Guidelines for a Baby’s Nutrition Monitoring System

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ABSTRACT
In this paper we present our initial investigation about a baby-care system that monitors the food served to a baby. We present the results of a formative study that we conducted with mothers of newborn children, and indicate guidelines for the design of a food-monitoring systems for babies. Based on our study and design guidelines we also present a concept-prototype of a system capable of sensing food properties, alerting parents for possible allergies or high temperatures, and informing about the food nutrition values. The system also is capable of recording the history of usage, of making suggestions about future meals and of sharing information and pictures through social media.

Author Keywords
Baby food; Child’s health; Baby nutrition information; Smart Spoon.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Infancy is the stage from the first two weeks after birth up to 30 months, and in such period of time an infant undergoes a rapid growth [9]. Being properly fed with appropriate nutrients is critical during infancy because it directly affects the infant’s development, eating habits, and its health. Mothers play the main critical role for maintaining a correct and appropriate nutrition and must be educated on proper procedures [7]. They must be aware of the child’s unique characteristics and avoid under feeding proteins, vitamins, and any other nutrients supporting their child’s health [4], a task for which parents are usually not trained and which causes great worries and frustration [7].

For such reasons, several researchers have developed specific tools to help parents in this task. Using current techniques to control the food quality served to children and to correctly time the baby’s eating pattern. For example, Baby Lucent [5] is a system that informs parents about the baby’s food nutritional content, and Sproulling [10] is a commercially available system to monitor and log infants’ activities and conditions through a wearable sensor. Although these tools propose new technological advancements that effectively help parents in their task of feeding and monitoring their babies, some researchers [5] raised concerns whether these technologies actually are beneficial to parents. In fact, heavy reliance on automation might, for example, hinder parental intuition about the baby’s conditions. Moreover, parents also expressed doubts about the reliability of the data and privacy concerns [5].

These reactions from parents could be caused by a misalignment between the parents’ actual needs and the designers’ view of technology.

Following previous work [3], in this paper we use a formative study based on the speed-dating technique with user scenarios to clarify the users’ needs and construct the design-space around which developers should focus. Specifically, we present the design space of an automated food-serving tool (the Smart Spoon) that helps parents monitoring the temperature, nutrition values and timing of the meals served to their babies. We contribute to the body of previous work by conducting a comprehensive formative study that addresses users needs, and shows how parents (especially mothers) can use an automatic system to track and supervise the eating habits of their babies.

This paper is organized as follows. In the next session we review the related work and highlight common problems. Then we show the results of a formative study, designed to explore the potential of a smart-spoon that tracks food properties and notifies parents. We derive some design guidelines from this study and design a concept prototype that reflects our findings. Finally, we discuss future avenues of research and possible extensions.

RELATED WORK
Several applications have been recently proposed for monitoring baby’ activities and health, and for supporting and enhancing the user experience of expectant parents. Weinberg et al. [11] introduced the BabySense Environment, an integrated tele-presence system to allow parents to remotely monitor the baby’ development and interact with the child through physical actuators. Lendari et al. [8] conducted a preliminary exploration toward the design of location sharing through mobile interfaces to promote offline social gatherings. The authors of this work discussed five different themes and suggested some design implications to cope with the conflicting needs of different stakeholders groups (father, mother and baby), and the trade-off between location sharing, privacy and schedule flexibility. Baby Steps [6] is a system designed to help parents recording and keeping an archive with the activities
of children during their early years. Differently from previous work, Baby Steps is not an automatic tracking system, but rather a tool that helps parents to frequently record and review information about their children. A study revealed that parents who used the system had higher confidence in reporting their children’s activities, and improved parent-pediatrician communication.

More recently, numerous works have been proposed for also monitoring baby’s health conditions in order to reduce parents’ stress and supervision. Baby Lucent [5] is a design prototype of a smart pacifier and a feeding bottle, which combined together, tracks the baby's health (e.g., likelihood of catching infections in nearby areas) and nutritional data, and broadcasts information to the parents’ smartphones. Bouwstra et al. [1] presented the Smart Jacket, a wearable unobtrusive continuous monitoring system realized with a body sensor network to help monitoring critically ill new born babies admitted in an Intensive Care Unit. Finally, Sprouling [10] is a commercially available system with similar purposes. Such system is capable to track infants’ activities and bio-parameters using a wearable sensor module and broadcast them to the parents’ smartphones. The system is also capable to predict baby’ needs and activities based on past behavioral patterns.

**DESIGN STUDY**

We designed a formative study as in [3], using a speed-dating technique in which participants were individually requested to discuss and elaborate their opinions about six different scenarios about the task of feeding babies. We adopted a non-technological perspective and tried to elicit the users’ opinion about their needs and possible pitfalls.

**Participants**

We described the objective of the research and initially recruited participants thorough a child community portal bulletin. We then pre-screened those willing to participate in the research through simple questions through email, such as residence, personal information for both the mother and the baby, and known medical issues for the baby (e.g., allergies, diseases, etc...). We finally selected 8 mothers, with age between 20 and 30 years (average of 28.7). Three participants have part time jobs such as internet businesses, while the other five are housewives. All mothers but two have a single child. Two participants’ babies have kiwi allergy and another participant’s infant has weak digestion symptoms.

**Method and material**

The experiment took a total of 80 minutes and it was divided into three different stages. First, the participants were given a thorough introduction of the purpose of the experiment and later were asked to create a user survey based on 36 questions for 15 minutes (demographics). Also, they were asked five additional open questions regarding their behaviors in raising the babies (10 minutes). Secondly, following previous work on formative studies [3], participants were presented with pictures of six different scenarios and after reading the related descriptions, were encouraged to express their opinions and concerns regarding the particular situations depicted in the scenarios (40 minutes). Finally, participants were asked to comment and give suggestions about the overall experiment (10 minutes). Through the experiment we were able to collect users’ opinion about the relevance of the problems described in the scenarios, as well as gaining knowledge on usage patterns when feeding babies, and suggestions on wanted product functionalities and their appearance.

**Demographics questionnaire**

The initial questionnaire was composed by 36 questions divided into four parts to appropriately categorize users. The questionnaire was based on users’ experiences regarding their competency, expertise, frequency of feeding babies. Questions were displayed using a 7-points Likert scale.

Part 1. Personal tendencies.

Part 2. Attitudes toward their children’s behaviors.

Part 3. Attitudes when preparing baby food.

Part 4. Usage of smart phones and social media (SNS).

**In Depth Interview**

An in depth interview was conducted to gather accurate information on users’ behaviors including those in unexpected situations, preferences and any other issues raised by users. The following questions were asked to the users:

- How do you prepare the baby’s meals?
- Do you use a thermometer to check food temperature?
- Do you face inconveniences using a diary in comparison to smart phone scheduler?
- Do you think the nutrient information will be helpful?
- Do you think social media information regarding baby food is trustworthy?

**Formative Study**

We conducted a formative study using the speed dating
Figure 1. The six scenarios used in the formative study.
technique as described in [3]. A paper storyboard was used to stimulate the users’ discussion about inconveniences and inefficiencies of systems used to feed babies. Each scenario (Figure 1) describes a set of different functionalities and situations of an imaginary system, attempting to exemplify common routines and pitfalls.

Scenario 1 (Figure 1A): This scenario describes the role of a diary for keeping a scheduler or a diary to record a child’s activities. The scenario also explores how mothers adjust their schedule according to different priorities and special occasions, how they do shopping in a mart with a list and finally how they inquiry the calories of a meal.

Scenario 2 (Figure 1B): This scenario is based on being aware of a baby’s sickness. The mother uses searching functionalities depending on particular situations, specifically, using social media. The scenario shows ways to improve methods to search health related topics using specific keywords or finding doctor recommended meals and nutrients. By additional “favorite” items, a mother can also save meals preferences for later usage.

Scenario 3 (Figure 1C): The scenario describes a situation where the mother needs immediate assistance with a sudden unexpected event in regards to the baby’s health. The storyboard explains the stages where the baby is crying and shows the mother’s reaction. It focuses on using an application to find the appropriate temperature of the meal and to provide mothers with baby’s meal patterns and ways for searching recommendations. The scenario also aims to leverage opinions about ways for recording temperature and setting alerts.

Scenario 4 (Figure 1D): The scenario shows common situations when mothers are preparing the meals and how the system can affect the baby’s meal patterns. The scenario explores the situation of using push alarms that trigger at correct times and that also provide accurate nutrition information. Through this scenario, we show how mothers can control proper nutrients for their child and how to prepare for certain meals.

Scenario 5 (Figure 1E): This scenario is focused towards controlling children’s eating habits. It shows how mothers can decide and avoid ingredients that might cause allergic reactions for children. The main concept is concentrating on children’s past behaviors and reactions and how mothers can adapt to certain situations.

Scenario 6 (Figure 1F): The scenario is based on a traveling vacation causing concerns and uncertainties with local food. Solving the language barrier is the concept in this case and how mothers can achieve feedbacks on local food ingredients is the main issue. Figuring out the hidden ingredients and finding any risks to avoid allergies is the most important functionality described in this scenario.

RESULTS

User’s priorities and preferences were identified from the affinity diagram using insights from the formative study (Figure 2). They were categorized into 3 different parts and were again divided into subcategories. From these results, we investigated design issues, such as, product functionalities and appearance as well as users preferences and priorities. We used the users’ opinions to build a set of preferred VS unnecessary list of functionalities.

Most participants recognized that they did not face difficulties using the application due to their familiarity with smartphone usage and its applications. From the 8 participants, 3 were already using a smartphone diary application, 4 were using hand writing for their diaries, and the last participant was using post-it notes. However, users raised doubt about the complexity of using smartphones applications in the described scenarios, mentioning that even a simple alarm application for meals could really add too much complexity for most users. The participants also commented that if the functions presented in the scenarios were available, mothers would lose their instincts in raising their children and would solely depend on the application.

We describe here some of the design issues emerged from the study.

Figure 2. The affinity diagram.

Automatic Temperature

Most participants were positive regarding the automatic temperature function. A participant noted “it is better to have the exact temperature rather than a simple yes or no
feedback.” Five participants preferred a color-like appearance for the temperature rather than a simple vibration notice. Three participants were raising issues on trustworthiness of the temperature function.

**Nutrition data and reliability**
Most participants were concerned on the accuracy of analyzing certain nutrients for the baby’s foods. A participant noted that if the allergic reaction test was too simple (e.g., checking a simple phone application) she would doubt its correctness. They also commented about the risks of putting a probe in the baby’s mouth. Others commented that the spoon application is efficient and effective in scheduling the baby’s meals with the appropriate nutritional values for the day, week or month.

**Straightforward information**
Most participants preferred a simpler application using visualization rather than a complex nutrition-data analysis. They wanted only to visualize the nutrients relevant for their children. They also wanted their own way of scheduling meal times and settings rather than using pre-set doctor recommendations. These opinions have a direct effect on trustworthiness and safety for the application.

**SNS information exchange**
Most participants were already active in infancy related communities. They were already sharing their information with others. Half of the participants commented that they needed to concentrate on their babies of age one year or younger rather than going outside to receive information. They argued that it is easier for them to search information online using keywords rather than searching information through medical-related books. They finally noted that social media are convenient but they also felt more comfortable with using only simple functions such as push alarms or sharing, rather than complex media features.

**CONCEPT PROTOTYPE**
All the feedback and opinions were used for finalizing the finished product (a concept prototype of the Smart Spoon). The prototype (Figure 3) is emphasizing functionalities related with the thermometer, scanning food for identifying nutritional information visualization. Since most users considered the mouthpiece of the spoon as the most sensitive part of the interface, the head of spoon was designed with a rubber type of material to increase its safety. An infrared sensor allows to analyze the nutrients. Temperature warning are displayed using a LED on the spoon handle (OK to eat : Green / Too hot : Red), an intentionally simple design.

The smartphone application main interface (Figure 4) is divided into three sections; temperature, nutrition visualization, and a diary to efficiently monitor dieting patterns on per day, week, or month basis. The Spoon allows the users to compare past and present diaries so to better control the baby’s diet. Personal information can be shared only if the product serial number and a verified personal e-mail address are provided, a requirement necessary to mitigate unwanted sharing of information. Regarding the SNS functionality, the Smart Spoon only showcases a sharing button, so limiting the possible leak of information accredited to social media by the formative study participants. Finally, the spoon allows users to see recommendations for baby food and allow mothers to share information conveniently with other mothers, using categories for easier access.

**CONCLUSIONS AND FUTURE WORK**
This research presents work on the development of a system apt to check the temperature, patterns and nutritional values of personal meals for babies. This
research extends previous work by showcasing the results of a formative study aimed to collect users needs and concerns about baby food and feeding strategies. Using such data we also described some possible design guidelines that could be used by engineers when developing feeding systems to assist mothers. Using the data from the study, we also developed a concept prototype that illustrates the potential of new products in this area. In future work we plan to investigate issues related with baby healthcare, data analysis and social media systems meant for nursing parents.

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