's vocalizations (Tamis-LeMonda et al., 2001) it was anticipated that mothers of older infants (e.g., 12 to 15 months) would spend less time on their smartphone because these infants would be making more bids for attention compared to infants in the 6 to 9 month age group.

Support Through Use of Social Media

While digital communication may have drawbacks, it also has the potential to aid mothers in many ways. Access to a smartphone is helpful to mothers because it allows them to obtain relevant information through the internet and communicate more efficiently (i.e., parents can quickly text message rather than spending more time on a phone call). For instance, a study found that sending email reminders to visit an e-health Web site was very helpful to mothers who wanted to prevent putting on excessive weight during pregnancy (Graham et al., 2014). Another

program discovered that the rate of breastfeeding increased with the use of text-messaging reminders (Beard, 2014). One important aspect of smartphones is that they allow new mothers to remain in contact with people for support, thereby boosting their mental health (McDaniel et. al., 2012). Previous studies have determined that mothers seek and give support through social media (Duggan et al., 2015) and frequency of social media use is associated with maternal wellbeing (McDaniel et. al., 2012). However, these benefits should be examined critically in terms of how they affect infant language development.

One study demonstrated that 75% of caregivers with children under the age of 18 use social media platforms regularly; these platforms are used because many caregivers view them as a parenting resource rather than a distraction (Duggan et al., 2015). Conversely, parents who devote a substantial amount of time to social media are more likely to have authoritarian parenting styles (Ante-Contreras, 2016) which can contribute to negative parent-child relationships (Sampasa-Kanyinga et al, 2020). Since mothers use social media as a source of parenting information (Duggan et al., 2015), they may be more preoccupied with these applications compared to others. Specifically, they may be paying more attention to social media applications because they are trying to absorb new information, which can lead to distraction and a decline in maternal responsiveness. It is critical to examine if social media applications impact maternal speech differently. *Social media usage* was defined as applications that could be used to share any online content with others (e.g., Twitter, Facebook, Instagram, Pinterest, TikTok, etc.). *Smartphone usage* was defined as any of the applications that were already available on a mother's phone when the study began. This included all types of smartphone activities such as phone calls, texting, internet searches, etc.; smartphone usage was examined separately from social media usage.

There has been a lag in research examining how social media applications impact language development when compared to the numerous studies on television and language development. Social media applications like Facebook have become a new way for mothers to maintain relationships and provide parental support (Gibson & Hanson, 2013), therefore it was chosen as a category of interest and was recorded separately from all other types of smartphone usage. It was important to determine if these applications influenced the amount of speech heard by infants because social media applications have been found to support maternal mental health (McDaniel et. al., 2012). Despite this, these gains have not been examined critically in terms of how they impact a mother's language output.

Current Study

A cross-sectional research design was used to examine how maternal smartphone usage and maternal social media usage impacted infant language input. The purpose of this study was to determine whether different types of maternal smartphone usage could impact the amount of speech heard by infants. Mothers recorded their language interactions at home with their infants during a 4-hour period while an application simultaneously tracked how often they used their smartphone. The mothers then sent their smartphone usage to be analyzed with the collected audio recording. The first hypothesis was that mothers of 6 to 9 month-old infants will spend more time on their smartphones than mothers of 12 to 15 month-old infants. This reasoning can be traced to past research showing a drop in responsiveness when caregivers with children zero to five years-old used their smartphones more frequently (Abels et al., 2018). The second hypothesis was that there would be a negative relationship between maternal smartphone usage across the 4-hour recording and the overall amount of speech all infants heard. The third hypothesis was that smartphone usage and amount of speech will be negatively correlated at a

tighter level of analysis, i.e., for a given 5-minute period within the 4 hours. The rational being that it's easier to measure how maternal responsiveness is affected by smartphone usage on a 5-minute timescale than across several hours. The fourth and final hypothesis was that higher levels of maternal social media usage was expected to lead to less conversational exposure in the infant language environment across both age groups.

Methods

Impact of COVID-19

The first reported case of COVID-19 in Canada was on January 25th, 2020 (The Canadian Press, 2021); this was prior to data being collected for the current study. The COVID-19 pandemic impacted the collection of audio recordings and the implementation of the consent process in several ways because of concerns that the virus could be transferred from one person to another through the air and/or through shared surfaces. To prevent the COVID-19 virus from spreading during data collection, sanitation procedures were outlined and approved by the Research Ethics Board. Each LENA device and LENA vest was fully sanitized between participants to prevent the transmission of the COVID-19 virus from any materials that were handled by both the research team and participating families (Appendix A). Additionally, it was impossible to sanitize paper documents from the COVID-19 virus, therefore all forms were printed a minimum of 3 days before each scheduled appointment. This prevented the virus from being passed to participating families from the research team during the study and vice versa.

Furthermore, the consent process, implementation of questionnaires and instructions for the recording had to be conducted remotely. An application designed for video meetings called ZOOM Cloud Meetings (Version 5.4.0) was used by the research team to contact all participants. Lockdown restrictions did not allow members of the research team to enter participants' homes

and prevented mothers from bringing their children to the Baby Language Lab located at the University of Manitoba Fort Gary Campus. Zoom was therefore considered the best way to communicate with participants "face-to-face" while maintaining social distancing.

The initial plan for the study was to request that each mother provide 3 10-hour audio recordings to participate. However, we received very few responses to our initial request from eligible participants. This was likely due to the stress and time constraints on parents during the global pandemic. The recording commitment was therefore reduced to a single 4-hour recording to minimize the participation time commitment (Appendix B). For participants (N = 3) who had already provided 3 10-hour samples, the collected data was edited to the first 4-hours of audio.

Participants

A total of thirty mothers were recruited at the onset of the study. Two mothers were excluded from the first and second analyses due to technical difficulties with the application *RealizD;* both mothers were iPhone users and belonged to the 6 to 9 month age group. These mothers were removed from most analyses because they were unable to provide reliable smartphone data. One of the two mothers was also excluded from the final analysis because she was unable to provide a screenshot of her social media usage once the 4-hour audio recording was complete. Fortunately, social media usage was collected separately for iPhone users (via screenshot) so technical difficulties with *RealizD* did not impact the final analysis.

Twenty-eight mothers (M = 32.21 years, SD = 4.76 years) and their infants were split into one of two age groups based on the age of their infant at the time of study enrollment. Since there was no measure of effect size available in the literature, thirty participants were chosen as the sample size based on what was considered to be a reasonable recruitment time frame for completing a Master's thesis. Inclusion criteria were that the infant was typically developing (i.e., did not have hearing loss, diagnosed disorders or delays in development, language, or speech) and

was 6 to 9 (*N* = 13, *M* = 7.46 months, *SD* = 1.05, *Female* = 7, *Male* = 6; *Maternal Age M* = 33.23 years, *SD* = 5.89 years) or 12 to 15 months-old (*N* = 15, *M* = 12.8 months, *SD* = 0.77, *Female* = 10, *Male* = 5; *Maternal Age M* = 31.33 years, *SD* = 3.48 years) at the time of participation. All families spoke English and/or French. All mother-infant pairs were audio-recorded for a period of 4-hours while an application simultaneously tracked how often mothers used their smartphones during that time. See Table 1.

Recruitment advertisements for both groups were placed on Facebook and Instagram. A recruitment pamphlet was also created for the current study but due to COVID-19 restrictions concerning in-person research, these were not distributed. Interested individuals were asked to directly contact the research laboratory to discuss their infant's language background and book their first appointment.

Materials

The Language Environment Analysis (LENA) System

LENA is considered the most effective approach to capturing accurate interactive audio recordings (Casillas & Cristia, 2019). A meta-analysis of studies examining the accuracy of LENA software's output for the number of adult words heard by an infant found that it was highly correlated with human estimates of the same measure, *r* = .92 (Wang et al., 2020). LENA also captures significantly more information from the infant language environment than structured dyadic interactions conducted in laboratories (Cristia, 2013; Ganek & Eriks-Brophy, 2018; Walle & Warlaumont, 2015). It was important for caregivers to avoid changing their normal behaviours during the 4-hour recording to capture when smartphones were interfering with parent- infant interactions due to previous research demonstrating that parents tend to alter their smartphone use when they are aware they are being observed (Vanden Abeele et. al., 2020).

Use of LENA provides an inconspicuous way to examine language development among infants and contributes to less parental reactivity during the research process (Greenwood et al., 2011; Greenwood et al., 2018).

The 4-hour recordings collected for this study were further divided into 5-minute increments; this was done to determine how smartphone use (also calculated in 5-minute increments) would impact the speech heard by infants during the study at a more precise level. The Language Environment Analysis (LENA) device was used because it captures a variety of linguistic input and could be fitted into the pocket of a small vest worn by the infant. The device weighs 2 ounces and can record up to 16 hours of audio.

The LENA computer software processed the collected audio recordings from each device to produce quantitative and qualitative reports of the audio using automated speech processing algorithms. The current study made use of LENA's automated estimates of the number of words heard by each infant and spoken by an adult, called the Adult Word Count (AWC). AWC represents how many adult words an infant heard over a specified period (e.g., 27 words heard from 12:00 pm – 12:05 pm). A separate AWC estimate was obtained for each 5-minute period in the 4-hour recording. The timestamps for each estimate were later used to match a mother's smartphone usage data to their infant's LENA data in RStudio. Once the recording had been processed and 5-minute AWC estimates were calculated by the LENA software, each file was exported from LENA in.csv format.

Applications to Collect Smartphone Usage

To determine maternal smartphone usage, Android users were asked to install the app *QualityTime* (*N* = 9; Mobidays Inc.) and iPhone users were asked to install the app *RealizD* (*N* = 19; RealizD Ltd.). These applications were used to track how often a mother used her

smartphone. The smartphone usage data was then exported via .csv to the Baby Language Lab. The smartphone usage data listed start and stop clock-times for each usage period. See Appendix C. The LENA data was used as a template to match the smartphone data because the LENA data only contained 4-hours of audio recording while the smartphone data indicated all instances that the mother had used her device once the application had been installed. It was therefore necessary to restructure the smartphone data to match the LENA output according to the 5 minute clock times that were reported. This was accomplished using the following coding script: https://github.com/casarm/PublicSmartphoneStudy

Social media usage was calculated separately from general smartphone usage. Certain obstacles arose when creating the social media usage for each mother: the data exported from *QualityTime* and *RealizD* contained different levels of detail. The information exported from *QualityTime* (Android) contained data about *when* the mother used her phone and *which applications* she used (Appendix D). For this reason, the data exported via .csv for each Android-user was used to create their social media usage once it had been matched to the LENA output. The applications selected for the social media summation were chosen based on an international report listing the most popular ways to social network (Statista, 2021). However, due to third-party application restrictions for Apple products, the information exported via .csv from *RealizD* only contained information about *when* the mother used her smartphone but *not which applications* she used (Appendix E).

Apple does not allow access to their users' information from third-party applications. Therefore, mothers with iPhones were asked to send a screenshot of their social media usage (Appendix F) in addition to their *RealizD* output. The social media category of the screenshot (located under *Screen Time* in iPhone Settings) contained the total amount of time a mother had spent using apps like Instagram, Facebook, Twitter, etc. This data was recorded in a .csv file

labelled for mothers who were iPhone users to create their social media summary scores. This allowed for the comparison of social media usage between mothers who were Android users and mothers who were iPhone users, but only at the 4-hour level. Therefore, social media usage was collected for all mothers during the 4-hour audio recording but not at the 5-minute level.

RStudio Packages

The code used to transform all data is saved in following repository: https://github.com/casarm/PublicSmartphoneStudy. The *janitor* package and *tidyverse* group of packages were used to transform the smartphone data so that it could then be analyzed alongside the LENA 5-minute data (Firke, 2021; Wickham et al., 2019). Start/end times were transformed into calendar dates with corresponding 24-hour timestamps (e.g., 2021-10-19 14:00), audio durations were transformed into a time difference format using total seconds (e.g., 300 seconds), and infant ages were relabelled according to age group (e.g., 6, 7, 8, or 9 months was relabelled 6 to 9 months; 12, 13, 14, or 15 months was relabelled 12 to 15 months). All smartphone data collected from mothers who were Android-users was filtered according to application type to create a social media summary score. The Android social media summary scores were then added to the iPhone social media summary scores; this data was transformed into a time difference format using hours, minutes, and seconds (e.g., 5:00:00 = 5 hours). The *car*, *rstatix*, *lme4* and *lmerTest* packages (Fox & Weisberg, 2019; Kassambara, 2021; Bates, Maechler, Bolker, & Walker, 2015; Kuznetsova et al., 2017) were used to examine the relationship between quantity of language spoken to the infant and the amount of time mothers spent using their smartphones. These packages were used in R version 4.0.5 (2021-03-31) and an alpha level of .05 was used for all statistical tests. All effect sizes were labelled following Field's (2013) recommendations and results were obtained using the *report* package (Makowski, et al., 2020).

Procedure

Once mothers had the study explained to them (Appendix G; Appendix H), they contacted the Baby Language Lab to schedule the first meeting. During the first meeting, mothers were instructed on how to complete the Consent Form, the Demographic Questionnaire (Appendix I), the Home Recording Guide for Parents (Appendix J), and the LENA Recording Sheet (Appendix K). They were also encouraged to ask any questions about the LENA device and vest. If the mother had an Android smartphone, she was asked to install the application *QualityTime*; if she had an iPhone she was asked to install the application *RealizD*. Mothers with iPhones were also asked to send a screenshot of their social media usage (Appendix F) once the 4-hour recording was complete. Both *QualityTime* and *RealizD* applications immediately began tracking the mother's smartphone usage once installed but only the 4-hour recording period was kept for further analysis. After each mother completed her recording, she contacted the Baby Language Lab again via phone and/or email to schedule her final meeting. During this final meeting, the information collected by both applications was exported to an email address used specifically for this study. All mothers were then asked for their permission to maintain the audio recording for future research. The study materials were picked up from the participant's home and a $10 electronic gift card was provided for each recording collected as a thank-you for participating. Android users were given an additional $10 to cover the full cost of the *QualityTime* app ($9.49 with tax); the *RealizD* app was free for iPhone users.

Analysis

All information was processed according to the type of data collected; these steps are listed in the data collection flowchart in Appendix L. RStudio was used to combine each participants exported .csv files into a final dataset. One would have the participant's maternal

smartphone usage (e.g., Appendix C) and another would have the infant's AWC data processed from the LENA recording device (e.g., Appendix M). These .csv files had information about when the mother used her smartphone *or* when she spoke to her infant during 5-minute periods within the 4-hour recording. Each participant's AWC was also analyzed using a summary score across the full 4-hour recording period. This was then compared to *QualityTime*/*RealizD* data during the same time periods (full 4-hour recording or 5-minute intervals). The third analysis was the only one conducted at the 5-minute level while all others were conducted at the 4-hour level. As noted above, Android smartphone usage data contained a higher level of detail than iPhone usage data. For this reason, the social media summary score for mothers who were iPhone users was collected via screenshot (Appendix F). The social media data for mothers who were iPhone-users was then recorded in excel by-hand. This was later combined with the social media usage for mothers who were Android-users in RStudio. The social media entries for mothers who were Android-users was obtained using exported data from *QualityTime* (Appendix D) and later converged in RStudio. This created a summation score for all mothers who were Android-users that could then be compared to the social media scores collected from mothers who were iPhone-users.

The variables used in each statistical model are defined as follows:

Smartphone_Total: The amount of maternal smartphone usage from each mother during the *entire 4-hour audio recording* (recorded in seconds). This included *any type of application* a mother used during the study. This variable also represents the summation of all Smartphone_5Min values for each mother who participated in the study.

Smartphone_5Min: The amount of maternal smartphone usage from each mother during each *5-minute period* from the 4-hour audio recording (recorded in seconds). This included *any type of application* a mother used during the study.

Social_Media: The amount of time each mother spent using social media on her smartphone during the *entire 4-hour audio recording* (recorded in seconds). This included all *social media applications* a mother used during the study.

Infant_Age: Each infant was assigned a group based on their age at the time of the audio recording (6 to 9 months or 12 to 15 months).

Participant: An anonymized data code assigned to each participant when the audio recordings were processed to protect their anonymity during data analysis (e.g., 202).

AWC_5Min: The number of adult words spoken to the infant during each *5-minute period* from the 4-hour audio recording. These values were then matched with the amount of maternal smartphone usage from each mother during the same 5-minute period (i.e., Smartphone_5Min).

AWC_Total: The number of adult words spoken to the infant during the *entire 4-hour audio recording*. Therefore, this variable also represents the summation of all AWC_5Min values for each mother who participated in the study.

The first analysis examined the categorical effects of age on total maternal smartphone usage using a Welch *t.test* from the *stats* package (R Core Team, 2021). Infant age was the independent variable while maternal smartphone usage was the dependent variable in this analysis. The model's total explanatory power was assessed using the *t*-value, *p*-value, and Cohen's *d*. The *t*-value determined how far the data deviated from zero and the *p*-value determined the probability of obtaining said *t*-value if the null hypothesis was correct. Cohen's *d* was an effect size measure between the two means being tested (i.e., 6 to 9 month age group versus 12 to 15 month age group) and represented the number of standard deviations between them.

The second analysis determined how maternal smartphone usage impacted AWC during a 4-hour recording. This was accomplished using the following linear regression model with the *lm()* function from the *stats* package (R Core Team, 2021):

AWC_Total ~ Smartphone_Total * Infant_Age

In the second model, the total number of adult words spoken to the infant during the 4-hour recording was the dependent variable. Infant age group and total maternal smartphone usage were predictors. This model also tested the interaction between total maternal smartphone use and infant age group. All continuous variables were centered around their means before being added to this model. The second model's total explanatory power was assessed using the R^2 value, which is the variability explained by the regression model divided by the total variability in the data. A higher R^2 value confirms that the proposed model fit the data well, while a lower R^2 value indicates that the model did not accurately fit the data. In other words, a higher R^2 value would indicate that the model was a good fit and support the hypothesis being tested.

The third analysis examined 5-minute periods during the 4-hour audio recording from each mother to see if they were affected by smartphone usage. High vs. low 5-minute intervals of maternal smartphone usage were compared to determine how they impacted AWC using the following linear mixed-effects model with the *lmer()* function from the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015):

AWC_5min ~ Smartphone_5Min * Infant_Age + (1|Participant)

AWC was the dependent variable used in the third model. Infant age group was a fixed effect while individual participants and maternal smartphone usage during 5-minute periods were considered random effects. The third model also tested the interaction between 5-minute maternal smartphone usage and infant age group. This linear model's total explanatory power

was assessed using marginal and conditional R^2; marginal R^2 evaluated how much variation in the dependent variable the fixed factor accounted for (i.e., infant age group), while conditional R^2 evaluated how much variation in the dependent variable all predictors accounted for. A higher marginal and/or conditional R^2 value confirms that the proposed model best fit the data, while a lower R^2 value indicates that the model did not accurately fit the data. Therefore, higher R^2 values indicate that the linear model was a good fit and supports the hypothesis being tested.

The final model used the main effect of social media and the interaction between social media and infant age group on AWC during the 4-hour recordings. This was analyzed using the following linear regression model tested with the *lm()* function from the *stats* package (R Core Team, 2021):

AWC_Total ~ Social_Media * Infant_Age

Total AWC during the 4-hour recording was the dependent variable used in this analysis. Infant age group and maternal social media usage were predictors. The final model also tested the interaction between maternal social media use and infant age group. All continuous variables were centered around their means before being added to this model. The final model's total explanatory power was also assessed using the R^2 value, which is the variability explained by the regression model divided by the total variability in the data. A higher R^2 value confirms that the proposed model fit the data well, while a lower R^2 value indicates that the model did not accurately fit the data. The goal is to obtain a high R^2 value because this would indicate that the model was a good fit and support the hypothesis being tested. Although the second and final model both use total AWC from the 4-hour recording as the dependent variable, a Bonferroni correction was not applied because it would further reduce the power of these analyses which were already impacted by a limited sample size (N = 28).

Results

Mothers in the 6 to 9 month group used their smartphones on average 56 minutes (*N* = 13, *M* = 3,360 seconds or 56 minutes, *SD* = 2,425 seconds or 40 minutes and 25 seconds) and mothers in the 12 to 15 month group used their smartphones under 34 minutes during the 4-hour recording (*N* = 15, *M* = 2,022 seconds or 33 minutes and 42 seconds, *SD* = 2,128 seconds or 35 minutes and 28 seconds). In other words, mothers in the 6 to 9 month group used their smartphones on average 20% of the time during the study while mothers in the 12 to 15 month group used their smartphones less than 15% of the time during the study. Additionally, mothers in the 6 to 9 month group had an average AWC of 6,494 (*SD* = 3,345) and mothers in the 12 to 15 month group had an average AWC of 8,010 (*SD* = 2,346). It is worth noting that there was a significant amount of variability concerning maternal smartphone usage when examined according to infant age group (*N* = 28).

Further information about the total amount of data processed is presented in Table 1 below.

Table 1

Language, Smartphone Usage, & AWC by Infant Age Group

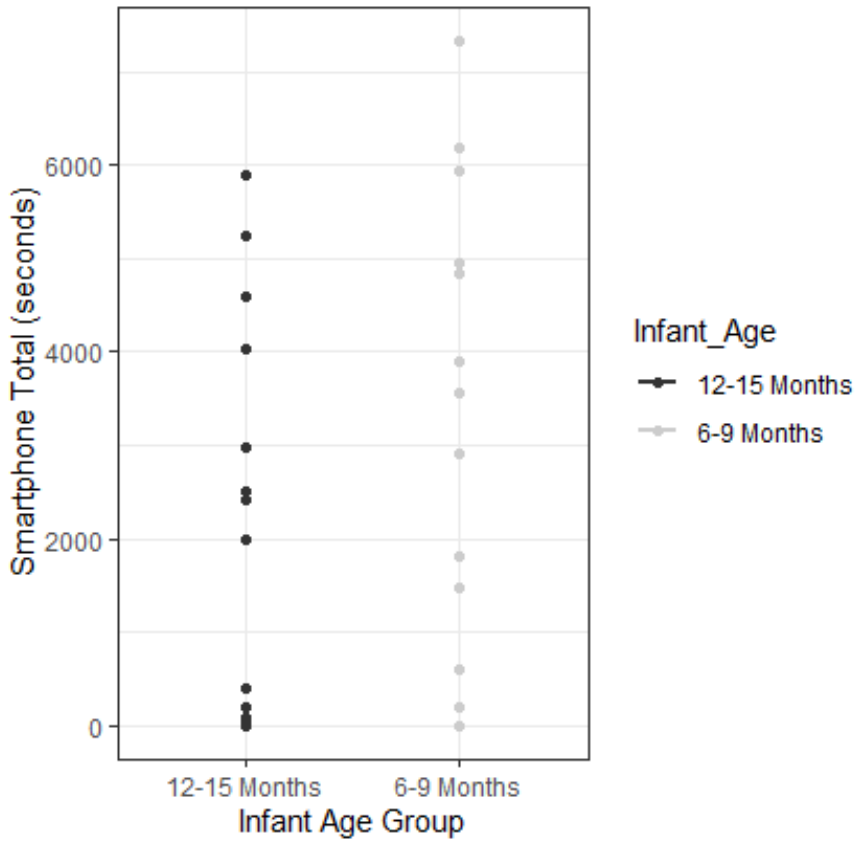
	12 to 15 Months	**6 to 9 Months**

English	*N* = 9	*N* = 9
French	*N* = 0	*N* = 0
Both Languages	*N* = 6	*N* = 4
Total	*N* = 15	*N* = 13
Mean Smartphone Usage (Hours:Minutes:Seconds)	00:33:42	00:48:32
Average AWC	6,494	8,010

A Welch t-test examined if maternal smartphone usage changed according to infant age group. There was not a significant difference in maternal smartphone usage depending on the infant's age group (difference = -1,338 seconds or 22 minutes and 18 seconds, 95% CI [-3,129.7, 454], $t(24.2) = -1.5$, $p = .136$; Cohen's $d = -0.63$, 95% CI [-1.4, 0.2]). Mothers with 6 to 9 month-old infants (M = 3,360 seconds, SD = 2,425 seconds) used their smartphones slightly more often than mothers with 12 to 15 month-old infants (M = 2,022 seconds, SD = 2,128 seconds; Figure 1), however this effect was statistically insignificant due to a substantial amount of variability for maternal smartphone use scores within each age group (6 to 9 month group N = 13, 12 to 15 month group N = 15, Total N = 28).

Figure 1

4-Hour Maternal Smartphone Use by Age Group

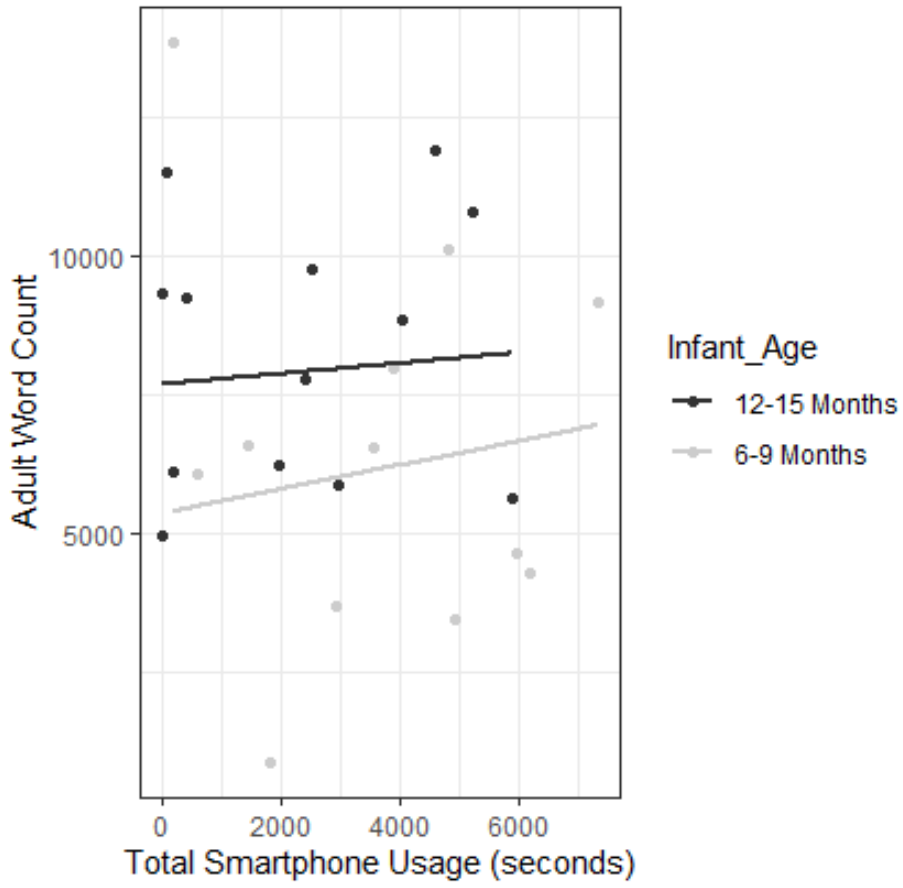


A linear regression model was used to determine if maternal smartphone usage impacted the AWC over the 4-hour audio recording and how this interacted with infant age. The model explains a non-significant and weak proportion of variance (R^2 = .10, F(3, 24) = 0.90, p = .456, adj. R^2 = -.01). The model's intercept, indicating no maternal smartphone usage and infant age group at 12 to 15 Months corresponded to 862.4 (95% CI [-762, 2486.8], t(24) = 1.1, p = .284). The effect of total maternal smartphone usage during the 4-hour audio recording is statistically non-significant and positive (β = 0.26, 95% CI [-0.5, 1], t(24) = 0.7, p = .493; Std. β = 0.2, 95% CI [-0.4, 0.8]), meaning that maternal smartphone usage did not affect AWC at the 4-hour level. The effect of assigned age group is statistically non-significant and negative (β = -1531.17, 95% CI [-3917.1, 854.8], t(24) = -1.3, p = .198; Std. β = -0.53, 95% CI [-1.4, 0.3]), suggesting that the

reference age group (i.e., 12 to 15 months) typically had higher AWC scores during the 4-hour audio recording than the comparison group (i.e., 6 to 9 months), but this difference did not approach the level of significance. The interaction effect between infant age group and maternal smartphone usage during the 4-hour audio recording is statistically non-significant and negative (β = -0.46, 95% CI [-1.5, 0.6], t(24) = -0.9, p = .376; Std. β = -0.37, 95% CI [-1.2, 0.5]; Figure 2), which implies that both age groups had similar patterns concerning the effects of maternal smartphone usage on AWC when examined at the 4-hour level.

Figure 2

Influence of Total Smartphone Use on Total AWC

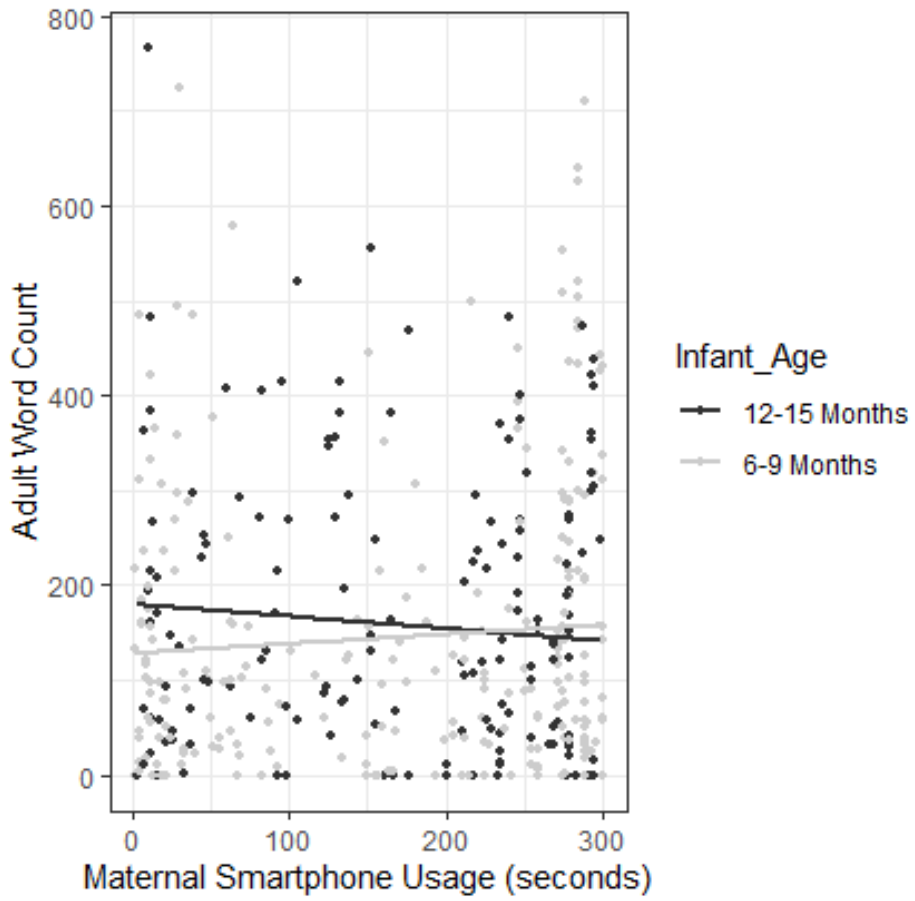


A linear mixed model was used to predict how much language infants heard during 5-minute intervals using maternal smartphone usage during the same 5-minute interval and assigned infant age group. Each participant's anonymized data code was included as a random effect. Five participants were excluded from this analysis for missing data: the two mothers due to technical difficulties with the application *RealizD* and three additional mothers because they did not use their smartphones during the 4-hour recording period (N = 5; 6 to 9 Months = 3; 12 to 15 months = 2). Four of these mothers were iPhone-users and one was an Android-user. The three mothers with no smartphone usage confirmed that this was typical when their infant was present, which is why their data was maintained in all other analyses. Therefore, N = 25 participants were examined in the third analysis. The model's total explanatory power was moderate (*conditional* R^2 = .22); however, the fixed factor alone did not account for a large proportion of variance (*marginal* R^2 = .03). In other words, infant age group did not contribute very much to the model's total explanatory power. The model's intercept for no maternal smartphone usage during a 5-minute period and infant age group at 12 to 15 Months corresponded to 209.6 (95% CI [158, 261.2], $t(701) = 8.0$, $p < .001$, N = 25). The main effect of maternal smartphone usage during a 5-minute period was statistically significant and negative, meaning that more smartphone usage was associated with less AWC at the 5-minute level (β = -0.33, 95% CI [-0.5, -0.2], $t(701) = -3.8$, $p < .001$; Std. β = -2.18e-03, 95% CI [-3.32e-03, -1.04e-03]). The main effect of the 6 to 9 month age group was also statistically significant and negative, which suggests that the number of words heard during a 5-minute interval reduced when mothers from the 12 to 15 month group were compared to mothers from the 6 to 9 month group (β = -78, 95% CI [-146.9, -9.1], $t(701) = -2.2$, p = .026; Std. β = -0.52, 95% CI [-1, -0.1]). The interaction of infant age group at 6 to 9 months and maternal smartphone usage during a 5 minute period was statistically significant, which meant that the patterns of 5-minute smartphone

usage relating to 5-minute AWC changed depending on the age group an infant was assigned to (β = 0.44, 95% CI [0.2, 0.7], $t(701) = 4.2$, $p < .001$; Std. β = 2.93e-03, 95% CI [1.55e-03, 4.31e-03]; Figure 3). An increase in maternal smartphone usage in the 12 to 15 month age group was related to a decrease in the number of adult words heard by the infant. However, an increase in maternal smartphone usage for the 6 to 9 month group was associated with no decrease in the number of adult words heard by the infant. It is important to note that this analysis contained 5-minute periods where there was no maternal smartphone usage (i.e., Smartphone_5Min = 0) however maternal speech was still present (e.g., AWC = 15). Therefore, the current model had a zero-inflated sample. For this reason, a follow-up analysis was done to observe whether removing all 5-minute intervals where no maternal smartphone usage occurred would affect the final model outcomes. The results obtained were very similar to those that were presented above, suggesting that these findings were not driven by time periods when mothers avoided using their smartphones.

Figure 3

Influence of 5-Minute Maternal Smartphone Use on 5-Minute AWC

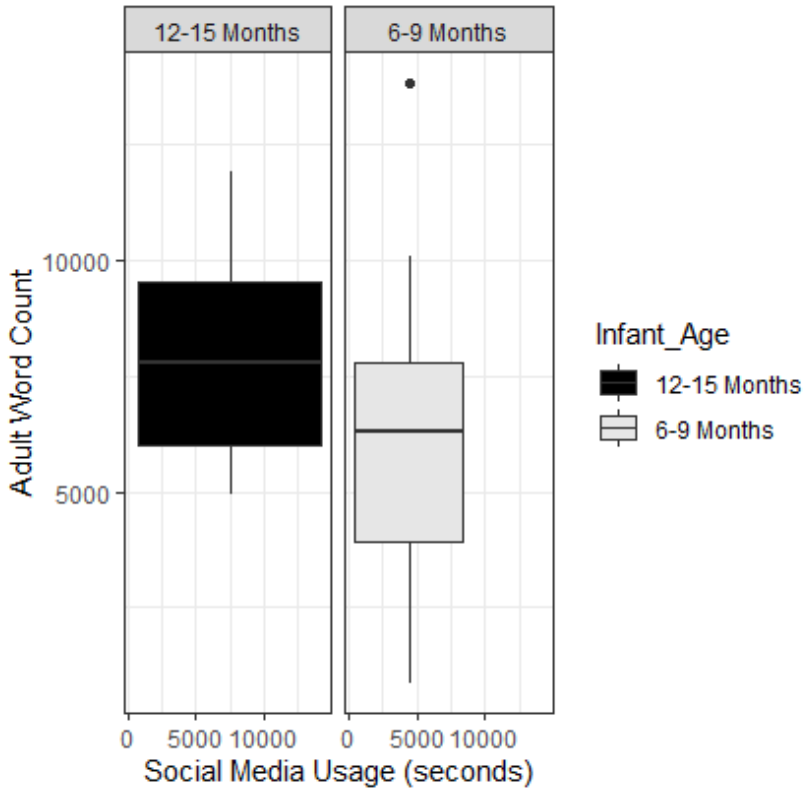


A linear regression model was used to determine if maternal social media usage impacted the AWC during the 4-hour audio recording and how this interacted with infant age. On post hoc examination of the data, it was noticed that one participant's AWC score was 4.33 standard deviations above the mean for that age group. This mother's data was at the top range of AWC in the second analysis; this was also one of three participants' whose data significantly widened the range of AWC scores for the 6 to 9 month group. A second linear regression model was therefore run as a robustness-check to determine if maternal social media usage impacted AWC with the outlier's data removed. Therefore, two mothers were excluded from the post-hoc analysis, one due to technical difficulties and one due to being an outlier; both mothers were iPhone users and belonged to the 6 to 9 month age group (N = 28).

The final model with the outlier's data included explained a non-significant and moderate proportion of variance (R^2 = .25, F(3, 25) = 2.8, p = .060, adj. R^2 = .16). The model's intercept, indicating no maternal social media usage during the 4-hour recording and infant age group at 12 to 15 Months corresponded to 640.7 (95% CI [-793.1, 2074.5], t(25) = 0.9, p = .366). The effect of total maternal social media usage was statistically non-significant and positive (β = 0.33, 95% CI [-5.03e-03, 0.7], t(25) = 2.0, p = .053; Std. β = 0.41, 95% CI [-6.38e-03, 0.8]), suggesting that maternal social media use did not reduce the number of adult words heard by infants in the study. The effect of assigned age group was statistically non-significant and negative (β = -1334.58, 95% CI [-3415.6, 746.5], t(25) = -1.3, p = .199; Std. β = -0.46, 95% CI [-1.2, 0.3]) which suggests that mothers in the 6 to 9 month group used *slightly* less social media compared to mothers in the 12 to 15 month group, but it is important to note that this difference did not approach the level of significance (Figure 4). The interaction effect between infant age group and maternal social media use was statistically non-significant and negative (β = -0.01, 95% CI [-0.7, 0.6], t(25) = -0.04, p = .969; Std. β = -0.02, 95% CI [-0.8, 0.8]), implying that both age groups had similar relationships concerning the effects of maternal social media use on the number of words an infant heard during the 4-hour recording.

Figure 4

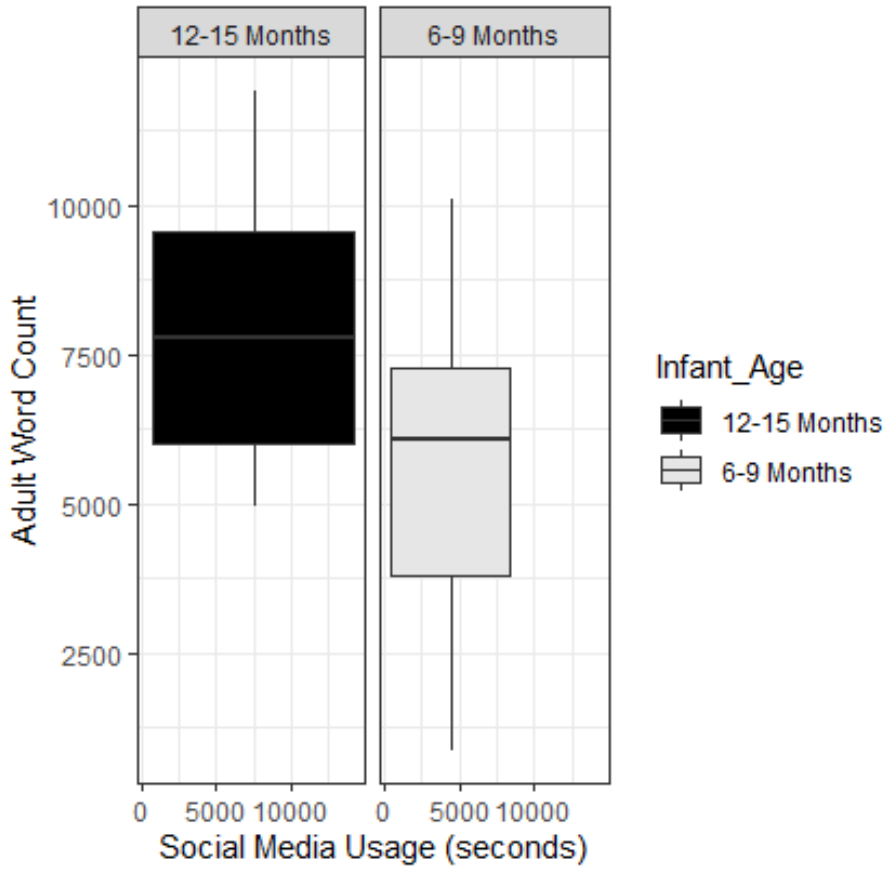
Influence of Social Media Use on Total AWC



The results for the post-hoc analysis with the outlier's data excluded were roughly equivalent to the first analysis except that the effect of infant age became significant (β = -2131.09, 95% CI [-3993.1, -269.1], $t(24) = -2.36$, $p = .027$; Std. β = -0.80, 95% CI [-1.5, -0.1]; Figure 5). These findings are consistent with the results shown in the third analysis where infant age group was also found to be a significant predictor. Because this decision was made after viewing the results from the first model, this analysis should be interpreted cautiously.

Figure 5

Influence of Social Media Use on Total AWC – Outlier Excluded



Discussion

The main goal of this study was to determine how maternal smartphone usage would impact the amount of speech infants heard. Mothers of younger infants (i.e., 6 to 9 months) were anticipated to spend more time on their smartphones than mothers of older infants (i.e., 12 to 15 months) since older infants have increased mobility and conversational skills at this stage (among other factors). The first analysis concerning if there was a difference in maternal smartphone usage based on infant age group was not confirmed by the data. In other words, mothers who cared for 6 to 9 month-old infants did not use their smartphones more than mothers caring for 12 to 15 month-old infants. A possible explanation is that mothers are using their smartphones more often during the COVID-19 pandemic, making it difficult to see a meaningful difference in overall usage. Another important factor concerns the number of participants relative to the standard deviations for each age group: both mothers in the 6 to 9 month age group and

mothers in the 12 to 15 month age group generated large standard deviations. This may have contributed to the difficulty in determining if there was a significant difference among group means because the variation within each of the age groups is greater than the variation across them (given the small sample size; $N = 28$). Despite this, the means were in the predicted direction so high within-group variability compared to between-group variability may have played a role given the variation of the data. It is possible this effect may have become apparent if there was an increase in the number of participants used in the study.

It was predicted that smartphone usage during the entire four-hour recording would reduce the amount of speech mothers spoke to their infants in both age groups. The second hypothesis was not confirmed by the data. Infants with mothers who used their smartphones more during the 4-hour recording did not hear fewer words (AWC) compared to infants with mothers who used their smartphones less. The 12 to 15 month age group typically had higher AWC scores during the 4-hour audio recording compared to the 6 to 9 month age group, but this difference did not approach the level of significance. This means that mothers who were caring for 12 to 15 month-old infants generally spoke more words during the 4-hour recording compared to mothers who were caring for 6 to 9 month-old infants. (Figure 2). This reasoning makes sense from a developmental point of view since infants in the 12 to 15 month age group are beginning to learn to say their first words (Ramírez-Esparza et al., 2014), while infants in the 6 to 9 month age group are typically still at the babbling stage (Goldstein & Schwade, 2008). It is also consistent with previous research which has found that infant age is a positive predictor of maternal speech across various cultures (Bornstein et al., 1992) and that maternal speech becomes more complex as infants get older (Genovese et al., 2020). The results obtained from the second model further supports these findings.

Each four-hour recording was further divided into five-minute periods to examine how maternal smartphone use impacted language output at a more precise level. Five-minute periods with increased maternal smartphone usage were expected to negatively impact the amount of speech infants heard in both age groups. This was due to previous research which has demonstrated that smartphone usage interferes with responsiveness (Abels et al., 2018). To answer the third hypothesis, all 4-hour recordings were separated into 5-minute intervals to gauge the affect of maternal smartphone usage on AWC in greater detail. Results differed depending on the age group a mother was assigned to. For mothers in the 12 to 15 month age group, increased smartphone usage was generally related to a decrease in AWC. In comparison, increased maternal smartphone usage from mothers in the 6 to 9 month group had no increase of AWC during the same 5-minute period. Despite the reduced participant numbers in the third analysis (N = 25), increased maternal usage during 5-minute intervals was related to less speech directed to infants during the study. This finding indicates that smartphone distractions during a 5-minute interval may contribute to a loss of linguistic input for mothers with infants 12 to 15 months-old, however it does not seem to be as influential for mothers with infants 6 to 9 months-old.

Recall that the interaction between infant age group and maternal smartphone usage was observed to be an important predictor of AWC at the 5-minute level but not at the 4-hour level. It is possible that the interaction between smartphone usage and infant age is only seen with increased data specificity. The effect of this interaction may have been minimized when analyzed at the 4-hour level because each mother only contributed a single data point to the second analysis but multiple data points to the third analysis. It is also possible that conversations are simply easier with older infants (i.e., 12 to 15 months old) compared to younger infants (i.e., 6 to 9 months old). Since only the 12 to 15 month infants would be capable of producing words,

infants in the 6 to 9 month age group may have been challenging conversational partners. This may have enabled mothers in the 6 to 9 month group to use their smartphones more frequently because they were less focused on the verbal exchanges between themselves and their infant.

The results of the final analysis indicate that maternal social media usage did not impact the language heard by infants in either age group when examined at the 4-hour level. The hypothesis that maternal social media usage would impact the number of words heard by the infants during the study was not confirmed by the data. This hypothesis was made based on previous research demonstrating mothers use social media as a source of parenting information (Duggan et al., 2015) and frequency of social media use is associated with maternal wellbeing (McDaniel et. al., 2012).

Study Strengths

The data collection methods used in this study were all designed to be minimally intrusive for both the mother and her infant. The LENA device minimizes parental reactivity so it is considered one of the best ways to capture accurate audio recordings (Greenwood et al., 2018). This helped increase ecological validity and was used in hopes that mothers would act naturally during the 4-hour recording period. Finally, all audio recordings were captured in the home environment which provided the most naturalistic setting possible for a mother interacting with her infant.

Limitations and Future Directions

The participants for this study were mothers who were recruited from within the city of Winnipeg, Manitoba. Further studies concerning the effects of smartphone use on maternal speech should be conducted elsewhere with both mothers and fathers as the primary caregiver to increase the generalizability of research findings. Recruitment posts were made using the Baby

Language Lab's social media platforms. The sample may be slightly skewed since mothers needed an existing social media account to view these posts. In other words, mothers recruited for the current study likely had social media access to begin with. It is possible there are mothers who use social media less and were therefore not aware of this study, especially because the recruitment process relied heavily on social media in the COVID-19 environment. In the future, researchers should consider the implications of this recruitment process when reaching out to participants. Furthermore, this study did not consider that infants themselves (instead of the mothers) may have been using the smartphones during the 4-hour recording period.

Another restriction was Apple's policy concerning third-party application tracking. The application used for iPhones (i.e., *RealizD*) was not able to track which applications were being used by the mothers during the study. Therefore, the only way to track social media usage was to access the Screen Time section under iPhone Settings (Appendix F). Apple does not list which applications are used to create the *Social Media* usage category. For this reason, the social media usage for iPhone users was not calculated the same way it was for Android users and an analysis could not be run using 5-minute increments. The iPhone social media times were recorded in excel via .csv then compared to a summation of social media applications from Android-users across the 4-hour level in RStudio.

Additionally, two mothers experienced technical difficulties with the application that was used to track smartphone usage ($N = 2$). It is important to note that these problems were only experienced by mothers who used the *RealizD* application for iPhone users. In later studies, it is recommended to use an application that tracks both maternal smartphone use and the number of adult words heard by infants simultaneously to avoid having to combine data from two different sources (i.e., LENA data and smartphone application data). Such an application would be

immensely helpful in future research concerning maternal smartphone usage and linguistic output, however this type of application software has yet to be developed.

The final limitation for the present study concerns sample size (N = 28). A higher number of participants would have contributed to increased statistical power for each model and created a sample that was more representative of the population. Thirty participants were chosen due to time constraints for completing a Master's thesis and because there was no reasonable measure of effect size in the available literature. When performing regression analyses, a rule-of-thumb is to have 10-20 participants per predictor; therefore, I would recommend a sample of 60 mother-infant pairs if this study were to be replicated. A larger sample size is an important consideration for anyone conducting future studies concerning different types of maternal smartphone usage and speech directed to infants.

Conclusion

The effects of general and social media smartphone use on maternal speech to infants requires further study. While smartphones are useful devices, the benefits require critical examination regarding their impact on maternal speech in the home environment. Maternal smartphone usage has a bearing on AWC at the 5-minute level, but this pattern was not evident at the 4-hour level. This study determined that an increase of smartphone usage by mothers had a negative influence on the number of words heard by 12 to 15 month-old infants when examined at the 5-minute scale, but this finding should be examined with a larger sample. Age was also seen to be an important determinant in how often a mother speaks to her infant. In closing, smartphones are a resource used by many mothers, but the proportion of usage should be further researched concerning their impact on linguistic output in the home environment.

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Appendix A

Sanitizing LENA Devices

1. Any member of the research team who will be handling LENA equipment or clothing must be wearing a face mask at all times; this is to be donned *before* any sanitization procedures occur
2. Perform hand hygiene
    - *Soap and Water: rinse hands, add soap to palms, lather hands for 15-20 seconds, dry with single use paper towel or hand dryer, and turn off the tap with a clean paper towel
    - Alcohol-Based Hand Rub: nickel sized amount, rub hands together thoroughly, continue until dry

      *Soap and Water method is preferable
3. Remove 1 Ziploc bag for each device to be delivered and label it with the appropriate subject code using a permanent marker
4. When disinfecting the LENA device(s), wring out all excess liquid from wipes *before* cleaning the device(s)
5. Wipe down the LENA device(s)
6. Allow surfaces to remain wet according to the type of sanitation wipe:
    - 1-Minute dry-time for INTERVention wipes*
    - 3-Minute dry-time for PREVention wipes*

    *If INTERVention/PREVention wipes cannot be purchased, PREVention One Step Surface Cleaner & Disinfectant will be used with a new j-cloth for each device
7. Dry the LENA device(s) with a clean microfibre cloth
8. Place device(s) in labelled Ziploc bag and place each labelled Ziploc into a large freezer-sized Ziploc bag before transporting to the participant's home
9. Upon arrival to the participant's home, a member of the research team will sanitize their hands using an alcohol-based hand rub method that follows the protocols outlined by Manitoba Health (shown below) *before* removing the correctly labelled Ziploc out of the freezer-sized Ziploc
    - Take a nickel sized amount of hand sanitizer
    - Rub it on fingertips, between fingers, and on both sides of each hand
    - Continuously rub until both hands are dry
10. A member of the research team will deliver the device by placing it in the participants mailbox
11. When retrieving the LENA devices from a participant home, we will request that they place the used device within the original Ziploc bag in the mailbox to be collected by a member of the research team who will be wearing latex gloves

Cleaning the LENA Outfit

1. Any member of the research team who will be handling LENA equipment or clothing must be wearing a face mask at all times; this is to be donned *before* any sanitization procedures occur
2. Perform correct hand hygiene (steps listed above)
3. The LENA clothing used to carry the device will be brought to a member of the research teams home after each recording session
4. The clothing will be washed using High-Efficiency fragrance-free detergent on the Allergiene cycle, specifically designed for baby clothing and dried with a High-Efficiency dryer*
   *Perform correct hand hygiene before transferring clothing from washer to dryer
5. Each item of clothing will then be placed inside a freezer-sized Ziploc bag; these Ziplocs will then be placed into a new garbage bag before being delivered to the participant's home

Appendix B

Participant Enrollment Schedule

Task	Description	Time Frame
Participant Contact (Phone Call/Email)	The Study Team Members will be using multiple recruitment strategies to reach potential participants. Interested participants may call the study line to speak with a Study Team Member and set up a meeting.	First point of contact. Day 0
First Video Call Meeting	During the first meeting, the participant will be invited to sign the Consent Form and complete the Demographic Questionnaire. The LENA Recording Sheet and the Guide to Using LENA will be explained fully as well. They will also be instructed on how to download and use the app that will be tracking their smartphone usage. Before this meeting, the participant will be given the LENA equipment and vest to be worn during the recording session. **The LENA DLP & vest along with all written documents will be collected after the recording session** **Before the recording is picked up by a member of the study team, the research investigator will video call the participant to discuss whether or not the recording will be deleted once processed through the LENA software.**	Day 1 The participant's enrollment in the study begins when they sign the consent form, and lasts until their final video call meeting with the study team 1 x 4-hour recording over the next week
LENA recording	During this time period, participants will be completing one LENA recording with their infant on a day that is convenient for them. We ask that this recording be at least 4 hours in length and that mothers retroactively describe the activities they participated in with their child using the LENA Recording Sheet.	Days 2-6
Final Video Call Meeting	The mother will be asked if she would like to delete the recording and to indicate her choice at the end of the consent form. Any further questions the mother might have about the study may be answered at this time before she prepares the study materials for pick-up.	Recording Day
Pick-Up LENA & Vest	A member of the research team will pick up the LENA, vest, and all written materials before replacing it with the 10-20$ Amazon giftcard **Email mother to confirm she has received Amazon giftcard**	Recording Day cont'd

Appendix C

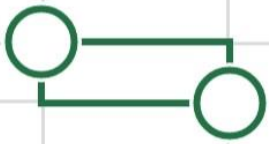
	A	B	C	D	E	F
1	start_time	end_time	duration			
2	18:05	18:10	287			
3	18:10	18:15	287			
4	18:15	18:20	595			
5	18:20	18:25	564			
6	18:25	18:30	564			
7	18:30	18:35	564			
8	18:35	18:40	287			
9	18:40	18:45	421			
10	18:45	18:50	387			
11	18:50	18:55	287			
12	18:55	19:00	287			
13	19:00	19:05	287			
14	19:05	19:10	287			
15	19:10	19:15	287			
16	19:15	19:20	180			
17	19:20	19:25	8			
18	19:25	19:30	0			
19	19:30	19:35	0			
20	19:35	19:40	0			
21	19:40	19:45	0			
22	19:45	19:50	0			
23	19:50	19:55	276			
24	19:55	20:00	273			
25	20:00	20:05	271			
26	20:05	20:10	271			
27	20:10	20:15	271			
28	20:15	20:20	7			
29	20:20	20:25	0			

Appendix D

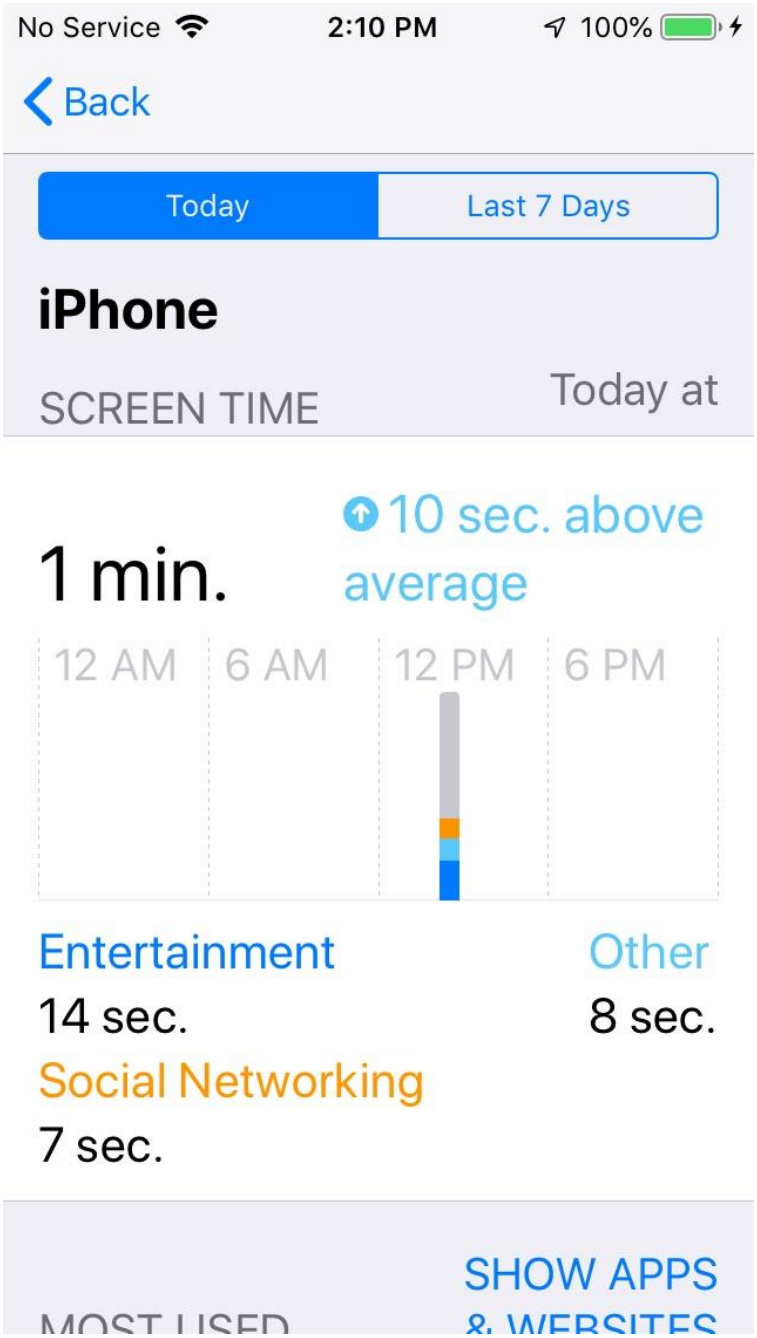
	A	B	C	D	E	F	G	H
1	com.samsung.android.incallui	Call	###	11:37:58 (29-Jul-2020)	###	11:38:05 (29-Jul-2020)	7 sec	
2	com.zerodesktop.appdetox.qualitytime	QualityTime	###	11:39:31 (29-Jul-2020)	###	11:40:01 (29-Jul-2020)	30 sec	
3	com.android.settings	Settings	###	11:41:15 (29-Jul-2020)	###	11:41:21 (29-Jul-2020)	6 sec	
4	com.samsung.android.dialer	Phone	###	11:41:22 (29-Jul-2020)	###	11:41:37 (29-Jul-2020)	15 sec	
5	com.samsung.android.incallui	Call	###	11:41:37 (29-Jul-2020)	###	11:41:46 (29-Jul-2020)	9 sec	
6	com.microsoft.office.officehubrow	Office	###	11:41:54 (29-Jul-2020)	###	11:42:24 (29-Jul-2020)	30 sec	
7	com.microsoft.office.officehubrow	Office	###	11:43:52 (29-Jul-2020)	###	11:44:00 (29-Jul-2020)	8 sec	
8	com.samsung.android.calendar	Calendar	###	11:44:02 (29-Jul-2020)	###	11:44:40 (29-Jul-2020)	38 sec	
9	com.samsung.android.calendar	Calendar	###	11:44:42 (29-Jul-2020)	###	11:44:55 (29-Jul-2020)	13 sec	
10	com.samsung.android.dialer	Phone	###	11:44:56 (29-Jul-2020)	###	11:45:05 (29-Jul-2020)	9 sec	
11	com.samsung.android.incallui	Call	###	11:45:05 (29-Jul-2020)	###	11:46:02 (29-Jul-2020)	57 sec	
12	com.samsung.android.dialer	Phone	###	11:46:02 (29-Jul-2020)	###	11:46:14 (29-Jul-2020)	12 sec	
13	com.sec.android.app.sbrowser	Samsung Internet	###	11:46:15 (29-Jul-2020)	###	11:46:50 (29-Jul-2020)	35 sec	
14	com.sec.android.app.sbrowser	Samsung Internet	###	11:48:51 (29-Jul-2020)	###	11:48:56 (29-Jul-2020)	5 sec	
15	com.sec.android.app.sbrowser	Samsung Internet	###	11:49:39 (29-Jul-2020)	###	11:49:45 (29-Jul-2020)	6 sec	
16	com.sec.android.app.sbrowser	Samsung Internet	###	11:49:47 (29-Jul-2020)	###	11:49:53 (29-Jul-2020)	6 sec	
17	com.sec.android.app.sbrowser	Samsung Internet	###	11:50:14 (29-Jul-2020)	###	11:50:20 (29-Jul-2020)	6 sec	
18	com.sec.android.app.sbrowser	Samsung Internet	###	11:50:49 (29-Jul-2020)	###	11:50:54 (29-Jul-2020)	5 sec	
19	com.sec.android.app.sbrowser	Samsung Internet	###	11:51:03 (29-Jul-2020)	###	11:51:07 (29-Jul-2020)	4 sec	
20	com.samsung.android.dialer	Phone	###	11:51:10 (29-Jul-2020)	###	11:51:24 (29-Jul-2020)	14 sec	
21	com.samsung.android.incallui	Call	###	11:51:24 (29-Jul-2020)	###	11:51:32 (29-Jul-2020)	8 sec	
22	com.microsoft.office.officehubrow	Office	###	11:51:35 (29-Jul-2020)	###	11:53:07 (29-Jul-2020)	1 min	
23	com.samsung.android.dialer	Phone	###	11:53:14 (29-Jul-2020)	###	11:53:24 (29-Jul-2020)	10 sec	
24	com.sec.android.app.sbrowser	Samsung Internet	###	11:53:57 (29-Jul-2020)	###	11:55:35 (29-Jul-2020)	1 min	
25	com.samsung.android.calendar	Calendar	###	11:59:43 (29-Jul-2020)	###	11:59:44 (29-Jul-2020)	1 sec	
26	com.samsung.android.calendar	Calendar	###	11:59:45 (29-Jul-2020)	###	12:00:18 (29-Jul-2020)	33 sec	
27	com.samsung.android.calendar	Calendar	###	12:01:20 (29-Jul-2020)	###	12:01:20 (29-Jul-2020)	0 sec	
28	com.samsung.android.calendar	Calendar	###	12:01:21 (29-Jul-2020)	###	12:01:52 (29-Jul-2020)	31 sec	
29	com.samsung.android.calendar	Calendar	###	12:04:08 (29-Jul-2020)	###	12:04:39 (29-Jul-2020)	31 sec	
30	com.samsung.android.calendar	Calendar	###	12:07:01 (29-Jul-2020)	###	12:07:32 (29-Jul-2020)	31 sec	
31	com.samsung.android.calendar	Calendar	###	12:12:07 (29-Jul-2020)	###	12:12:08 (29-Jul-2020)	1 sec	
32	com.samsung.android.email.provider	Email	###	12:12:11 (29-Jul-2020)	###	12:12:49 (29-Jul-2020)	38 sec	
33	com.microsoft.office.officehubrow	Office	###	12:12:49 (29-Jul-2020)	###	12:12:53 (29-Jul-2020)	4 sec	
34	com.samsung.android.email.provider	Email	###	12:12:53 (29-Jul-2020)	###	12:13:00 (29-Jul-2020)	7 sec	
35	com.microsoft.office.officehubrow	Office	###	12:13:00 (29-Jul-2020)	###	12:13:02 (29-Jul-2020)	2 sec	
36	com.samsung.android.email.provider	Email	###	12:13:02 (29-Jul-2020)	###	12:13:52 (29-Jul-2020)	50 sec	
37	com.samsung.android.incallui	Call	###	12:24:52 (29-Jul-2020)	###	12:25:14 (29-Jul-2020)	22 sec	
38	com.samsung.android.incallui	Call	###	12:25:51 (29-Jul-2020)	###	12:25:52 (29-Jul-2020)	1 sec	
39	com.samsung.android.dialer	Phone	###	12:25:53 (29-Jul-2020)	###	12:25:55 (29-Jul-2020)	2 sec	
40	com.samsung.android.incallui	Call	###	12:25:55 (29-Jul-2020)	###	12:26:36 (29-Jul-2020)	41 sec	
41	com.samsung.android.messaging	Messages	###	12:30:06 (29-Jul-2020)	###	12:30:07 (29-Jul-2020)	1 sec	
42	com.samsung.android.app.contacts	Contacts	###	12:30:07 (29-Jul-2020)	###	12:30:09 (29-Jul-2020)	2 sec	
43	com.samsung.android.messaging	Messages	###	12:30:09 (29-Jul-2020)	###	12:30:54 (29-Jul-2020)	45 sec	
44	com.samsung.android.bixby.agent	Bixby Voice	###	12:57:17 (29-Jul-2020)	###	12:57:17 (29-Jul-2020)	0 sec	
45	com.samsung.android.bixby.agent	Bixby Voice	###	12:57:17 (29-Jul-2020)	###	12:57:26 (29-Jul-2020)	9 sec	
46	com.samsung.android.bixby.agent	Bixby Voice	###	12:57:27 (29-Jul-2020)	###	12:57:55 (29-Jul-2020)	28 sec	
47	com.samsung.android.bixby.agent	Bixby Voice	###	12:58:06 (29-Jul-2020)	###	12:58:10 (29-Jul-2020)	4 sec	
48	com.samsung.android.bixby.agent	Bixby Voice	###	12:59:41 (29-Jul-2020)	###	12:59:54 (29-Jul-2020)	13 sec	
49	com.samsung.android.bixby.agent	Bixby Voice	###	12:59:54 (29-Jul-2020)	###	12:59:55 (29-Jul-2020)	1 sec	
50	com.samsung.android.bixby.agent	Bixby Voice	###	13:00:33 (29-Jul-2020)	###	13:00:35 (29-Jul-2020)	2 sec	
51	com.samsung.android.email.provider	Email	###	13:00:36 (29-Jul-2020)	###	13:00:51 (29-Jul-2020)	15 sec	
52	com.samsung.android.calendar	Calendar	###	13:03:43 (29-Jul-2020)	###	13:03:51 (29-Jul-2020)	8 sec	
53	com.samsung.android.calendar	Calendar	###	13:10:06 (29-Jul-2020)	###	13:10:10 (29-Jul-2020)	4 sec	
54	com.samsung.android.calendar	Calendar	###	13:18:00 (29-Jul-2020)	###	13:18:02 (29-Jul-2020)	2 sec	
55	com.samsung.android.email.provider	Email	###	13:37:55 (29-Jul-2020)	###	13:38:47 (29-Jul-2020)	52 sec	
56	com.microsoft.office.officehubrow	Office	###	13:38:47 (29-Jul-2020)	###	13:39:25 (29-Jul-2020)	38 sec	
57	com.sephora	Sephora	###	13:41:01 (29-Jul-2020)	###	13:41:14 (29-Jul-2020)	13 sec	

Appendix E

	A	B	C	D
1	session start	session end	duration(seconds)	
2	7/30/2020 14:29	7/30/2020 14:29	0	
3	7/30/2020 13:22	7/30/2020 13:22	0	
4	7/30/2020 12:36	7/30/2020 12:37	88	
5	7/30/2020 11:58	7/30/2020 11:58	0	
6	7/30/2020 11:55	7/30/2020 11:57	91	
7	7/30/2020 11:47	7/30/2020 11:47	0	
8	7/30/2020 11:41	7/30/2020 11:41	24	
9	7/30/2020 11:37	7/30/2020 11:37	1	
10				
11				
12				
13				
14				
15				
16				
17				
18				



Appendix F


No Service
2:10 PM
100%
Back
Today
Last 7 Days
iPhone
SCREEN TIME
Today at
1 min.
10 sec. above average
12 AM
6 AM
12 PM
6 PM
Entertainment
14 sec.
Other
8 sec.
Social Networking
7 sec.
SHOW APPS & WEBSITES

Appendix G

Script for Speaking to Potential Participants - Phone

Introduction

- Thank you for calling the Baby Language Lab
- My name is Mercedes Casar (from the Baby Language Lab at the University of Manitoba)
    - Master's student in Developmental Psychology
- I would like to give you more details about the research study

This call should take about 10 minutes. Is now a good time to talk?

- *If NO schedule an appropriate time to call back*
- *If YES… continue below*

Tell a little bit about your participation in the study:

Study Goal

- To learn more about the language heard by infants with mothers who use smartphones regularly, and how that relates to maternal speech

Participants

- Eligibility Criteria
    - Mothers (with infants who are 6-9 or 12-15 months of age during time of study enrolment)
    - English and/or French speaking
    - Mothers should be with their infant for *at least 3 days of the week* (Includes work days if mom is home w/infant in the evening)
    - Regularly use their smartphone

Brief Participation Description

- Researchers at the Baby Language Lab from the University of Manitoba are looking at the development of language in infants aged 6-9 and 12-15 months with parents who regularly use their smartphone.
- Participation means either a single 4-hour session or three 10-hour sessions during which you would be asked to record everything your infant hears (Based on availability)
- Download an application to track smartphone usage
- We hope to combine these two sources of information to learn more about how smartphone use impacts the amount of speech your child hears.
- You will be given a $10 gift card per recording session for your participation (plus $10 extra for full version cost).
- You have the right to withdraw your data at any time.

Check for Questions

Study Outline

- We will first drop off a document package and the recording device at your home before scheduling our first video call. This is where we will go over the consent form, which is an agreement for you to participate; during this video call we will also be asking you to fill out a brief questionnaire so we can learn more about you and your family; we will also explain how to download the application that will be tracking your smartphone usage during the study
- We will leave you with a special recording device; don't worry, we will show you how to use this during the first video call
- We ask that you record during a normal day with your infant, for a 4-hour/10-hour period; the application you downloaded will also be tracking your smartphone usage during this time
- Once you complete your 4-hour/10-hour recording, you will text a member of the research team to schedule the (final) video call. My phone number is available at the top of the consent form.
- During this video call, a research team member will ask you to send the information collected by the smartphone application to a University of Manitoba email address used only for this study and mark if you would like your recording to be deleted
- A research team member will stop by to pick up the recording device and all written materials as well as drop off your gift card for participating (when the last 10-hour recording is submitted)
- Please let us know in advance if you are unable to record on a particular day and we will extend the study timeline to accommodate your needs
- Using the information we learn from your, and other mothers', recordings we are hoping to learn things that will help us give advice to mothers with smartphones on how to improve their infant's language environment

Participant Honourarium

- You will be given a $10 VISA giftcard or giftcard to a local store for each recording submitted
- You may be given an additional $10 if you are required to purchase the full version of the application

Is this something you might be interested in doing? (Check for further questions.)

End

- Schedule zoom call (if interested), thank mother for her time

Appendix H

Recruitment Follow-Up email:

Hi _____(name)

Thank you again for speaking with me about my research!

I wanted to send you an update regarding the amount of time needed to participate in my study; *we are now asking that mothers record at home with their child once for only 4 hours*. This would be an option in addition to the 10-hour recording sessions 3 times a week I originally discussed with you.

In addition to making it easier to plan for recording days, we also hope to limit the amount of video conference calls to one *before* and one *after* the 4-hour session.

Additionally, if you know any mothers with children less than 15 months-old who would enjoy being a part of this study, you can direct them to our online web form used to add new participants using this link:
https://babylanguagelab.org/contact/

Please feel free to contact me if you have any questions or concerns
at

Best,
Mercedes

Book First Appointment email:

Hi _____(name)

As we discussed over the phone, your first appointment will be on
_____(date) and we will be doing our video call
using the Zoom link below:
_____(link)

Additionally, the Director of the Baby Language Lab will be joining us
on this video call. Please feel free to let me know if you have any
questions!

Best
Mercedes

End of Participation email:

Hi ____(name)

Hope you are doing well!

Did you receive the Amazon gift card as our thank-you for participating?

Best,
Mercedes

Appendix I

DEMOGRAPHIC QUESTIONNAIRE

Please Note: Responses to these questions are entirely voluntary. The information you provide us will be very helpful in our research. Please ask if you have any questions or concerns about your responses or how they will be used.

Parental Information:

To be filled out by experimenter:

Child's data code: _____

Study code: _____

Date: _____

Parent 1:

Age:_____ Ethnicity:_____ Gender: M/F/Other:_____

Parent 2:

Age:_____ Ethnicity:_____ Ger

Completed Education:

Parent 1: Number of years spent in post-secondary education (e.g. University, College, Trade School) ☐

Other:_____ (ex. Partially completed education/in progress education)

Parent 2: Number of years spent in post-secondary education (e.g. University, College, Trade School) ☐

Other:_____ (ex. Partially completed education/in progress education)

Parent 1: Experience with children prior to becoming a parent: None ☐ Some ☐ Extensive ☐

Briefly describe experience:_____

Parent 2: Experience with children prior to becoming a parent: None ☐ Some ☐ Extensive ☐

Briefly describe experience:_____

Children in your Family:

Child participating: Date of Birth (Day/Month/Year)_____/_____/_____ ☐ Male ☐ Female ☐ Other

Siblings ☐ None OR DOB:_____/_____/_____ ☐ Male ☐ Female ☐ Other

DOB:_____/_____/_____ ☐ Male ☐ Female ☐ Other

DOB:_____/_____/_____ ☐ Male ☐ Female ☐ Other

Who are the adult members in your household?

Briefly describe:_____

Child Care Arrangements (on a regular basis):

How often is Parent 1 the sole/primary caregiver?_____

How often is Parent 1 away from the child?_____

How often is Parent 2 the sole/primary caregiver?_____

How often is Parent 2 away from the child?_____

Are the grandparents or other family members involved in child care? If so, please describe:

Formal Childcare ☐ No ☐ Yes

☐ In home (licensed) ☐ In home (unlicensed) ☐ Child Care Centre

Other: _____ How often: _____

Child Background

Is your child from a multiple-birth? ☐ No ☐ Yes

If yes, please circle: Identical Fraternal Not Sure

Are you aware of any hearing impairment or difficulties in your child? ☐ No ☐ Yes

If yes, please explain:

Are you aware of any language or cognitive impairment or delay in your child's development? ☐ No ☐ Yes

If yes, please explain:

Is there anything else we should know about your child (e.g. physical characteristics) not addressed above that might influence how they behave in studies? ☐ No ☐ Yes

If yes, please explain:

Language Background

What percentage of the time are the following languages used in your (your child's) household?

Canadian English	0%	<10%	10%	25%	50%	75%	90%	100%
Canadian French	0%	<10%	10%	25%	50%	75%	90%	100%
Other Languages (please specify)	0%	<10%	10%	25%	50%	75%	90%	100%

Appendix J

Home Recordings – A Guide for Parents

Using the LENA Device

1. To turn the device on, press and hold the power button.
2. To start a recording, press and hold the REC button. An indication that the device is recording will appear on the screen.
3. If you need to pause the recording press and hold the REC button again. An indication that the device is paused will appear on the screen. You will want to pause the device at the end of the recording before turning it off.
4. To turn the device off, press and hold the power button.
5. The device may be paused during the recording; all we ask is that you accurately record the time you pause the device as well as the time that you un-pause and continue the recording.
6. Please do not turn the device off for naptime! It can simply be removed from the vest and placed in close proximity to the child i.e. under the crib or on a nearby table.

The Vest

1. Use whichever one fits your child better. It's easier to put the vest on the child, and then turn on the device before slipping it into the pocket.

Using the Observation Sheet

1. Please accurately record the time that you start the recording, as well as the time that you finish at the end of the recording session. This is a big help when it comes to matching the observation sheet to the recording!
2. As best as you can, record the activities your child engages in as well as the time of each.
3. The Comments column is for recording anything you feel might interfere with the recording (music, loud noises) or anything else you want to let us know.
4. Detail is always appreciated.

Your contribution to the project is very much appreciated. We thank you for your time and effort!

Appendix K

Impact of Maternal Smartphone Use on Language Output

LENA Recording Sheet

DATE: _____

ID: _____

RECORDING #: _____

START TIME: _____ END TIME: _____

UNIVERSITY OF MANITOBA

BABY LANGUAGE LAB

Please record times that you paused the recorder throughout the day:

PAUSES

START TIME (HH:MM AM/PM)	END TIME (HH:MM AM/PM)

Please record naptime throughout the day:

NAPTIME

START TIME (HH:MM AM/PM)	END TIME (HH:MM AM/PM)

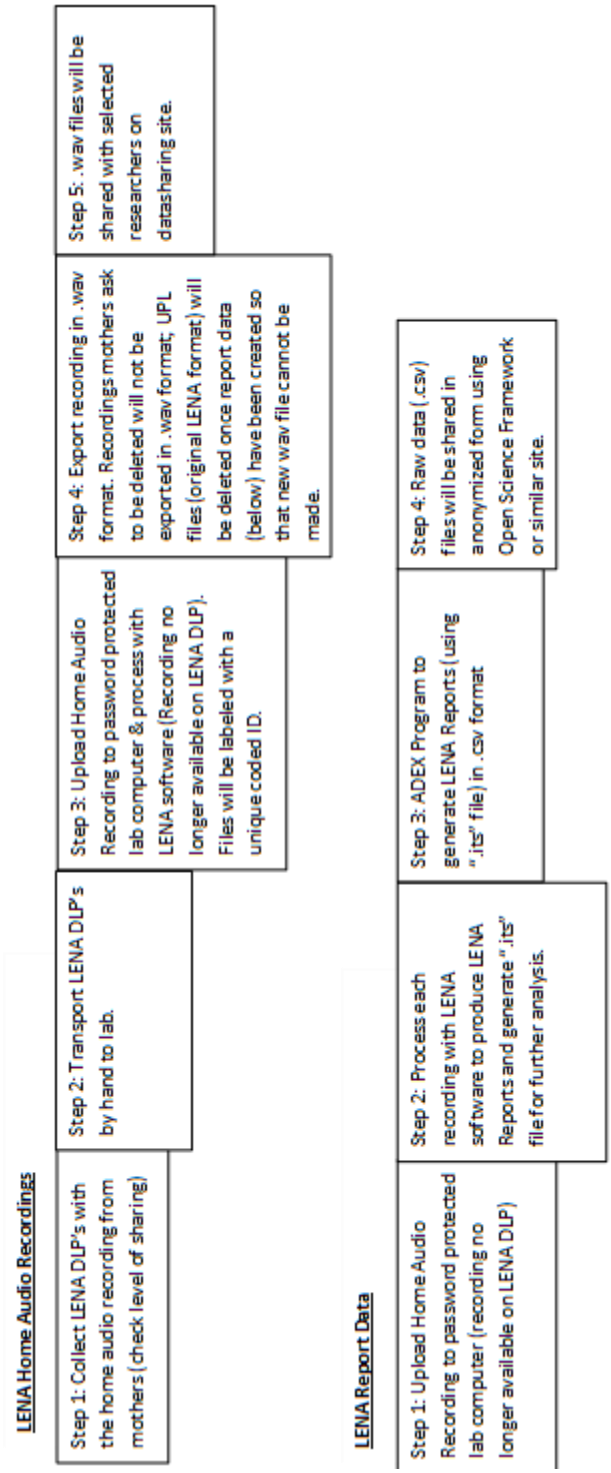
Please record an overview of activities completed throughout the day on the next page. Please complete this *at the end of the day* (not throughout the day while interacting with your child), as a summary:

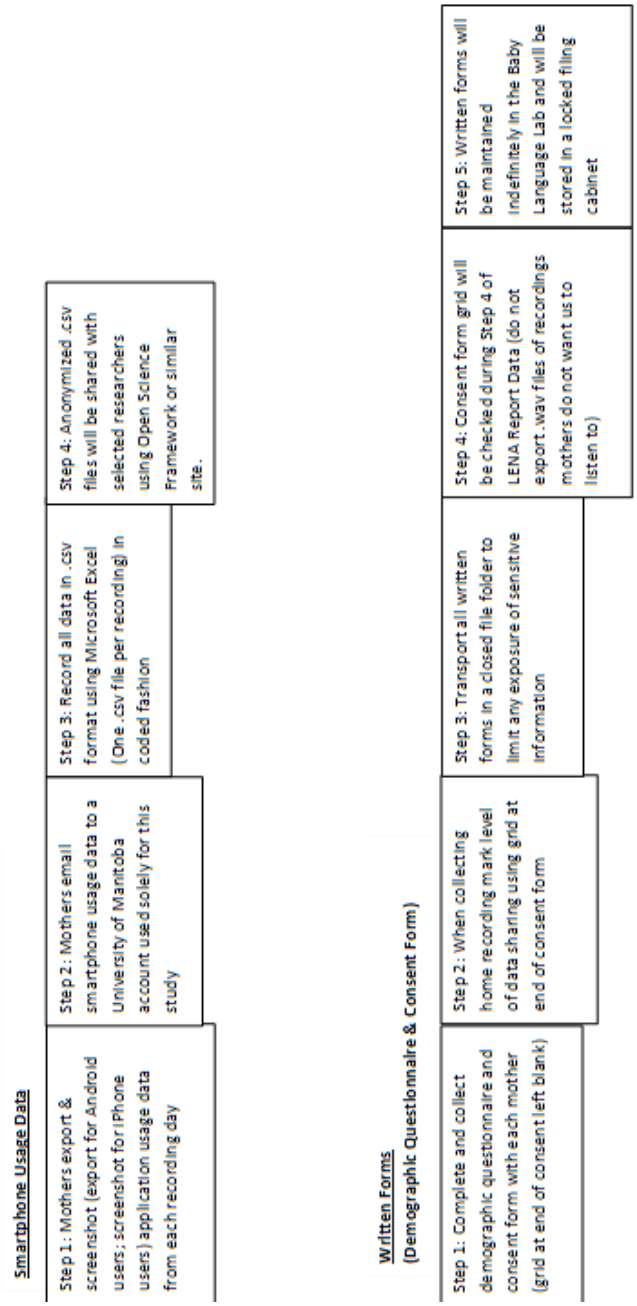
ACTIVITY CATEGORIES (examples):

PLAYTIME *STORYTIME* *OUTSIDE VISITS* *TV TIME* *BATH TIME*

ACTIVITIES (approximate start and end times)	LOCATIONS	COMMENTS

Appendix L


LENA Home Audio Recordings
Step 1: Collect LENA DLP's with the home audio recording from mothers (check level of sharing)
Step 2: Transport LENA DLP's by hand to lab.
Step 3: Upload Home Audio Recording to password protected lab computer & process with LENA software (Recording no longer available on LENA DLP). Files will be labeled with a unique coded ID.
Step 4: Export recording in .wav format. Recordings mothers ask to be deleted will not be exported in .wav format; UPL files (original LENA format) will be deleted once report data (below) have been created so that new wav file cannot be made.
Step 5: .wav files will be shared with selected researchers on datasharing site.
LENA Report Data
Step 1: Upload Home Audio Recording to password protected lab computer (recording no longer available on LENA DLP)
Step 2: Process each recording with LENA software to produce LENA Reports and generate ".its" file for further analysis.
Step 3: ADEX Program to generate LENA Reports (using ".its" file) in .csv format
Step 4: Raw data (.csv) files will be shared in anonymized form using Open Science Framework or similar site.


Smartphone Usage Data
Step 1: Mothers export & screenshot (export for Android users; screenshot for iPhone users) application usage data from each recording day
Step 2: Mothers email smartphone usage data to a University of Manitoba account used solely for this study
Step 3: Record all data in .csv format using Microsoft Excel (One .csv file per recording) in coded fashion
Step 4: Anonymized .csv files will be shared with selected researchers using Open Science Framework or similar site.
Written Forms
(Demographic Questionnaire & Consent Form)
Step 1: Complete and collect demographic questionnaire and consent form with each mother (grid at end of consent left blank)
Step 2: When collecting home recording mark level of data sharing using grid at end of consent form
Step 3: Transport all written forms in a closed file folder to limit any exposure of sensitive information
Step 4: Consent form grid will be checked during Step 4 of LENA Report Data (do not export .wav files of recordings mothers do not want us to listen to)
Step 5: Written forms will be maintained indefinitely in the Baby Language Lab and will be stored in a locked filing cabinet

Appendix M

		AL	AM	AN	AO	AP	A
1	ng	Elapsed_T	Clock_Time_TZAdj	Audio_Duration	Average_	eak_Si	ev
2	1	0	07/29/2020 11:41:01	239	65.39	84.7	
3	1	239	07/29/2020 11:45:00	300	54.67	81.22	
4	1	539	07/29/2020 11:50:00	300	61.19	86.16	
5	1	839	07/29/2020 11:55:00	300	52.61	84.23	
6	1	1139	07/29/2020 12:00:00	300	51.09	82.57	
7	1	1439	07/29/2020 12:05:00	300	52.13	82.55	
8	1	1739	07/29/2020 12:10:00	300	48.93	66.31	
9	1	2039	07/29/2020 12:15:00	300	48.93	66.31	
10	1	2339	07/29/2020 12:20:00	300	53.86	82.39	
11	1	2639	07/29/2020 12:25:00	300	52.28	83.7	
12	1	2939	07/29/2020 12:30:00	300	49.47	67.26	
13	1	3239	07/29/2020 12:35:00	300	49.39	62.73	
14	1	3539	07/29/2020 12:40:00	300	49.39	62.73	
15	1	3839	07/29/2020 12:45:00	300	50.8	77.91	
16	1	4139	07/29/2020 12:50:00	300	50.12	74.92	
17	1	4439	07/29/2020 12:55:00	300	51.2	80.81	
18	1	4739	07/29/2020 13:00:00	300	52.11	79.7	
19	1	5039	07/29/2020 13:05:00	300	50.18	73.66	
20	1	5339	07/29/2020 13:10:00	300	51.23	82.42	
21	1	5639	07/29/2020 13:15:00	300	49.7	76.05	
22	1	5939	07/29/2020 13:20:00	300	53.56	85.86	
23	1	6239	07/29/2020 13:25:00	300	54.48	86.58	
24	1	6539	07/29/2020 13:30:00	300	52.8	77.35	
25	1	6839	07/29/2020 13:35:00	300	50.12	78.86	
26	1	7139	07/29/2020 13:40:00	65.24	55.48	82.47	
27							