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BabyHCI: Evaluating the Experience for Babies and Caregivers in the Context of an iPad App to Encourage Babbling

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Fig. 1. Infant 'babbling' in order to produce coloured shapes within the BabblePlay App

This work presents early findings from the evaluation of a prototype iPad game designed to encourage pre-linguistic vocalisations (baby 'babble') which support language development in babies. The core functionality within the prototype is already known to be effective and this work sought to evaluate and understand the experience of the app within the parent-baby dyad. The study was carried out with 10 babies (and caregivers) where the baby 'played' with the iPad app for five minutes and the caregiver then completed a short survey. This work is one of only a very small number of studies within the IDC community involving babies. The key contributions from this early work are a set of challenges which are valuable to other working within the field of 'BabyHCI'.

CCS Concepts: • **Human-centered computing** → **User studies**; Sound-based input / output; **User interface design**.

Additional Key Words and Phrases: BabyHCI, Babble, Pre-linguistic Vocalization, HCI, User Experience (UX), Baby, Infant, Child, Touchscreen, iPad, App

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1 Introduction

Pre-linguistic vocalization is an important stage of language development and refers to intentional sounds made as an infant develops speech. A significant vocalizing milestone is that of babble: Babble typically begins between the ages of 6 - 12 months and includes reduplicated babbling - repeated syllables consisting of consonant and a vowel (e.g. “da da da” or “ma ma ma”) - and then variegated babbling where strings of different syllables are combined [23]. Infants with delayed language development (often termed ‘late talkers’) who begin to babble and develop language later than their peers are known to be at risk of lower academic performance in later childhood [34] [3]. Groups at higher risk of delayed language development include those from Low-SES (Socio Economic Status) families, where infants may be spoken to far less, and using simpler language, than in higher-SES families [38] [15]. Children with Intellectual and Developmental Disabilities [32], and infants at risk of autism spectrum disorders (ASD) (younger siblings of those diagnosed with ASD) [28] may also benefit from interventions to encourage language development such as babbling.

In this paper we report on an evaluation of an existing prototype iPad app called BabblePlay which has been created to support language development in babies by providing real-time visual feedback to pre-linguistic vocalizations (canonical and variegated babble sounds) [17]. The intention of the app is that the babies learn that coloured shapes are produced in response to the babbling sounds they produce, and this encourages the baby to continue babbling which helps to support language development; the app in use is shown in Figure 1. Prior studies involving the BabblePlay app have shown that the app responds appropriately and rapidly to babble sounds [6], and that babies are able to learn the contingency between their vocalizations and the visual responses appearing in the app [17]. In this work we take a HCI, as opposed to a linguistic, lens to the app to both understand the practicalities of usage of the current prototype along with the experience for both baby and caregiver. Within the HCI community, evaluation of technologies with babies, and within a baby-caregiver dyad, has received relatively little prior attention. While research studies with babies in many domains are conducted under tightly controlled lab conditions, taking a HCI/UX approach we adapt core aspects of usability testing and usability evaluation to the ’BabyHCI’ context. From observations during the evaluation study, analysis of data collected, and experiences of the surprising and diverse challenges encountered in this work, we provide a set of findings relevant to others conducting HCI studies with young infants. We also highlight ’BabyHCI’ as a novel and important area to explore within the IDC community.

2 Related Work

Language development within the first three years of life happens at a rapid pace. Babies acquire language quickly, but this development is sensitive to the quality and quantity of the language inputted [19]. By their second birthday, neuro-typically developing children have gained around ten times the number of words they had when they were 16 months old, and 200 times that of an 8 month old. To achieve this rapid learning, babies engage an extensive network of brain regions including the frontal, occipital and cerebral cortices [31]. Language quantity and lexical diversity are not only indicators of strong literacy development in babies but predictors of mathematical abilities, social skills and executive function [33]. Babbling, or pre-linguistic vocalization, has been known to have an important correlation with language development [4]. Children that show delayed canonical babbling can be at risk of language development delays later on [24], suggesting that supporting children’s babbling development could scaffold future language skills.

Many papers within the HCI community that reference babies are in fact focused on interactive technology for adults who have babies like baby monitor design [40], breast pump design [37], nutrition tracking [27] and milestone tracking [2]. When looking for papers and research, care has to be taken to also not include papers where ‘baby’ is used

in speech, like the paper entitled "baby you can ride my bike" [22] or where the baby of interest is actually a robot [20]. In more directly related work, [14] studied how babies interacted with tablets by surveying 208 YouTube videos. This work highlighted that most of the younger <17 month old babies interacted with either music or pictures on the iPads, that their parents typically held the iPads or they were laid flat, and that their ability to use the iPad, on a scale of 1 - 5 was typically quite low (1 or 2). A review paper by [12] studied papers that reported interactions with children and voice based agents with seven of these papers including children under the age of two, showing that, especially with the proliferation of smart speakers, even young children are learning to attend to sounds from digital devices. Technology that interacts with babies has included robots like the ChiCaRo [35] which is a small teleprescence robot specifically intended for infants. Such technology centred papers, as well as those on infant mother interaction [18] can inform us on how to set up data collection with babies e.g. through the insights gained from paradigms like the Face-to-Face Still-Face (FFSF) procedure [36], where it is observed that if babies sit facing a parent who doesn't interact with them, they become anxious as they expect faces to respond to them. Other related work includes [25] which used babies attending to a virtual human (as an avatar) on a screen while sat on their caregiver's knee to capture, using gaze tracking, the extent of the babies attention to the screen. [26] played sounds to babies seated in high chairs, and, using gaze tracking technology, rewarded the babies with small videos if they appeared to attend to the sounds. Using babble sounds, the babble blanket [10] was designed to output baby babble to non-verbal babies in response to the baby leaning on, or crawling over, actuators in a blanket. Closely related work by Fell et al. [9] [7] [8] used a vocalization analyser with infants (visiBabble) and focused primarily on technical testing of their system but inspired the procedure used in our study.

3 The Study

3.1 Participants

Participants were recruited through baby groups local to the university. Leaders of these groups were contacted to enquire if they would be agreeable to the research team running the study at their group. This resulted in the research team visiting three baby groups, where those with babies, who met the criteria for the study (at least 6 months old and babbling) were approached and invited to participate in the study. Participants were also recruited through word-of-mouth via the immediate social networks of the researchers involved in the work. The study was either carried out in a quiet room at a baby group or in the home of the baby. Participant Information and Consent sheets were used for all participants, ethical approval for the study was granted by the University of Central Lancashire and participants were given an Amazon voucher after completing the study. All participants had English as a first language and lived in the North West region of the UK. The mean age of participating babies was 15.4 months and all babies were in the babbling stages of language development (as reported by caregivers and observed by researchers facilitating the studies); this also included the oldest baby (participant 8, 25 months old) whose parents were concerned about their language development.

3.2 Apparatus

We used the prototype iPad app called BabblePlay which provides real-time visual feedback to voiced sounds [17]. The app begins with a black screen but on detection of a baby vocalization (within 160 ms) a shape appears on the screen and continues to move for the duration of the vocalization. The initial features of the shape, its colours, texture, initial size and location are random, but the shape's size grows if the vocalization becomes louder or shrinks as it becomes

softer. For information regarding the algorithms used to build BabblePlay please see [6]. Once started, the app runs for five minutes then stops automatically. For our study, a single 10.9 inch Apple iPad 10th generation was used with all the participants; this device had a black protective rubber case and can be seen in Figure 1. An evaluation questionnaire was designed to be given in paper form to the caregiver directly after the study. The evaluation questionnaire was based on an existing survey that had been used successfully in another stream of ongoing research work with the BabblyPlay app [16].

3.3 Procedure

Once the baby and caregiver were in a quiet room and seated, a facilitator explained the purpose of the BabblePlay app, the purpose of the study, and the procedure; that the app would run for five minutes then stop, but that the session could stop earlier for any reason such as the baby becoming bored or distressed. Once each study started the facilitators remained in the room to observe the baby and iPad screen (sessions were not video recorded). The facilitators returned any eye contact from the baby during the five minute period with a smile to help keep the infant at ease. Returning eye gaze with a smile is known as an Ostensible Signal and subsequent shifts of gaze by the facilitator could have directed the gaze of the baby [39]. Once the five minutes has elapsed the caregiver was then given a paper copy of the evaluation questionnaire to complete then thanked for their time and given an Amazon voucher. After each study the facilitators held a debriefing discussion as soon as practical where anything interesting or unusual was noted.

4 Results

Results from the caregiver questionnaire showed that all the babies interacted with the iPad in some way, even if they did not manage to trigger the visualization, confirming that the iPad was noticed by, and easily accessible to, the babies. When asked whether the app responded to sounds from the baby, seven caregivers responded that their babies triggered visualizations in the app by making sounds, this was confirmed by the explanation given (and corresponded with observations by facilitators in all cases). Figure 2 shows scores for how enjoyable the experience of using the BabblePlay app was on a five-point scale (1 = Not at all enjoyable, 5 = Very enjoyable) as assessed by the caregiver. The mean score was 2.90 for the babies and slightly higher at 3.60 for the caregivers. Both questions included a request to explain why that answer was given. For the caregiver, of the eight explanations given, four made specific reference to observing the baby interacting with the app being *interesting* (e.g. p1 “It was interesting watching her figure out how to make the shapes appear”). Responses related to baby enjoyment received nine explanations, of these three were positive with associated scores of 4: p1 “She started to understand that she was making the shapes appear”, p5 “Was curious once shapes appeared”, p8 “Enjoyed the colours and shapes all different”. The four most negative scores also had clear justifications as to why the trial of the app was unlikely to have been enjoyable for the infant: p3 “Needs to be more continuous stimuli to keep engaged”, p4 “Child very quiet nothing picked up”, p6 “She was confused why no one was speaking”, p9 “She didn’t really understand”.

Two questions within the questionnaire enquired what could be changed to improve the baby experience and the caregiver experience. The responses to these questions were collaboratively analysed (by the two facilitators that carried out the studies) using an inductive Thematic Analysis approach [5]; the coders firstly familiarised themselves with the data and considered this in relation to the question asked, then worked through the data developing and refining codes that were assigned to the data. In cases of disagreement, coders discussed their interpretations of the data and codes until agreement could be reached. Each question was coded individually. Codes were assigned to relevant fragments of

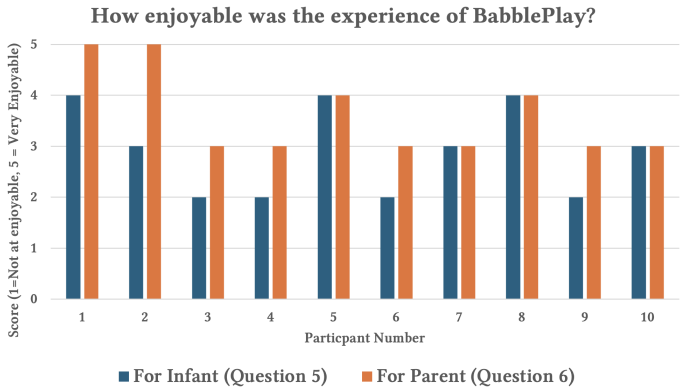

Fig. 2. Responses to Questions on enjoyment of experience or Infant and Parent

text within a response, only a single code was needed for each fragment of text. The coders then discussed and decided upon the final themes which are shown in the following paragraphs.

Themes: Improving baby experience

Encouragement to babble (n=4) Suggestion for the app to actively encourage babbling instead of showing a blank screen e.g. p2 "Something to use to encourage child to make noise."

Visualization Design (n=3) Suggested changes to the design of visualization including shape size (e.g. p9 "...bigger shapes"), duration (e.g. p8 "...shapes that stayed longer on screen") and colour (e.g. p9 "More light colours...")

Auditory Feedback (n=2) Suggestions to provide auditory feedback in addition to visualization when babbling is recognised e.g. p6 "Noise when shapes come up - would get her attention more."

Themes: Improving caregiver experience

Auditory Feedback (n=2) Suggestions to provide auditory feedback in addition to visualization when babbling is recognised e.g. p3 "Perhaps also have a noise as well when symbol comes up."

No changes needed (n=2) Specifically stating that no changes were needed e.g. p1 "Nothing, I thought it was easy to navigate as a parent."

Encouragement to babble (n=1) Suggestion for the app to actively encourage babbling instead of showing a blank screen e.g. p9 "It's just a black screen so there isn't much to encourage them to talk at the start."

Larger Screen (n=1) Suggesting a larger screen would improve the app e.g. p10 "Use a larger screen for the app - so that the child is more likely to stay engaged."

5 Discussion

From the results shown in the previous section it is clear that the response to the app from the caregivers (and through the caregivers assessments, the babies) was generally positive, as evidenced by the quantitative and qualitative data collected. The qualitative data primarily related to observing the baby interacting being "interesting", related to the caregiver identifying enjoyment in the baby when they were interacting, and related to new and novel experiences. While this data provided valuable insights, the question of how baby 'enjoyment' can be understood, monitored and interpreted should not be underestimated. While validated tools for measuring infant enjoyment/experience in a

technology context do not yet exist, in other domains such as food preference behaviour analysis of infant video footage is used [13] [11] along with detailed survey tool and evaluation procedures for caregivers [21].

No serious issues were observed or reported with the procedure for the study or associated data collection. The survey was filled-in while the caregiver was still with the baby and as such the number of questions was kept to a minimum and printed paper forms were used to reduce the risk of technical problems and delays. While this strategy worked well, with overall explanations and free-text responses being minimal, a lower-effort solution for the caregiver may have been a semi-structured interview (particularly for the open-ended questions) where a caregiver could have more easily provided responses in greater detail while still attending to their baby if necessary. Initially the researchers were concerned that five minutes may be too long for babies to sustain interest in the iPad/app while the caregiver and facilitators remained silent. However, in only one case was the app trial stopped before the five minute limit (p6). Even for the youngest infant (6 months, p3), and for cases where the infant did not babble (p2, p4, p7), it was possible for the infant and caregiver to remain with the iPad without the baby becoming excessively bored or unhappy.

The focus of the analysis in this paper was on enjoyment of the app and areas for improvement; as demonstrated in the previous section, a range of valuable insights were gathered. As was evident from the previous section, some babies remained silent and struggled to and learn the 'contingency' of their own sounds triggering the visualization [17]. Issues related to this featured prominently in the themes for improvement. In this study the technology (iPad/App) was effectively a way to deliver an intervention (visualization in response to babbling) rather than being a new app delivered within an already familiar technology ecosystem. Therefore baby learning in this context poses additional challenges which are not found in children over the age of two years where interaction with touchscreen devices becomes both cognitively easier and more commonplace [1] (in addition to this older age group typically being able to understand instructions to some extent).

6 Conclusion

This paper presented results from a study evaluating the use of an iPad app (BabblePlay) which encouraged pre-linguistic vocalisations (baby 'babble') which support language development. The study involved 10 babies (aged 6-25 months, mean 15.4) interacting with the app followed by completion of a questionnaire by a caregiver. BabyHCI is under-explored within the IDC community and this paper provides a set of early results and associated findings valuable to others wishing to work with babies and caregivers within HCI and User-Experience (UX) contexts. We consider it is important to elucidate what is meant by BabyHCI. Child-Computer Interaction, an existing and active sub-field of HCI, has been defined as focusing on "Children as they interact with computer technologies, often with the intervention of others (mainly adults) in situations that they partially (but generally do not fully) control and regulate."[30], children being broadly defined as those under the age of 18. More recently the term "Small CCI" was used to describe studies with children aged 3-4 years in a preschool context [29], where children could not reliably read or write but could follow instructions with minimal support from adults. Moving down the ages we define 'BabyHCI' as being concerned with children aged two years or younger interacting with technology under close support and supervision from a caregiver who is sharing the experience. The important differences here, between CCI and SmallCCI, are the support (e.g. holding the technology, ensuring the infant is able to interact etc.), supervision (e.g. interactions taking place, intervening if not), and the need for a 1:1 caregiver with close involvement sharing the interaction experience with the baby. All of these factors are unique in that they are a prerequisite for BabyHCI. We hope that this paper will inspire others to consider working within the field of BabyHCI and that the findings we present are valuable towards their work.

7 Selection and Participation of Children

Ethical approval for the study was granted by the University of Central Lancashire. Participants were recruited through baby groups local to the university. Leaders of these groups were contacted to enquire if they would be agreeable to the research team running the study at their group. Participating caregiver-baby dyads were invited to participate if they met the criteria for the study (at least 6 months old and babbling). Participants were also recruited through word-of-mouth via the immediate social networks of the researchers involved in the work. Participant Information and Consent sheets were used for all participants. Participants were given an Amazon voucher after completing the study.

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