Designing a communication device for deaf parents and a hearing infant

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Abstract: This paper presents an ongoing interactive design project aiming to assist the parenthood of deaf couples and promote a high-quality parent-infant relationship with their hearing infant. The design and development process includes: (1) literature review regarding to deaf parents' parenting issues and the design of assistive devices for the deaf, (2) user needs and requirement acquisition on the basis of focus group discussions and two ethnographical case studies of deaf families, (3) analysis of competing products in the market as well as concept designs for the deaf, (4) concept design, and (5) a series of iterations between prototyping and evaluations. The design focuses on attachment or the emotional bond between deaf parents and their infant, rather than simply overcoming deafness-related barriers. The proposed design solution comprises of three items: a plush toy for the infant, a vibrating "watch" for the deaf parents and several ambient lighting modules for the room environment. The latter two items could keep deaf parents informed about their infant's status, which is detected by a cry detector embedded in the plush toy.

Key words: Deaf parents, parent-infant interaction, interactive device

1. Introduction

In this article, we focus on designing for families of deaf parents and a hearing infant aged 0 to 24 months. The first two years is a critical period to build trust and attachment between parents and the infant, regardless of parents and infants' hearing status [1]. The trust and attachment built in this period would in turn have long lasting impacts on the child's healthy development. Research shows that successful formulation of this initial emotional bond is largely subject to parents' sensitivity and responsiveness to the infant's physical and emotional needs [11]. Inability to hear sound unaided, however, severely hinder deaf parents from accessing to their infant's primary means of need expression, i.e., crying. The comparatively low incidence rate of deaf families makes this communication barrier is largely overlooked by existing baby monitors, which mostly relies on audio alerts. We thus initiated a design project exploring new parenting aid targeted at deaf parents with a hearing infant.

2. Literature Review: Deaf Parents and Hearing Children

Families of deaf parents and hearing children are not exceptional. It is estimated that 6 people out of 1,000 are not able to hear speech unaided, and the prevalence rate could rise to 86 per 1,000 persons if including those with some degree of hearing loss [8]. Endogamous marriage rate of deaf people is very high; approximately 85-95% of deaf adults marry each other [9]. Over 90% of deaf couples give birth to normally hearing babies [7,10]. Mismatched hearing status is in fact a normative pattern for a family formed by deaf adults and their children.

Meadow-Orlans' study showed that mismatched hearing status casts negative impact on building parent-infant relationship [5]. The quality of interactions between a deaf mother and a hearing infant was rated significantly lower than dyads of both parties are hearing or even both are deaf.

Deaf parents may not be confident of their childrearing abilities, nor gain as much social support as special services or programs targeting at deaf children [4,5]. Some deaf parents even give up their parental rights, as they "felt that their disability would place their children at a disadvantage in society if they raised the kids themselves" [3]. We realized that designers could do much more for the deaf than simply compensate their hearing impairment. A social model of assistive technology design [2], rather than a rehabilitation model, was thus adopted in this project.

3. Exploratory Studies about Deaf Families

To gain in-depth understanding of deaf parents with a hearing infant, our design team, in collaboration with the Singapore Association for the Deaf (SADeaf), conducted a series of exploratory user research and observations. SADeaf assigned a sign language interpreter to assist our investigation. A total of 11 deaf adults, including 4 couples with at least a young child, participated in two runs of focus group discussions. Using sign language and written notes (Figure 1), the participants not only shared with us the problems they had encountered, but also their own approaches to overcome those problems, as well as the available assistive devices they had exposed to.

Figure 1. Focus group discussions (face masked)

Based on the preliminary results gained in focus groups, we approached to two deaf families for ethnographical field observations. Parents of these two families are all deaf, and the infants are respectively 3 and 14 months old. Deaf parents, grandparents (all hearing), babysitters/maids were interviewed, and their interactions with the infant were observed in their own home environments. To capture infant's crying patterns, we provided each hearing infant a plush bunny toy embedded with a voice recorder, as shown in Figure 2. Each recording session lasted approximately 48 hours. 5 sessions had been captured till the date of paper drafting. The data revealed that most incidences of infant crying occurred without the presences of their parents, e.g., waking up from a nap, climbing out of the cot.

Deaf parents confirmed that deafness is a huge parenting challenge; they all expressed their worry about missing their babies' cry. Lack of baby monitors appropriate to deaf parents, two coping strategies were currently adopted, i.e., asking a hearing person (e.g., grandparents, maid) for assistance, and frequently checking the infant's status when s/he is out of visual field. At night, they always sleep with an arm stretch to reach the baby to feel their movement, and cries (Figure 3). None of these coping approaches could effectively help independent parenting of deaf parents.

Figure 2. Voice recorder embedded in a bunny to capture crying patterns of infants (face masked)

Figure 3. Deaf parents' own coping approach (face masked)

When asking for user needs for the design of a domestic parenting aid targeting at deaf parents, perhaps rooted in a compensation consideration, all deaf parents expressed their eager to be "connected" to their babies all the time. They do not only desire the ability to "hear" their child, but also to "feel" it when their child is beyond the range of vision. One parent used a quote from a book written by a Child of Deaf Adults (CODA) to represent her vision for parent-child interaction: "the fundamental basis of communication is not sound, but connection, not only whether one is able to express, but also whether one is heard [emphasis added]" [6].

On the basis of in situ observations, designers were able to layout schematic relationships of stakeholders and routine activities of a deaf family with a hearing infant (e.g., Figure 4). The elicited user needs and desires were translated into the design requirements to empower deaf parents the capability to give feedback on the hearing infant's actions all the time. In other words, information about the infant's conditions should be easily captured, transmitted and represented. The project was also named as "Fil'O", meaning for "feel it all the time".

4. Analysis of Competing Products and Concepts

A product review was conducted to better understand the state of arts of baby monitoring and prompting devices. The scope of review included the existing products available in the market and design concepts as emerging technologies. The existing products were selected from TopTenREVIEW.com and best sellers in Amazon.com, supplemented by Google search with key words. The design concepts were selected from a design website

CORE77.com and award lists of several international design competitions (e.g., Braun Prize, James Dyson award, Consumer Electronics Show [CES], etc.).

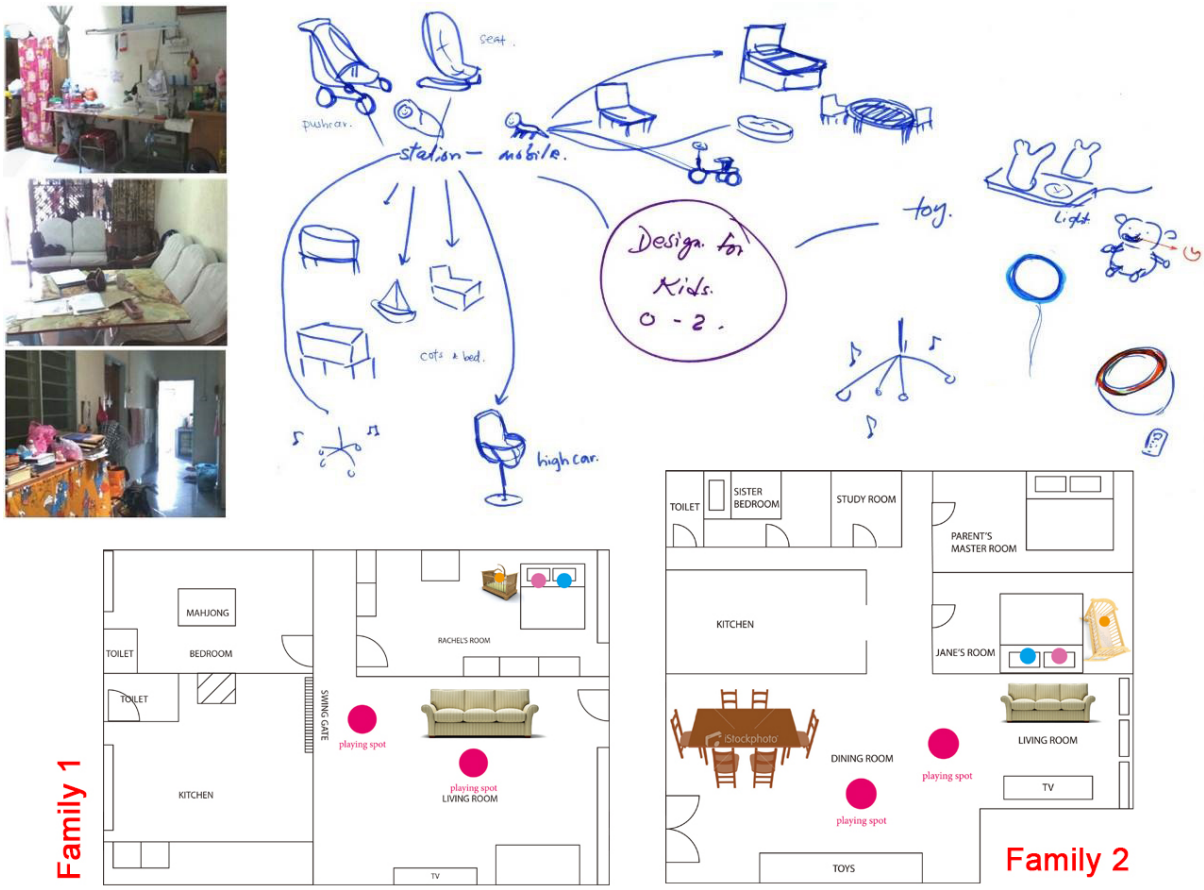

Figure 4. Ecological system of deaf family with a hearing infant

Figure 5 summaries the existing product review, by categorizing them according to output modality. Audition modality is the primary prompting solution for existing baby monitors, to which deaf parents do not have the access. Lighting is often used as a secondary prompting channel; lighting on a small screen or emitted from a LED would demand cognitive concentration if used as primary prompting function or in daytime. The tactile modality (to which deaf people has the access) is often missing in the existing products.

Deaf-specific products and concepts were summarized in Figure 6. A majority of reviewed products and concepts were alerting or prompting devices in general, while products related to baby-sitting or parenting were still in paucity. Right panel in Figure 6 reveals that a wristband or watch like shape tends to be popular in the emerging deaf-specific concepts.

Three competing baby monitors for the deaf were purchased and tested in deaf families to explore ergonomic issues while using this kind of assistive devices and other contextual understandings, as shown in Figure 7.

Figure 5. Analysis of baby monitors available in the market

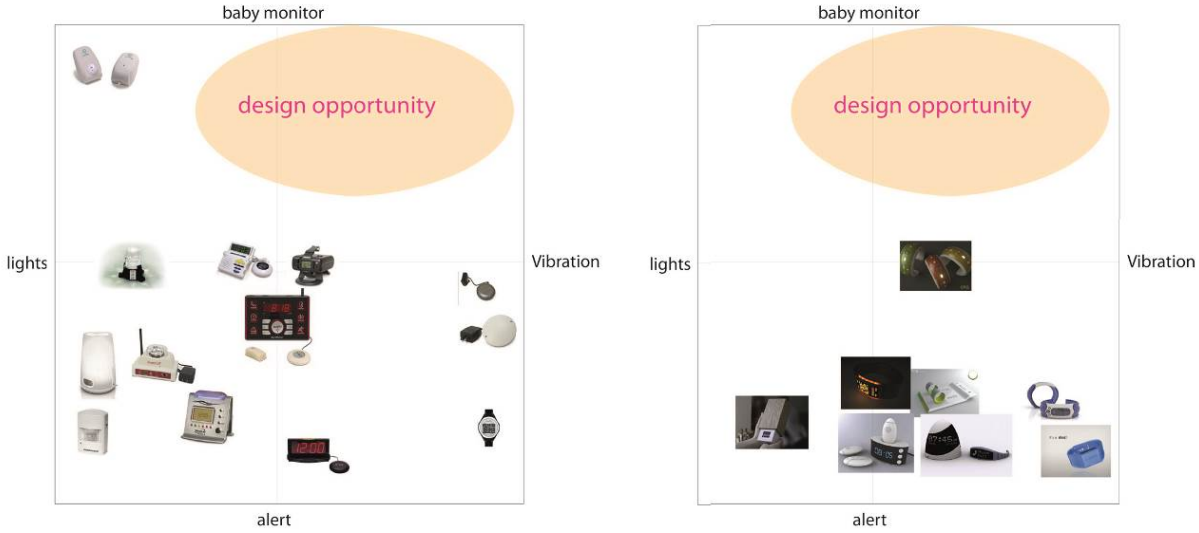

Figure 6. Products and concepts for the deaf (left: existing product in the market; right: concept designs)

Figure 7. Testing current products in the real context

5. Concept Design

On the basis of focus group, ethnographical case studies and product review, several design ideas have been explored, e.g., Figure 8. Ideation was focused on parent-infant communication and baby-sitting within the home environment. The result of ideation was a schematic structure of the novel parenting aid for the deaf, as shown in Figure 9. It comprises of three items: a “plush toy” for the infant, a “watch” for the deaf parent and several ambient lighting displays distributed in the rooms. The toy module would constantly detect the infant’s status and transmits signals to the watch module. The latter represents the infant’s conditions via different rhythms of vibration and a visual display on the watch. The ambient lighting devices strength the connection, and serve as additional alert at night. Figure 10 is a storytelling board describing a typical usage scenario using our design.

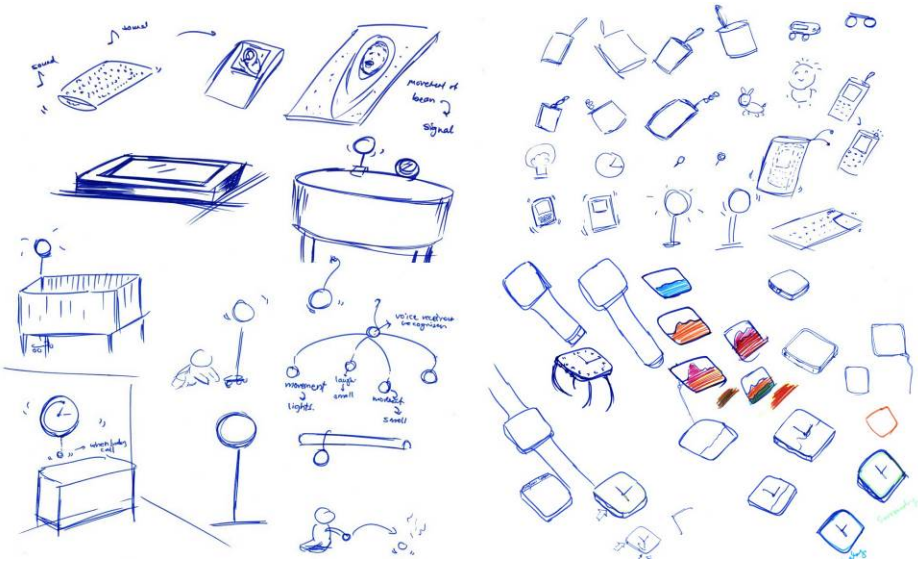

Figure 8. Thumbnail sketches during initial ideation

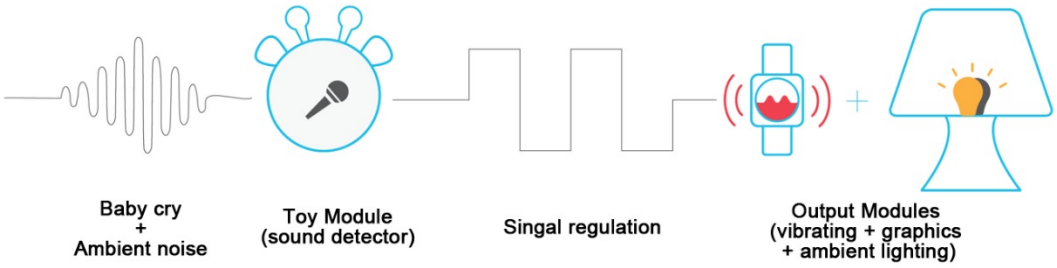

Figure 9. Schematic drawing of Fil’O

Figure 10. Usage scenario of Fil’O (faces masked)

6. Development of Prototypes

An iterative approach was adopted to develop this concept. For each run of iteration, we produced some physical representations of our design and asked deaf adults to try them out and share their experience with our designers.

6.1 Mockup and paper prototyping

The first iteration mainly focused on the semantic parts of our design. Basic forms of “plush toy” and “watch” modules were explored by the media of foam and card boards. The messages displayed on the “watch” were mocked up by different prints, as shown in Figure 11. Blue wavelets represent a comfortable status while red waves alarm parents’ attention to the infant.

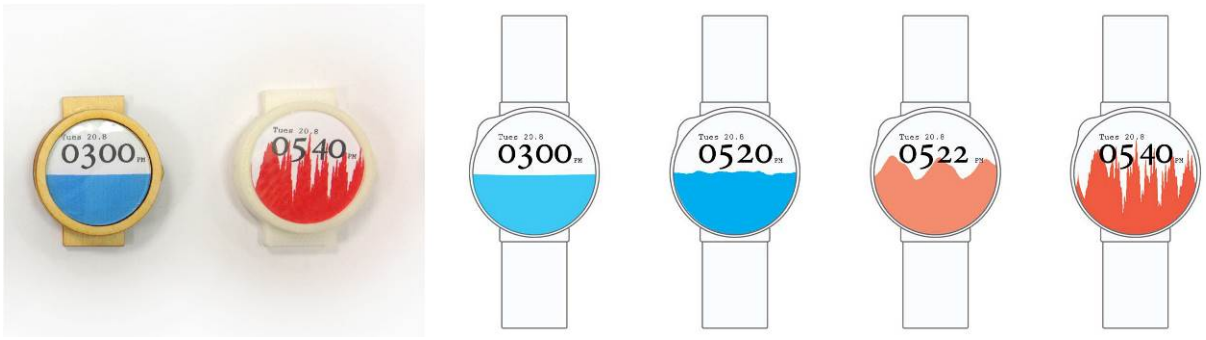

Figure 11. Mockup and paper prototyping of the “watch” module

The color coding and graphic displays were demonstrated in a local deaf community gathering. The intended messages were well communicated with the deaf adults. Several persons suggested an in-situ lighting system as they are more sensitive to the lighting signals, such as blink lightings. This comment was implemented in the additional ambient lighting devices, as shown in Figure 12.

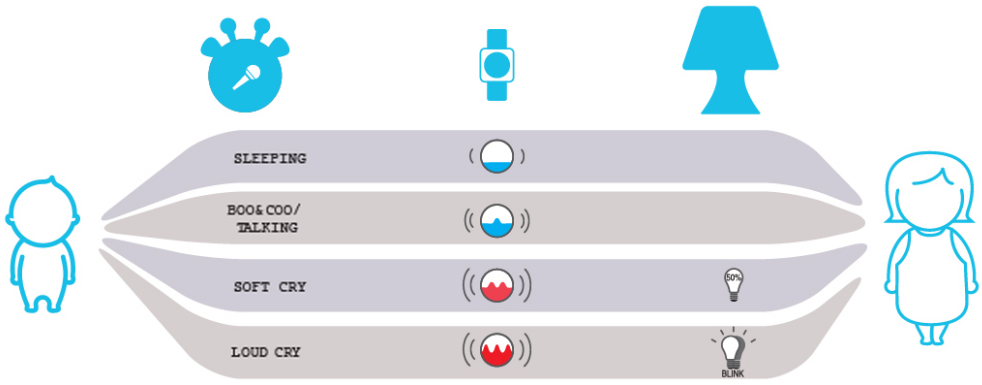

Figure 12. Prompting and alarming mechanisms

6.2 Functional Prototype (version 1)

The early functional prototype of Fil’O modules were built with an open-source electronics prototyping platform, Arduino (http://www.arduino.cc/). Figure 13 shows three quick-and-dirty prototypes, implemented by Adruino UNO and Arduino Pro Mini respectively. XBee radio modules (http://www.digi.com/xbee/) were used to facilitate wireless communication between “toy” and “watch” modules.

In addition to internal trouble-shooting type of testing, the vibrating intensity and rhythms were tested with deaf adults. A set of appropriate vibrating patterns were derived on the basis of deaf people’s feedbacks.

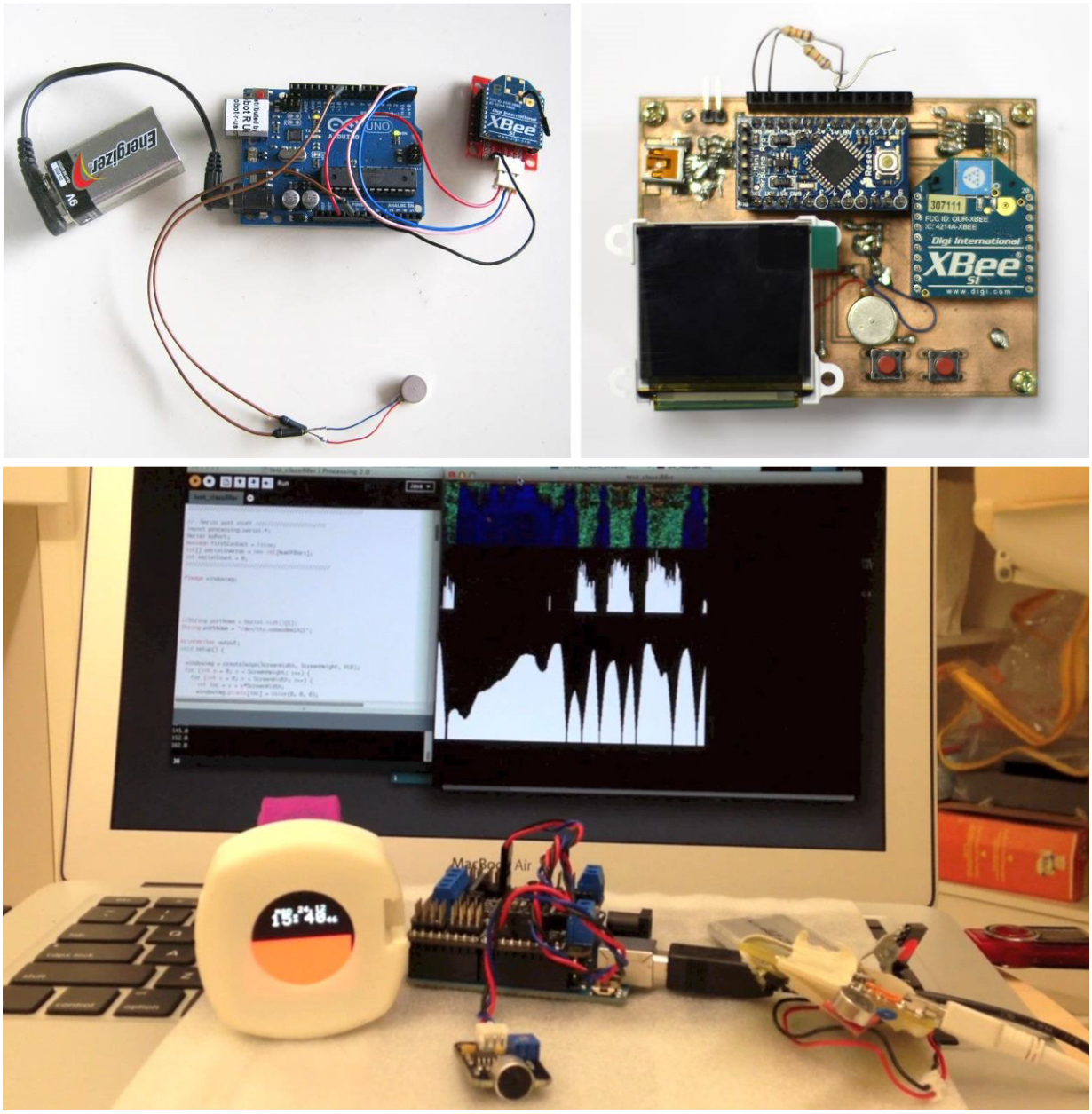

Figure 13. Prototyping “watch” module with Arduino

6.3 Functional Prototype (version 2) and User Evaluation

Different forms of the “watch” casting were explored with 3D printing. The rightmost casting in Figure 14 is in the dimensions of 50*50*28mm, which is the most compact size we could achieve so far to accommodate all the required electronic components (shown in Figure 15). This prototype was used for the in-situ user testing with three deaf families (2 families involved in the requirement acquisition plus 1 family with a girl aged 3 years), as shown in Figure 16.

In-situ user testing showed the wall may hinder wireless communication between the “toy” and “watch” modules. We thus modified the ambient display modules and made them also serve as routers to mediate toy-watch communications, as shown in Figure 17.

Figure 14. Exploration of the casing for the watch module

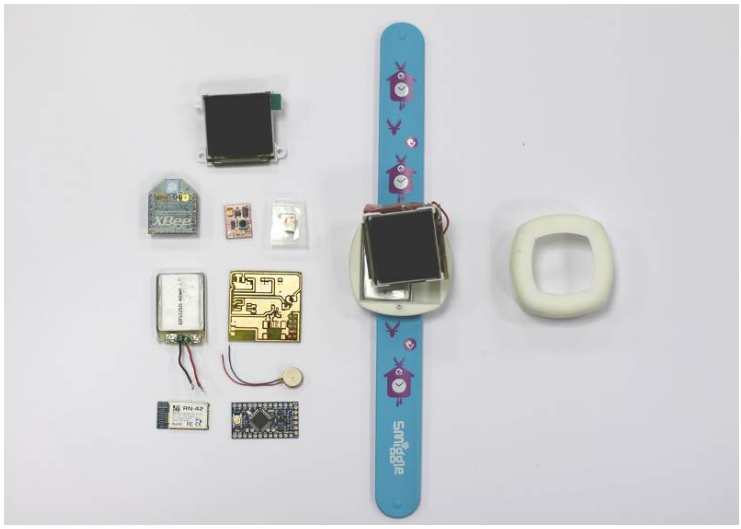

Figure 15. Wearable prototype for in-situ user testing

Figure 16. In-situ user testing (face masked)

Deaf mothers commented that their routine housework may wet their hands, such as washing dishes (shown in left of Figure 18). The “watch” module should be water resistant. For the hygiene consideration, the “toy” module should be washable. To address this issue, we designed the electronic components could be easily detached from the plush toy and the latter could be washed by normal washing machine, as shown in right of Figure 18.

Figure 17. Ambient Lights as routers mediating watch-toy communication

Figure 18. Water resistant “watch” and washable “toy”

6.4 Demonstration in Local Deaf Community

The while set of Fil’O kit had been demonstrated in the local deaf community gatherings (Figure 19). The feedbacks were very positive. Social workers in deaf community were keen on further developing this concept, and believed the release of Fil’O could benefit deaf people more than just baby-sitting.

Figure 19. Communicating our design to local deaf community (face masked)

7. Conclusions

This paper presents a novel parenting aid entitled Fil'O, which aims to connect the deaf parents with a hearing infant even when the latter is beyond parents' visible range. The concept is to keep deaf parents informed by their infant's status throughout the day and night, and alert parents when necessary. This design is based on a premise that trust between deaf parents and their hearing infant could be built if parents are able to attend and provide the infant's needs, and the parents' sensitivity and responsiveness would lead to a strong parent-infant relationship and increase future communication.

Till the date of paper drafting, this design is still under the development. The next stage is to improve wireless communication between the three items of Fil'O prototype, and conduct an in-situ longitude user evaluation (approximately 2 weeks to 1 month) to assure effectiveness and user satisfaction of this design. The algorithm which aims to distinguish baby's cry from ambient noise is also under the development and optimization.

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