Designing Peace of Mind

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1 Introduction

The Peace of Mind project aimed at developing an innovation on child safety as part of the strategy to expand Philips' domestic appliances portfolio for Mother & Childcare products. This section of Philips' business unit was recently expanded with the purchase of Avent, a brand known for excellence in products such as baby bottles and breast pumps. With the acquisition, Philips-Avent was created.

Philips-Avent's target customers are 25-40 years-old, high-income mothers of children aged 0-4 years old. According to consumer research commissioned for the brand, the typical Philips-Avent customer mother searches for *certainty* (peace of mind), *convenience* (ease child care; relieve time and mind pressure) and *performance* (have the best quality). When shopping for children's products, this typical mother is accompanied by other mothers, relies on the opinion of experienced women, searches exhaustively for information, and does not see price as a decisive issue. Currently, this typical mother purchases Philips-Avent products before the child is born. The business strategy for expanding the Philips-Avent portfolio is to focus on the needs that arise when the child is older. In this context, the children's safety was recently identified as a major business opportunity for Philips-Avent.

1.1 Child safety

Unintentional injuries are the leading cause of death of children living in high-income countries[1]. Children under four years of age are at greatest risk. Airway obstruction injuries[2] are the leading cause of fatalities among children younger than one year, followed by drowning and fire-related injuries[3]. Drowning is the leading cause of fatalities among children aged one to four years old, followed by fire-related injuries and airway obstruction injuries. Besides fatalities, falls are the main cause of hospitalizations of children younger than four, leaving life-long sequels and traumas behind.

Unintentional injuries can be prevented in about 90% of the cases[4]. The best preventive strategies are informed caregivers and adequate safety equipment. Philips-Avent's typical customer is aware of the dangers of unintentional injuries and of the importance of safety equipment. Recent consumer studies commissioned by Philips-Avent suggested that children's safety is parents' main concern, which justifies the investment in the current study.

1.2 The project

This section describes the stakeholders, the methodological approach, and the design iterations that guided the project throughout the internship.

1.2.1 Stakeholders

The family - Although safety equipment benefit primarily children, their main users and buyers are the *parents.* As the decision makers of the family, parents were the primary focus of the user studies presented here.

1 In middle- and low-income countries, contagious diseases are still the main cause of death for unintentional injuries among children.

2 Airway obstruction injuries include: suffocation, strangulation and choking. These three types of injuries are normally condensed in one category because their prevention behaviors greatly overlap.

3 Fire-related injuries include flame, contact burn and scalding.

4 According to the European Child Accident Alliance.

Normative associations - Other Governmental and non-governmental associations that govern child safety practices and equipment are key stakeholders. Such associations are normally country-specific, but rely on similar principles across nations. Guidelines provided by the main associations of this kind in the USA, EU, and UK were be taken into account when gathering and validating requirements. The following organizations have delivered norms that were taken into account: (a) European Child Safety Alliance; (b) UK's Child Accident Prevention Trust; (c) UK's Toy Safety Regulations; (d) UK's Health Care Commission and Audit Commission; Public Health Agency of Canada; (e) Safe Kids Worldwide; (f) USA's Consumer Product Safety Commission; (g) USA's Juvenile Products Manufacture Association; (h) France's Institut National de Prévention et d'Éducation pour la Santé.

Philips - The decision makers within Philips-Avent, who have a specific roadmap defined for the brand, are also stakeholders. Philips-Avent decision makers provided specific requirements considering brand positioning, products' distribution channels, and market share strategies. Still within Philips, the Applied Technologies group, who commissioned the project, is also stakeholder, and is represented by the project's industrial coaches.

TU/e – The Eindhoven University of Technology is responsible for the pedagogical guidance of the project in the figure of the academic coach.

1.3 Methodological Approach

This study followed the user-centered design paradigm, current state-of-the-art on computer systems' development. This paradigm was standardized with the release of the ISO 13407 in the nineties. The ISO 13407 stated the user-centered, formative design process, ran by a multidisciplinary team composed by user specialists, technicians, and representatives of users as a quality requirement (Bevan, 2001). If the user-centered paradigm became the standard only in the 90's, its principles can be traced back to the 50's with authors such as Faverge and Ombredane (1958), just to cite the francophone ergonomics.

Besides the ISO 13407 documentation, user-centered design guidelines are available, for instance, in Mayhew (1999). Human-Computer Interaction handbooks such as Dix and colleagues' (2003) and Sharp and colleagues' (2007) provide a more general but significant contribution on the subject. However, such authors focus on the design of the graphical user interface of PC applications. In the present study, the challenge was to apply the user-centered design to a domestic appliance. Therefore, this study limited the use of design guidelines to those proposed in Baumann and Thomas (2001), which focuses on appliances.

The *Value Proposition House* (VPH), current guideline for delivering innovations at Philips, was also incorporated to the design cycles. The influence of the VPH is present in the way the requirements were gathered and homologated, in the user studies performed, and in the nomenclatures employed to designate such steps and user studies.

The research aimed at pursuing a *participatory design model*, i.e., to involve parents as active participants in the design decisions for all iterations (Carroll, 2001). The first step in this direction was to create a website especially for parents. In this website, parents interested in the project could know more about the design phases and subscribe to be a participant. Figure 1 shows the homepage of the

website, which was hosted in the TU/e domain and responsible for recruiting the majority of the study's participants.

Figure 1. Screenshot of the project's website

1.4 Design Iterations

The design process was planned as follows. First, a review of the literature on child safety and current solutions in the market was performed. Second, two user studies were planned to understand the problem and to tailor the design requirements: the Diary Study and the Creative Workshops. Third, a design concept was defined together with the input of Philips engineers, leading to a first prototype. Fourth, that first prototype was submitted to usability inspections performed by specialists and to the evaluation of child safety specialists. Fifth, the concept was improved based on the specialists' recommendations, generating a second prototype. Finally, the second prototype was submitted to the evaluation of parents matching the target group of the product. Based on the parents' evaluation, new requirements and the conditions for the viability of the product were recommended. The structure of this report is presented in this same chronological order.

2 Gathering information

This section describes the results of the review of the literature and current solutions in the market.

2.1 Review of the Literature

Children experience their greatest developmental burst in the first years of life. The brain flourishes with billions of new synaptic connections every day (Gilles, 2002). Together with environmental interactions and motor experience, such developmental explosion makes very distinct the safety demands of an infant (0-12 months old), a toddler (12-36 months old) and a preschooler (37-60 months old).

The next sections present a short summary of the review of the literature on children's risk proneness, parental risk perception, and parental safety strategies performed for this research.

2.1.1 Developmental milestones and risk proneness

0-5 MONTHS

Newborns cannot move independently, so they are more susceptible to injuries caused by error or lack of attention of the caregiver. Newborns are at greatest risk of bathtub drowning, scalding, and SIDS (Sudden Infant Death Syndrome). Since 1994[5], parents have been oriented to prevent soft bedding in the crib and to put children to sleep in their backs. The baby sack has been seen as a solution to keep children in prone position and makes soft bedding unnecessary. The baby monitor also responded to the need of reassuring parents when the baby is alone in the crib, even though baby monitors are not proved to prevent accidents[6].

6-12 MONTHS

As soon as children start to move independently, home accident risk grows. Infants' waking time is shared between *exploring* and *playing* in the house environment. Putting objects in the mouth is the first step into exploration. Infants tend to repeat the same action over and over again, a strategy to consolidate knowledge and perceive that the reality is ruled by patterns (Giles, 2002; Scarlett, 2005). Imitation plays an essential role in exploration. At this age, children are exposed to fall from stairs and walker, choking with small objects, poisoning with cosmetics, medicine, and cleaning material, and electrical shocks in plug sockets.

13-24 MONTHS

The more children master mobility, the harder it becomes for caregivers to prevent accidents. Between crawling and walking phases, children tend to grab and climb objects. Some 12-months-old babies can already use planning (division of tasks) to achieve a goal by imitating the caregiver (Giles, 2002), as, for instance, opening a safety latch to access a drawer. If in one hand toddlers' cognitive development brings new challenges for caregivers, on the other hand toddlers acquire *behavior control*, i.e., they can understand social demands and initiate, maintain, and cease behavior if requested by caregivers (Kochanska et al, 2001). The main risks for this age group are kitchen burns

5 In 1994, The "Back to Sleep" campaign was released in the USA after researches correlated SIDS with suffocation caused by soft bedding and prone position. The cases of SIDS dropped drastically since then.

6 According to the American Academy of Pediatrics.

and cuts, falls, poisoning, entrapment by furniture and appliances, and strangulation in playpen or with phone cords.

25-36 MONTHS

After the third birthday, reality and fantasy are amalgamated in one behavior: playing and imitating is just one activity (Scarlett et al, 2005). Because children tend to imitate, they may want to handle dangerous objects previously handled by caregivers, and they can remember where caregivers stored it. The increasing running and climbing abilities enhance accident proneness, but by 24 months children acquire *self control*, i.e., ability to regulate their behavior even in the absence of surveillance. If self control helps preventing accidents, toddlers' memory span is a tricky drawback. Toddlers' memory is still short and categorical, so children that young cannot use learning rules flexibly enough to adjust them to slightly different situations (Kochanska et al, 2001). The main risks are burns and poisoning (when imitating parents' actions), drowning in pools and lakes, and cuts by sharp objects.

37-48 MONTHS

When children are 3 years old, planning strategies are completely developed. Cabinet lockers and child-proof latches can be easily opened. On the other hand, 36-months-old children are normally acquiring *self regulation*, i.e., the ability to flexibly control behavior in different situations. By 45 months, 85% of the children are supposed to comply with the caregiver's rules and requests by self regulating their behavior. However, compliance depends on children's memory and temperament and parenting style, so it cannot be fully predicted (Kochanska et al, 2001; Aken et al, 2007). In general, accidents inside the house are greatly reduced by this age. The interaction with other kids in the kindergarten or in the playground raises, however, the risk of accidents outside the home environment.

2.1.2 Social influences in accident proneness

Child's compliant temperament and parent's physical proximity to the child are important factors to prevent accidents (Morrongiello et al, 2001; Schwebel; Plumert, 1999; Aken et al, 2007). It is when children are out of parent's sight that about three quarters of accidents occurs. According to Aken and colleagues (2007), careful and more present parents are more successful in preventing their children to get injured.

Compliance to rules depends on children's moral development, which relies on biological determinants of temperament and social experiences – mainly interaction with the caregiver. Besides moral development, children may do wrongdoings that can lead to accidents to call the parents' attention.

2.1.3 Parental safety strategies

Morrongiello and Ondejko (2004) observed three types of preventive strategies in parental behavior: (a) *barriers*, i.e. safety equipment and changes in the house layout (e.g. installing a fence); (b) *supervision*, i.e., parents' monitoring chidren's actions; (c) *teaching and warnings*, i.e parents' verbalizations in order to make children understand hazards and prevent risks.

Safety strategies are normally combined to produce redundancy. When children are one to two years old, parents prefer barrier strategies. From two to four years old, parents prefer teaching and warning strategies. Supervision strategies are concomitant with the other two. Parents remove barriers when kids are older, normally overestimating their kids' knowledge about risks and compliance to rules.

When purchasing safety equipment, parents tend to rely on the following rationales: (a) how adequate the equipment is for the child's developmental level; (b) what is the equipment's efficiency in preventing the accident; (c) the extent of inconvenience of taking the measure, such as installation, maintenance and changes in the house's layout; (d) social influence, e.g., the living room is a place for adult amusement, not for babies, so barriers in this room are commonly rejected by parents; (e) partner's opinion; (f) child's vulnerability for injury, e.g. previous injury, mental or physical disabilities; (g) potential severity of injury (Morrongiello; Ondejko, 2004).

After buying safety equipment, parents tend to relax the supervision. This phenomenon, recognized in the literature of risk perception as *behavioral compensation* or *risk homeostasis*, was observed in child safety as well by DiLillo and Tremblay (2001).

2.2 Review of current solutions

A review of the current safety equipment available in the market was carried out during January and February 2008. Baby stores in Eindhoven and the main online shops in USA and UK were consulted. Forums hosted in such websites to the discussion of child products were also followed. Refer to Appendix 1 for detailed list of safety equipment analyzed.

The review of safety solutions comprised four categories, each representing solutions for one of the following hazards: (a) *fall and other mechanic accidents*; (b) *fire-related injuries*; (c) *access to dangerous materials* (e.g. poisonous); (d) *drowning and airway obstruction injuries*.

The current solutions in the market are generally characterized by cheap physical barriers made of plastic or metal. The simplicity and efficacy of such products in preventing an accident might make child safety innovations sound like an unproductive source of business opportunities. However, such solutions have as many drawbacks as benefits. To give the reader a flavor of common consumer complaints, *outlet plug covers*, *safe gates and grids*, and *latches and lockers* are described.

Outlet plug covers not only prevent electrocution; they also make the outlet plug use a hassle for parents, sometimes damaging the outlet. *Safe gates*, used to fence off stairs and entrances to dangerous rooms, and *safe guards*, used to fence off ovens and stoves, are clumsy to install and to transport. Several cases of accident are described due to bad lock system of safe gates or because the child learned how to climb it. Finally, *latches and lockers* for drawers, cabinets, and appliances might be open by children as young as 14 months. In general, safe equipment are also said to change the house appearance into a "nursery", a common complaint of many parents.

2.3 Conclusions of reviews of literature and current solutions

The review of the literature showed that newborns (0-6 months old) and toddlers (12-26 months old) are key user groups due to being at greatest risk of accidents. Newborns are very dependent on the caregiver, cannot communicate except by crying, and the chance of crib deaths pose a real threat to parents. Toddlers surprise parents with their growing mobility and ingenuity in exploring their environment, which increase their susceptibility to contact burn, choking, and drowning.

Considering the current safety equipment in the market, it is concluded that there is a need for *unobtrusive solutions* that can *relieve* caregivers' anxiety on the task of supervising. Based on this assumption, a first design brainstorming was carried out to explore the possibilities of the field for the

newborn and the toddler. Two concepts were created: the ***baby's wellness in the crib*** for newborns and the ***mom's surveillance control*** for toddlers. Table 1, Figure 2; Table 2, Figure 3 summarize these two concepts. The two concepts were presented to Philips-Avent stakeholders and to the coaches to give a flavor of what to expect from the current study. Because the concepts demonstrated interesting opportunities, it was decided to continue focusing on **child safety inside the house**.

	Solution	Assumption	Possible Product
Newborn	**Baby's wellness in the crib**: Monitoring body signals of the infant while in the crib;	Moms want to check if baby is happy, sad, relaxed, asleep, breathing well, etc.	- Baby sack (helps keeping prone position); - Communicate relevant information via baby monitor's parent unit; - Conductive textile to soothe (massage, light) and monitor body signals → silver is conductor and anti-bacteria

*Table 1. Description of the **baby wellness in the crib** concept.*
Figure 2. Sketches of that concept.

Toddler	**Mom's surveillance control** Prevents child's access to a dangerous place by switching mom's attention to risk	Mom cannot predict when child will learn to overcome a safety equipment	- RFID/GPS to mark unsafe places; - Mom and baby bracelet; - Report child's body signals and distance from mom (reassurance and fast decision in an emergency).

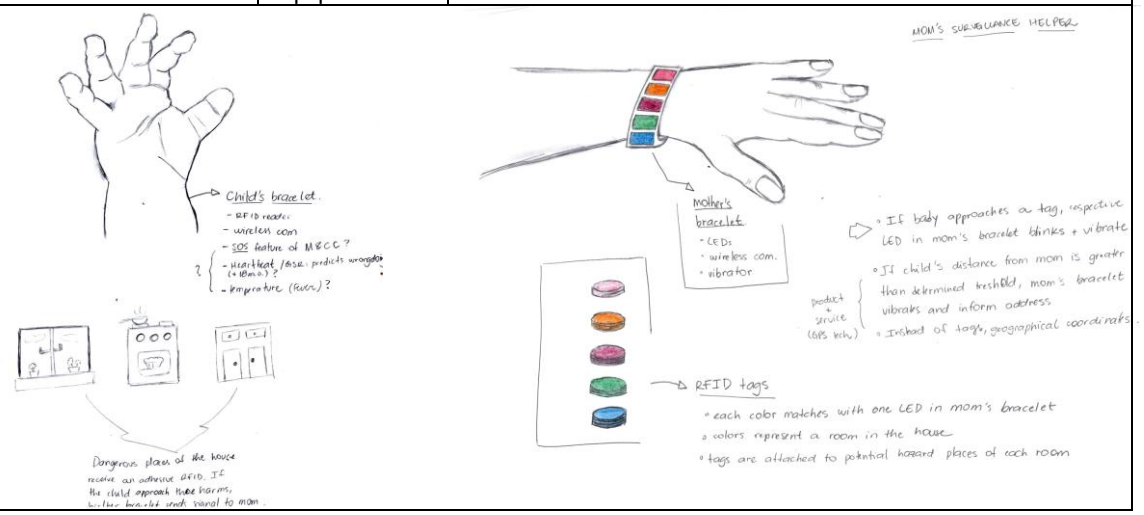


*Table 2. Description of the **mom's monitoring control** concept.*
Figure 3. Sketches of that concept

3 Defining the Problem

After gathering information, real-world experience was missing. It was not clear how parents *experience their children's safety*: strategies, needs, tricks to overcome limitations, and aspirations in child safety. To define the safety problem to be solved by the design, two user studies were designed: the Diary Study and the Creative Workshops. The Diary Study aimed at collecting general assumptions about daily life situations that triggered safety concerns, as well as brainstorming about solutions. The Creative Workshops delivered concrete requirements to one of the solutions chosen by users as the most promising, and that led to the final product delivered by this research: the **Safe Spot**. Both studies collected exclusively qualitative data, and will be described in the next sections. The Diary Study

The Diary Study was based on the assumption that child safety is experienced by parents as a conflict between the *anxiety* brought by the threat of the unsafe and the *peace of mind* brought by reassuring safety. Considering this assumption, the Diary Study had five goals:

- assess how parents experience *peace of mind* and *anxiety*;
- assess how the conflict *peace of mind vs anxiety* emerge in home safety issues;
- assess how the conflict *peace of mind vs anxiety* is solved in home safety issues;
- map opportunities for safety equipment;
- brainstorm for solutions.

3.1.1 Method

Ten parents of children between 10 weeks and 4.5 years old participated in the study. All parents were residents of The Netherlands. Parents' nationalities were: Dutch, German, Australian, New Zealander, Japanese, and Turkish. Four of the ten parents have two kids, and six of the parents have only one child. Parents were voluntarily recruited via the project's website.

Figures 4 and 5. The Diary Box

The data was collected in three steps. In the first step, the researcher visited the parents' house to deliver the Diary Box (Figures 4 and 5). In the Diary Box, parents found explanations about the study and five leaflets with five different questions about how they cope with safety issues in daily situations (Appendix 2). The leaflet questions should be answered one per day. To support the parents in answering the questions, pens, pencils, a disposable camera, and candies and puppets for the kids were included in the box. Parents were asked to answer the question by taking pictures, writing and

drawing. Still during the visit, the parent signed an informed consent document and answered a semi-structured questionnaire about safety issues (Appendix 3). The goals of the semi-structured questionnaire were: (a) to assess parenting style on dealing with safety, (b) provide support for the parents' answers that would come with the Diary, (c) and warm up the subject "safety" in parents' minds. Seven of the ten parents received the researcher at home for the interviews, while three of the parents received the researcher in their work environment.

The second step of the study was to collect and analyze the materials produced by the parents after five days. The analysis of such materials generated other questions based on interesting comments that the parent stated in the Diary.

In the third and last part of the study, the researcher returned to the parents' house to ask them the tailored questions generated during the materials' analysis. In this occasion, the parents received a Philips Imageo Candlelight in gratitude to their participation.

3.1.2 Results

The data reduction by affinity showed behavior patterns on how parents solve the conflict *peace of mind* and *anxiety* in child safety issues. Such patterns can be organized in a chronological chain of behaviors, which is summarized in the **Peace of Mind Cycle** (Figure 6). Each behavior in the Peace of Mind Cycle is influenced by specific factors that interact with each other. In the next sessions, each behavior observed in the Peace of Mind Cycle and its influencing factors will be explored in detail.

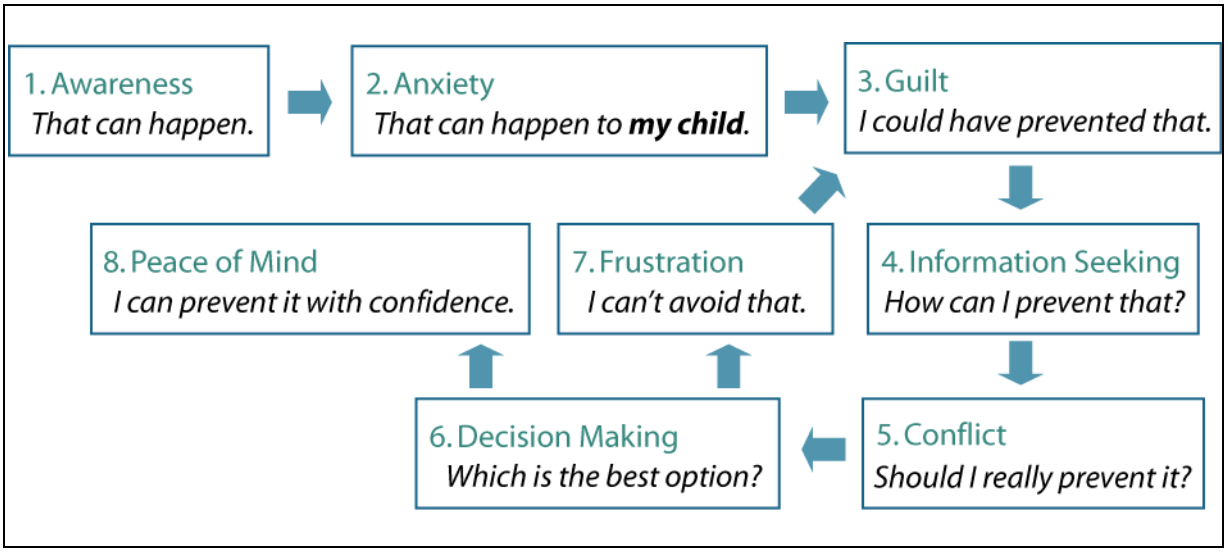


Figure 6. The Peace of Mind Cycle

AWARENESS

The trigger factor in the Peace of Mind Cycle is the awareness of the risk posed by a hazard. Parents reported that risk awareness is triggered by situations such as: (a) information acquired with accredited source, such as media or health advisors; (b) advice from family or friends; (c) own experience during childhood; (d) occurrence with acquaintances; (e) previous accident with own child. Many factors influenced parents' awareness of different risks, such as *children's age*, *family's community*, and *sibling interaction*.

Children's Age

During the four developmental stages between 0 and 5 years old (newborn, infant, toddler, preschooler), parents tended to perceive more hazards during the newborn and the toddler stages[7]. The high vulnerability perceived in **newborns** was justified by their *fragility* and *helplessness* (SIDS threat). Parents' perception of vulnerability decreases during **infancy** because in this age babies are already safe from SIDS and not mobile yet. The high vulnerability of **toddlers** was justified by their *exploratory and headstrong characteristics*. The low vulnerability perceived in **preschoolers** was justified by the fact that by this age children already *understand rules* and are *more aware of their physical limitations*.

The Family's Community

The community where the family lives influences the types of concerns parents experience considering their children's safety. The family's community defines the type of *place where the family lives*, the family's *cultural background*, and the family's *routine*. The place where the family lives can trigger diverse worries such as hazards by traffic and violence when inhabiting big cities, or drowning in a lake nearby the house by parents in the countryside. Cultural differences[8] among parents influence factors such as the age until which parents are supposed to supervise their kids, sex differences in protecting kids from hazards, and the role of being a kid in the culture. Considering the parent's routine, full-time working parents reported that they raise independent children who can cope earlier with their own safety; in other families, full-time mothers aim a pristine surveillance with more hazard awareness.

Sibling interaction

In the four families with two children, parents confirmed that the sibling interaction increased the awareness of hazards. Sibling interaction can lead children to expose themselves to risks due to, for instance, jealousness, inability to understand the physical and cognitive limitations of the younger, and engagement in very active play and fights that may lead to an accident.

ANXIETY

As soon as parents are convinced that a certain hazard is tangible, i.e., *it can happen to their children*, the anxiety is established as a protective response. Because anxiety is triggered when parents are aware of a new hazard, more informed parents tend to be more anxious. Informed parents know that accidents can be prevented, and they feel more guilt when accidents happen. *Not being around* or *not arriving in time* are the main expressions of anxiety:

- I am worried of what can happen in the blink of an eye. (mother of 3,5 and 5 y.o.)
- If he learns how to open the door, it may happen in a split of a second... (mother of a 2 y.o.)

Excerpt 1. Parents describing anxiety

Parents reported anxiety as linked to daily activities, when they have to adapt themselves to new responsibilities, or when their children faced social challenges and must learn their own limits. Common examples of anxious situations include: *when the first baby arrives, when a child gets*

7 Such finding is coherent with the literature on parent's risk perception (see section 2.1.).

8 The cultural influence in parent's hazard perception is confirmed by the literature (see, for instance, Junger, M. and Steehouwer, L., 1991; Jo Ann et al, 1999; and Porter et al, 2007).

mobile, when the care must be delegated to someone else, when travelling or visiting someone else's home.

When parents face hazards out of their control, such as violence done by other people or serious chronic diseases, the anxiety cannot be solved. The feeling of helplessness is so strong that parents do not believe an external help (e.g. safety equipment) can effectively prevent it. For this reason, such hazards will be considered *out of the design scope*.

- I use the baby phone. Even though I check him myself regularly to see if he is breathing well. (…) I always call the daycare when she is there. I want to make sure they are looking after her and maybe draw their attention to her. (mother of a 6 m.o.)

- She toddles unsteadily on her feet and I am afraid she might hit her head on sharp edges. (mother of 13 m.o.)

- The door in the hotel's room could not lock from inside. Our younger learned how to open it and was leaving away all the time. The constant worry made us come back home. (mother of 12 m.o. and 2,5 y.o.)

- I cannot sleep thinking if some burglar enters my house and my husband is not there to protect us. (mother of 2 y.o.)

Excerpts 2. Parents exemplifying their main anxieties

GUILT

Parents feel guilt when they fail to support their children the right amount of care in order to prevent an accident. Guilt depends on parents' self-image as caregivers. Some parents believe in the early independence of their children, who should cope with the responsibility of their acts. Other parents feel the whole responsibility over their own shoulders, which makes them feel more guilt. Full-time moms and first-time parents tend to feel more guilt if an accident happens.

- I left 1min to load the laundry and the accident happened. I fell guilt. I allowed it to happen by not being around. (full-time mother of 12 m.o. and 3,5 y.o.)

Excerpt 3. Full time mom reporting guilt

INFORMATION SEEKING

After realizing the potential of a hazard, parents start searching for safety solutions to solve their anxiety. The answer may be safety equipment, change in habits, improvisations to adapt furniture and appliances, etc. The ultimate goal is to reassure parents' peace of mind.

Seeking for the best solution is an exhaustive process that just ends when the outcome provided by the solution found is absolutely trustworthy. Therefore, information sources to ensure credibility may also be trustworthy. Main credible sources of information for parents are: (a) opinion of older mothers in the family and friends, (b) opinion of health advisors, (c) opinion of official organizations in websites and other communication channels.

Parents feel that there is lack of information about current solutions both in the market and by the healthcare system when the baby is born. Moreover, policies and efforts to spread safety guidelines are different from country to country.

CONFLICT

Parents described many conflicts when deciding how to act in order to protect their children from a perceived hazard. Parents agreed that safety issues should not shorten chidren's freedom to explore and train problem solving abilities.

If the child learned to open the drawers' latch, on one hand it is bad because the baby is now exposed to a hazard. But on the other hand, parents are obviously proud of their baby's ingenuity. Parents are also afraid of supervision excesses, the commonly expressed *control freak* syndrome.

Apart from the realization that freedom and exploration are essential for the children's development, parents agree that *extra freedom means extra supervision*. This will impact in which strategies parents will adopt to deal with a specific hazard.

DECISION MAKING

As parents feel like they have an overview of the available solutions to prevent a perceived hazard, they must choose a strategy that attenuates the anxiety without generating conflicts. As argued in the literature, strategies are commonly combined to provide redundant protection. The choices will depend on the factors affecting the perceived risk. Five strategies were observed in the visited houses: *house barriers*; *equipment barriers*; *improvisations*; *auditory supervision*; *visual supervision*.

House barriers prevent children from accessing places or leaving the house. Garden and pool fences, locked windows and doors are examples. The drawbacks of house barriers are that children learn how to open them, or keys can be left behind.

Equipment barriers provide safety when house barriers are not enough or not possible to be installed. Some parents recall safety equipment when describing peace of mind, such as the door and stair gates (for toddlers), and the playpen (for non-mobile infants). The drawbacks of equipment barriers are the fact that they might be break and that the child might learn how to overcome them.

Improvisations are creative ways to prevent a hazard when house and equipment barriers are not adaptable to existing appliances and house layouts (Figures 7, 8, 9). Another reason for improvising is when the solutions are not found in shops or unknown. As a mother expressed, *In the end, it's all about improvising or spending thousands of euros buying everything new*.

		
- We use the TummyTub structure to fix his seat, so I can bath him in our shower with me. (father of 11 m.o.)	- These drawers almost fell over her when she pulled it hard. There is no safety solution for metal drawers, so I improvised with sticks and Velcro. (mother of 13 m.o.)	- We will move out soon, so we needed a fast solution to stop the kids to use this stair – for now it is working! (mother of 12 m.o. and 3,5 y.o.)

Figures 7, 8, 9. Parents' own shots of such improvisations
Excerpts 4. Parents justifying the use of improvisations

Visual supervision is *close supervision.* The ultimate peace of mind is to have kids under parents' eyes. Visual supervision also intimidates the child from doing something he/she already learned is forbidden.

Auditory supervision is *distant supervision*. When the child is in another room, parents rely on auditory cues to check if the child is safe, such as: (a) when the parent is in a room where the child cannot enter, for instance while cooking, doing laundry, ironing, working in the garage, etc; (b) when the child is allowed privacy, for instance, in the toilet; (c) during the child's day naps. The baby monitor works in these situations enhancing the parents' abilities to listen and control their children. Parents estimated that they would rely on auditory supervision while their children are awake for only 5min per day.

- When she is in the toilet, I keep contact by asking questions, so she knows I am around. If I ask her what she's doing and she answers "I don't know…", that's a reason for checking: she is probably doing something wrong. (mother of 3,5 y.o.)

Excerpt 5. Parent expressing how she uses auditory supervision

FRUSTRATION

When parents cannot find a solution to solve the anxiety caused by a potential hazard, they feel frustrated. The frustration parents experience is an **unstable reassurance** that will lead to either **continuous anxiety** (need to solve the conflict) or **repression of anxiety** (giving up: *there's nothing I can do about it*). If the repression is the behavior, the anxiety may reappear when the parent is exposed again to that hazard. The degree of frustration that a parent will experience is related to parenting style (more or less tendency to feel guilt). Accidents lead to parents' peak of frustration. Parents report frustration as the feeling of helplessness when realizing that supervision is never enough.

- It's not possible to prevent it unless we would want them to wear helmets or so. (mother of 3,5 and 5 y.o.)
- I felt guilt, but also frustrated due to the level of supervision required. It is never enough. (mother of 12 m.o. and 3,5 y.o.)

Excerpts 6. Different ways of dealing with frustration

PEACE OF MIND

When a solution for the anxiety conflict is found and successfully implemented, the **peace of mind** is reassured. The feeling of peace of mind is **a stable reassurance**, since anxiety is not re-triggered. Peace of mind is described as a relaxing state of confidence. Typical peace of mind reassurances are: (a) acquiring a satisfactory safety equipment; (b) moving to a place where hazard is not a problem anymore; (c) moments when parent can relax from constant supervision, e.g. when care delegated a loved one (partner, mother, sister); (d) when the child is sleeping; (e) *our moment together* (e.g. breastfeeding);

- The ultimate feeling of wellbeing and safety is when I am breastfeeding. (mother of 6 m.o.)
- Whenever we visit my mother I get to have a nice break and I am completely at ease and need not to worry. (mother of 13 m.o.)
- My peace of mind moment is when they are sleeping, watching TV or reading books. In these moments they are relaxed, and I know they are not in trouble. (mother of 3,5 and 5 y.o.)

Excerpts 7. Parents exemplifying peace of mind

3.1.3 Defining the Design Problem

The Diary Study provided a rich sample of what makes parents anxious about their children's safety, as well as their strategies to solve conflicts and reassure their role as good caregivers. Parents were also invited to brainstorm different solutions to solve old problems. Based on the conclusions of the Peace of Mind Cycle and the solutions proposed by with parents, five design problems with potential to become business opportunities for Philips-Avent were identified.

Two design problems were classified as core insights by the stakeholders of the project (constantly expressed, high business opportunities): the **enhance monitoring** and the **sharing experience**. As it will be described, these two core insights were surprisingly similar to the concepts generated as a result of the review of the literature and current solutions. Apart from the core insights, two secondary design problems (constantly expressed, with drawbacks) were also identified: **fun while bathing and authorized only!**.

ENHANCE MONITORING

When a baby becomes mobile, parents need to enhance their supervising ability. Parents must be faster than children, by stopping kids attempting to access forbidden places or objects. Parents also need to have their attention drawn to children in the right moment, since an accident can happen *in the blink of an eye*. This design problem appears as soon as children get mobile, especially for toddlers. A product in this category will especially appeal for parents with non-compliant children.

- What you want is always know where they are and what they are doing, without throwing away the privacy - they should feel free. (…) The system would give an alarm if the child is near a danger. (mother of 2 m.o. and 3,5 y.o.)

- When the child is in danger, the device would beep sharp and loud (giving the child a fright warning that he is close to a danger) as soon as he approaches it by 50cm. I would receive a warning in my bracelet, where I could also see what is he doing. (mother of 12 m.o. and 3,5 y.o.)

- Children should not be able to enter in an open kitchen by some type of invisible fence – a magnetic barrier. (mother of 2 y.o.)

*Excerpts 8. Parents expressing the **enhance monitoring** insight*

The *Enhance Monitoring* insight asks for an easy to set up, universal, portable, and unobtrusive solution to enhance parental monitoring abilities even *on the go*. Providing safety adaptable to different environments and home layouts, this product should be an optimized solution for current safety guards. This insight was spontaneously suggested by four of ten participants of the Diary Study.

SHARING EXPERIENCE

Parents do not want to feel guilt when leaving a baby under someone else's guard, but they want to have more time for their careers and their hobbies. Form this contradiction emerges the *Sharing Experience* insight. This insight was less clear than the *Enhance Monitoring* insight, but had potential among fist-time parents of young babies. *Sharing experience* is a design problem for mothers of babies younger than 12 months.

Sharing Experience is described as the need for a sixth sense. Parents reported that they would like to know what their babies are feeling, such as pain, anger, distress, happiness, calmness, etc. They also want to have their attention drawn when their babies need from distance and have time to intervene. Finally, parents want to reassure their babies that they are looking after them, even at a distance.

- I would like to feel her movement all day through as if I was carrying her. That way I would be reassured that she is safe always. (mother of 6 m.o.)

- I don't trust anyone. That is a feeling that only by being a mother you can understand. (mother of 6 m.o.)

*Excerpts 9. Parents expressing the **sharing experience** insight*

SECONDARY DESIGN PROBLEMS

Fun while bathing

Parents like to bathe and shower with children. It is fun, it is a moment together. There is a need for a safety chair for showering and bathing that can also inform temperature thresholds, while providing a safe and playful environment for children. The *Fun While Bathing* insight was more common among parents of infants, being desirable as soon as kids can keep sitting position. The drawback of this insight is that it is not primarily a safety problem.

Authorized only!

All parents think that obviously dangerous objects and areas in the house should automatically be inaccessible for children, as for instance: (a) *dangerous windows and doors should recognize the kid and not open for them unless in fire emergency…*; (b) *outlet plugs should be turned inside the wall, only turning outside when adults want to plug in an appliance…* The *Authorized Only* insight appeared among parents with toddlers and non-compliant preschoolers. The drawback of this insight is that an equipment to solve this problem would probably be distributed in home improvement stores, which are not Philips-Avent distribution channels.

3.1.4 Conclusions

The five customer insights generated in the Diary Study were discussed with the supervisors and the Philips-Avent stakeholders. It was decided to further develop the two core insights (*Sharing Experience* and *Enhance Monitoring*) in the Creative Workshops, the next step in the iterative design process. This decision was based on the high frequency with which the core insights appeared in the Diary Study results and their suitability as business opportunities for Philips-Avent.

3.2 Creative Workshops

3.2.1 Method

Two groups of three parents (between-subject design, all women) participated in the 2h30min Creative Workshops sessions, held at the USI-TU/e user and kids labs on 4th of April 2008. One of the groups, with moms of kids between two and five years old, discussed the *Monitoring Safety* insight. The other group, with moms of kids from 14 to 15 months old, discussed the *Always Around* insight. Two of the six participants were former contributors of the Diary Study. All participants were recruited via the project's website.

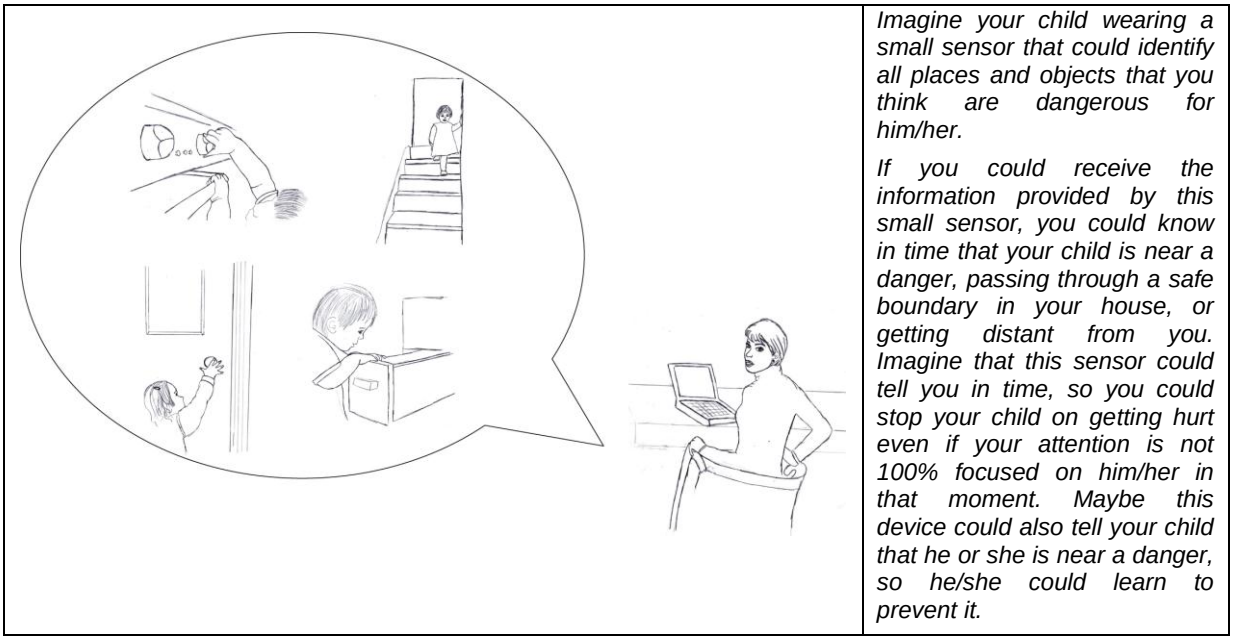
The two insights were firstly presented to the participants as a mosaic of conceptual images and phrases excerpted from the Diary Study, the *moodboards* (Figures 10 and 11). The parents were prompted to think about how the insights were experienced in everyday life. After discussing the insights, the participants were presented a scenario where a solution for the insight was proposed in a very high-level and abstract manner (Figures 12 and 13). Finally, the moderator followed a semi-structured questionnaire to guide the discussion about the solution (Appendix 4).

Figures 10 and 11. Moodboards presenting the two insights discussed in the Creative Workshop

Imagine that there is a sensor that can monitor many aspects of your baby's wellbeing. This sensor can identify if the baby is uneasy, sick, happy, sleeping, awake, stressed, etc.

From a parent unit, you could follow how your baby is doing, even if you are not near him/her, and feel reassured that he/she is ok. If, on the other hand, your baby is sick, stressed, or under risk, you could immediately act even at distance.

Figure 12. Use scenario for the Always Around insight as presented in the Creative Workshop



Imagine your child wearing a small sensor that could identify all places and objects that you think are dangerous for him/her.

If you could receive the information provided by this small sensor, you could know in time that your child is near a danger, passing through a safe boundary in your house, or getting distant from you. Imagine that this sensor could tell you in time, so you could stop your child on getting hurt even if your attention is not 100% focused on him/her in that moment. Maybe this device could also tell your child that he or she is near a danger, so he/she could learn to prevent it.

Figure 13. Use scenario for the Monitoring Safety insight as presented in the Creative Workshop

During the discussions, the participants were asked to write down in post-its their ideas and distribute them in three posters fixed in the wall. In the first poster, participants joined their ideas related to “What would motivate me to use this device”. In the second poster, participants joined their ideas related to “What would stop me to use this device”. In the third poster, participants joined their ideas related to “What this device must do”. By dividing the participants' comments in **motivators**, **stoppers** and **functionalities**, respectively, the workshop inspired participants to reflect and discuss pros and cons of insights. Both sessions were video recorded. All participants signed a document containing a non-disclosure agreements and an informed consent. Participants received a 20-euros *VVV-IRIS Cheque* in gratitude for participating.

3.2.2 Results

ALWAYS AROUND INSIGHT

During the workshop, the participants identified themselves very little with *Always Around* insight. The fact that participants had older children than the target group (0-12 months old) might have influenced this result. Because no fruitful discussion was generated, the workshop did not achieve its goal of deriving user requirements for this design problem.

Experiencing the insight through the moodboard (Figure 10)

When other obligations demand parents to delegate their children's care to someone else, the guilt is certain especially for first-time mothers. Participants agreed that delegating care is more difficult for the mother herself than for the child. Mothers feel irreplaceable: their "instinct" tells them what their children need. Different crying, for instance, can tell mothers about hunger, pain, tiredness, need to be comforted, or frustration even at distance. Moreover, participants agreed that children need to learn to stay alone sometimes to build their own self confidence.

Discussing the Scenario (Figure 12)

Participants reported that it is difficult to plan each moment during which they will not be visually monitoring their babies. In such moments, the baby monitor fits their needs. The baby monitor is used when parents are sleeping or in situations where they cannot rely on auditory supervision.

The participants rejected the idea, proposed by the scenario, of monitoring their babies' physical signals and reassuring their babies at distance. The mothers were unanimous in stating that nothing substitutes their presence to sooth their crying babies.

All participants agreed that they would not use the device described in the scenario while monitoring their own children. Caregivers in nurseries or parents of ill children could, however, be benefited from it.

Stoppers

The participants gave the following justifications on why the *Always Around* insight should not be continued as a product:

- the sleeping bag already provides peace of mind against suffocation and overheat; besides, SIDS cannot be prevented;
- women need to separate the *mommy* and the *woman* roles. In the proposed scenario, such a device would reinforce too much the *mommy* role by putting the mother *always* alert;
- people are already overwhelmed by mobile devices;
- the device may reinforce insecurity in some parents;

- some parents might transfer the responsibility of their children's safety to the device.

References to the *Monitoring Safety* insight

During the workshop, participants spontaneously referred to a hypothetical product that fits the *Monitoring Safety* insight. Some user requirements were suggested by participants, being discussed in the next session.

MONITORING SAFETY INSIGHT

The *Monitoring Safety* insight was well received by the three mothers. Interestingly, the exact same solution proposed in the scenario was spontaneously described by one of the participants during the presentation of the insight's *moodboard*. Together with the spontaneous description of similar concepts by four of ten parents that participated on the Diary Study, and the spontaneous suggestion of the same product in the *Always around* insight Workshop, this shows the potential of the *Monitoring Safety* insight

Experiencing the insight through the moodboard (Figure 11)

The mothers expressed their concern on *how much care is enough.* In one hand, parents do not want to become overprotective, but on the other hand, accidents might happen in a blink of an eye. This conflict might be solved by *preventing children from realizing that they are being watched*, putting the burden of the attention on parents to promote a free environment for children to explore.

Again, mother's instinct was strongly defended and considered irreplaceable in guaranteeing their children's safety and wellbeing. But all participants agreed that their supervision is never enough, especially when their attention must be shared among more than one child.

Discussing the Scenario (Figure 13)

Because the device described in the scenario is unobtrusive, the participants suggested that it could help them not to demonstrate overprotection for their children. Moreover, the mothers pointed out other user groups for the product: caregivers of persons with Alzheimer, parents with sleepwalker children, nursery staff, or even parents supervising multiple children at the same time.

The need to integrate the application in an already-owned mobile device was strongly supported by the participants. The mothers suggested that the product could be sold in starting kits, expansible depending on the number of children to be looked after, the age of the children – since different ages would require different child's accessories – and different devices used as parent unit (mobile phone, the parent's unit of the baby monitor, etc).

Considering the use cases applicable to this device, parents signalled three situations:

- children moving away from parents when outside the house (problem already addressed in other Philips-Avent design, so out of scope);
- children leaving the house;
- children accessing dangerous places in the house and interacting with something hazardous.

Stoppers[9]

The participants pointed out that they would stop using the product if it:

[9] *Motivators* and *Functionalities*, the other two categories of ideas brainstormed by the participants of this workshop, are presented in section 4.

- is oversensitive, ignoring caregiver's awareness of the situation, which may lead parents to overprotective behaviour or desensitization to the alarm;
- generates high social weight for the mom (seen as a *police of her child*) or for the child (feedback that stigmatizes the child in front of other children);
- can be misused as a substitution for parents' supervision;
- disturbs if child is playing or sleeping;
- exposes children's skin to strong magnetic field.

3.2.3 Conclusions of the Creative Workshops

The Creative Workshops highlighted a tendency observed in the Diary Study for divided opinions on the *Always Around* concept, which was the subject of many criticisms during the Creative Workshop. On the other hand, the *Monitoring Safety* insight had good acceptance and provided concrete user requirements based on the *motivators* and *functionalities* parents would like in the product (detailed in section 4). Consequently, it was decided to continue the ***Monitoring Safety*** insight as the design problem to be prototyped.

4 Requirements Analysis

This section summarizes the requirements gathered in the Creative Workshop of the *Monitoring Safety* insight, based on the motivators and functionalities specified by the participants for the product. The requirements specification was based on Robertson and Robertson's (1999) *Volere* template.

4.1.1 Product in Context

PRODUCT'S GOAL

The product should support caregivers in controlling safe boundaries inside the house for mobile children younger than 5 years, without using physical barriers.

USE CASES

To solve such problem, the following situations should be taken into account as use cases:

- preventing children from accessing dangerous places inside the house;
- preventing children from opening unwanted doors and windows;
- preventing children from leaving the house property.

KEY USERS

Parents fitting Philips-Avent target customers:

They are responsible for deciding where the product is needed. Parents with *more than one child* tend to receive the concept better.

Mobile children under these parents' responsibility:

Mobility starts with crawling. By the end of the preschooler years (around 5 years), children are normally compliant and spend less time at home.

Other caregivers than parents:

Caregivers may be of both genders, have very broad age range, and different levels of computer literacy and education. *Professional caregivers* (baby sitters and nursery staff) may take care of different children subjected to different parenting style. *Relatives as caregivers* (grandparents and other family members), whom parents usually trust more than in professional caregivers. Relatives – especially grandparents – may take care of children in a regular basis. It is important to notice that grandparents may have limitations while interacting with digital technology.

4.2 Functional Requirements

1. Parents[10] shall be able to fence off an area in the house.
2. Caregivers shall receive an alert if child is inside fenced area.
3. Parents shall be able to control the settings of the fenced areas installed in the property.
4. Parents shall be able to remove a fence from an area.
5. Parents shall be able to set up different fenced areas for different children*****[11].
6. Child may receive a feedback if he/she is approaching a fenced area*****.

4.2.1 User Experience and Performance Requirements

1. Installing a fence in an area shall take less than 5min.

[10] *Parents* are used to identify the persons responsible for installing and controlling the system's settings, while the *caregivers* are any persons watching a child.
[11] "*****" means that the requirement was not implemented in any of the two prototypes generated until now.

2. Product shall take into account the caregiver's awareness of the situation before alarming.
3. Product shall support more than one fenced area.
4. Product shall be suitable to use by different caregivers (grandparent, baby sitter, father, etc) supervising the same child.
5. Caregivers shall be signalled when battery in any part of the product must be replaced.
6. Caregivers shall be able to use the product to monitor different children at the same time*****.
7. Product shall be unobtrusive for children*****.
8. Product shall be easy to transport in a handbag-sized case*****.

4.2.2 User Interface Requirements

1. Caregivers shall be able to identify the source of the alarm in 2 seconds.
2. Parents shall be able to change the alarm mode, depending on situation, context and parents' preferences.
3. Product's interaction paradigm shall be consistent with up-to-date Philips-Avent's monitoring products.
4. Caregivers shall be able to set on/off child's feedback*****.
5. Caregiver shall be able to choose modality of child's feedback*****.

4.2.3 Solution Constraints

1. Parent's unit shall be implemented in existing mobile devices owned by parents.
2. Product shall rely on wireless communication, with range of existing baby monitors.
3. Product's starting kit must cost less than 150 euros*****.
4. Child's unit must be adaptable to the cognitive and physical changes that occur between the 5 first years of life*****.
5. Child's unit must be washable, resistant to mechanical shocks*****.
6. Child's unit must comply with the current European toy legislation*****.
7. Product's parts must have long-lasting battery*****.
8. Product must achieve a lifespan of 5 years*****.

4.2.4 Persona

To bring to life the requirements listed above, the persona **Anne** was created to highlight the key user requirements of the product.

ANNE

Anne is a 32 year-old English mother of two children: the 42-months-old Robert and the 24-months-old Rachel. Anne is married with Ryan, 37, who has a full-time job as a manager.

Robert is a very compliant child. He goes to the kindergarten three times per week. Rachel is very exploratory, relentless, and has difficulty complying. She already burnt herself twice on the stove. Rachel seems not to care about the danger and keeps looking for the appliance whenever no one is watching! Rachel is full-time at home.

Anne can count on a baby sitter once a week, when she has some time to do her work or go shopping. Anne stays alone with both kids at home for 50% of their time. In these moments, she avoids as she can to work to fully supervise her children. For this reason, Anne is always under time pressure. But she believes that the safety of her kids is her first priority, and she does not regret the effort it takes to make the house a safe environment for them: "parenting is a hard, consuming, but rewarding experience!".

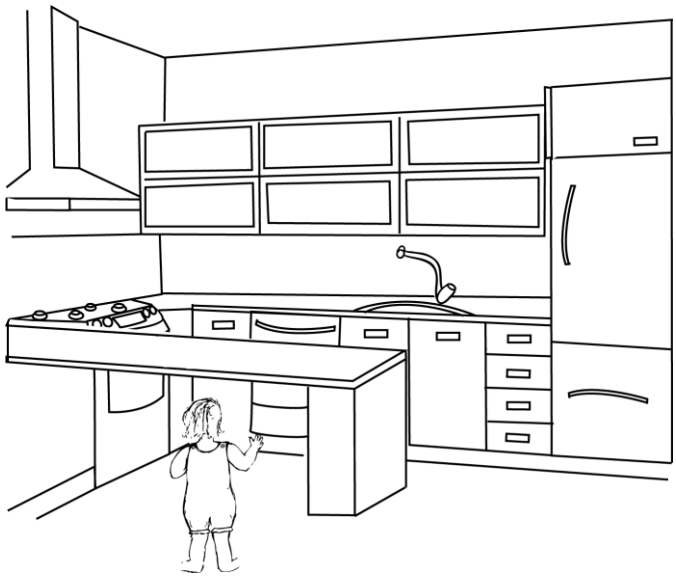
Anne uses the baby monitor when Rachel is sleeping, or when Anne and the kids are in different rooms. Anne encourages the baby sitter to use the baby monitor as well. Anne wishes that the baby monitor could also help her monitoring where her kids are and keep them away from dangerous

places, considering the limitations of each child and without taking away their freedom. Anne's main pedagogical principle is to raise independent and self confident adults.

4.2.5 Use scenario

A use scenario (Figure 14) was created to illustrate the product's concept to stakeholders. In this scenario, Anne, the persona, interacts with the product.

Anne installs the system in her open kitchen, invisibly fencing off an area that can be dangerous for Rachel. As Rachel approaches the "fenced" area, the system recognizes the child and alerts Anne.



Even if Rachel or the nanny is counting only with auditory supervision, he/she can prevent in time the child to interact with something hazardous in the house.

Using her parent's unit, Anne can configure the areas in the property to be fenced, configure the system's sensitivity to prevent false alarms, and change the alarm settings.

Figure 14. Product's use scenario

5 First design iteration

As the requirements for the *product* were defined, nine brainstorming sessions with Philips engineers were carried out to study its technical implementation. The brainstorming sessions had in mind that the design was a demand of the Domestic Appliances business unit. As pointed out by Baumann and Thomas (2001), the design of appliances bring many challenges to the user experience, which includes limited screen and little user's learnability tolerance. As a last constrain, domestic appliances' design are planned in order to hit the market in about two years, so the design must comply with existing know-how and reuse already-employed components to reduce production costs.

5.1 Searching for simplicity

As a result of the brainstorming sessions, a tripartite system was defined, as described in Figure 15.

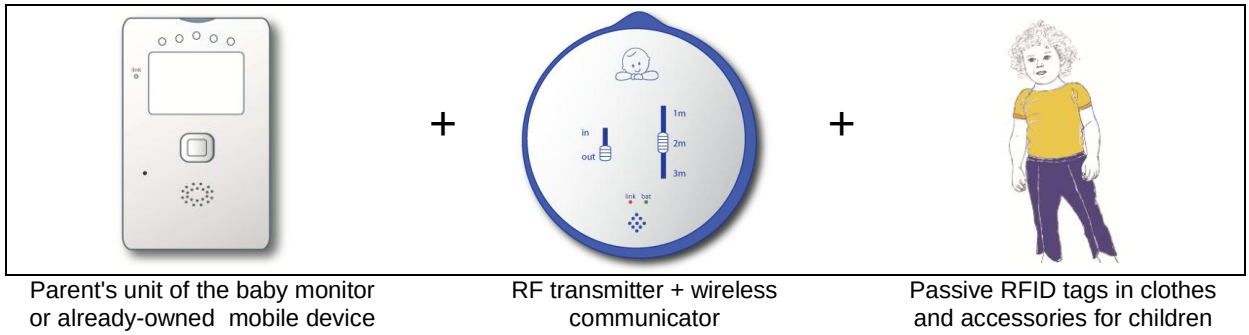


Figure 15. The product as tripartite system

The RF Transmitter monitors a certain area range configured by parents. If the child, wearing a passive RFID tag, enters in the monitored area, the RF Transmitter sends a signal for the Parent's unit. The Parent Unit evaluates the situation based on pre-set preferences set by the parent, and generates an alarm to alert the parent for a possible danger if necessary. In sum, the product adds up 15% of extra attention that the caregiver cannot provide, shifting the caregiver's eyes to a dangerous situation – and leaving to the caregiver the decision to act or not. By enhancing users' cognitive capabilities for best decision making, the product responds to the concept of *distributed cognition* applied to computing systems (Hutchins, 1995; Hollan, Hutchins, Kirsh, 2001).

The product design evolved in time in simplicity and usability, as the reader will note through the description of the two design iterations.

5.1.1 The RF Transmitter

The radio frequency (RF) technology was advised as the optimal way to implement the child identification in the fenced area. The RF technology is cheap and the know-how is available in Philips. If that RF transmitter is linked wirelessly to the parent's unit, the child's unit can be reduced to a simple passive RFID tag.

Contrarily to the current gates used by parents to limit the access of children in dangerous places, the RF transmitter recognizes *areas* instead of *boundaries*. This solution is more robust because it can keep track of the child's presence in the fenced area (not only when the child is crossing it).

By recognizing areas instead of boundaries, two instead of one use cases were identified. In the first use case (Figure 16), the parent chose to keep the child *inside the range* of the gate, substituting the playpens used to control the mobility of infants. It is a flexible and mobile solution that can be used on the go. In the second use case (Figure 17), the classic application suggested for this product, is used to keep children *outside* a dangerous area.

Figure 16. Playpen on the go: Keep infants within a safe boundary

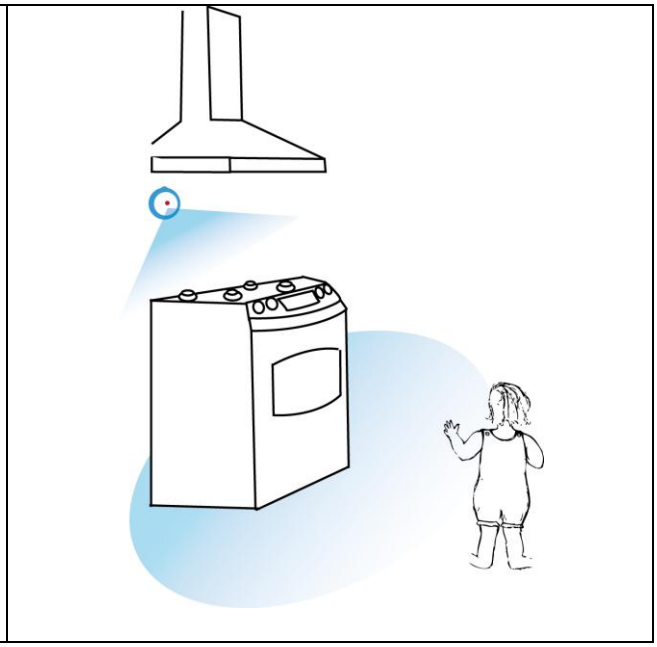


Figure 17. Gate: Keep toddlers and preschoolers away from dangerous places

With the benefits, some drawbacks of using RF with passive RFID tags were highlighted:

- the RF transmitter would demand high energy consumption;
- the RF range depends on the shape of the transmitter's beamer and the objects placed in the room – so it cannot be fully predicted;
- yet it is expected the product to fence off a specific room or part of such room, the RF signal can cross walls, which might bias the area parents are actually defining as fenced;
- because the RF range can vary, it is not possible to provide a visual model of the exact area covered.
- to reduce the reflection of the RF signal by other objects, the optimal place to install the RF transmitter would be the ceiling – which might difficult its manipulation to change settings and replace the battery.

5.1.2 The parent's unit

Reusing a mobile device that parents already own to control the areas to be fenced off was a key requirement identified in the user studies. This is tendency was observed as well in consumer studies carried out by Philips beforehand. Reusing technology reduces the costs of introducing the product in the market and the development time. As a final benefit, reusing technology contributes to lessen the environmental impact of the product, by reducing the amount of raw materials used to manufacture it.

Dedicated mobile devices such as the baby monitor are rapidly gaining processing power with the introduction of video communication. Such products will soon provide good screen quality and USB connection, which might allow parents to download different applications after purchasing the baby monitor. Mobile phones and smartphones might also be options, since they are pervasive in society. The drawback of mobile phones is that those are *personal, unalienable* devices, while the product might be used by several caregivers. As a last remark, reusing phones as the parent's unit also demands great software effort to guarantee compatibility between manufacturers, while baby monitors are already part of the Philips-Avent portfolio.

5.1.3 The Child's Unit

A passive RFID tag can be stamped in clothes and accessories for children, solving parents' worry of electromagnetic field near the children's skin generated by batteries or active wireless signals[12]. The passive RFID tag might also represent a potential market for child accessories.

The child's unit was not further developed at the current stage of the design cycle, since the project focused on checking the acceptance of the product among parents. Further user requirements about the child's unit were gathered with parents in the final user evaluation.

5.2 Wrapping Up: The First Prototype

Based on the requirements specified to the moment, a first prototype was designed. This first prototype focused on the functionalities carried out between the parent's unit and the RF transmitter.

It was chosen to keep the most part of the controls in the parent's unit, leaving to the RF transmitter only the minimum functionalities as possible. The reason behind that was to reduce production costs and to comply with the fact that the gate might be installed in the ceiling – which makes manipulation difficult.

The parent's unit was prototyped using an HTC Touch smarphone (Figure 19, left). The screen size was limited to 100x150px of resolution and one color (white with black background). The user interaction was also limited to the 5-button navigation control provided in the HTC touch. The navigation paradigm adopted was the *matrix interface*, the same used in the Philips *GoGear* line of MP3 players and a tendency of interaction in gaming. Figure 20 shows the navigation structure of the parent's unit with screenshots as delivered in the first prototype.

The reason for limiting the screen size and constraining the user input to the 5-button navigation control was to mimic the current settings of the Philips-Avent baby monitor with LCD screen, model SCD520. This decision was supported by the assumption that if the product's functionalities can be successfully delivered with the minimal settings, then designing the parent's unit for a *smarphone* with high resolution, colored screen, and multiple interaction possibilities would be much easier.

A non-functional RF transmitter was handcrafted in wood (Figure 19, right) based on the conceptual model presented on Figure 18. The interaction was mimicked with the help of a *wizard of oz* Java application serving the HTC via a wireless router. The child's unit was not included in this first prototype.

12 The electromagnetic worry is a trend observed in the user studies ran by this project and also in Philips-Avent's previous consumer researches.

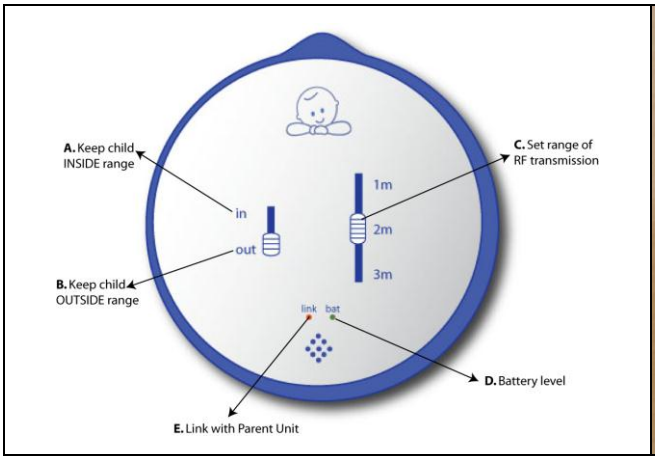


Figure 18. Conceptual model of the RF Transmitter: 1ST prototype. Battery case is the in the back of the box

Figure 19. parent's unit (left) and RF transmitter (right) in the first prototype

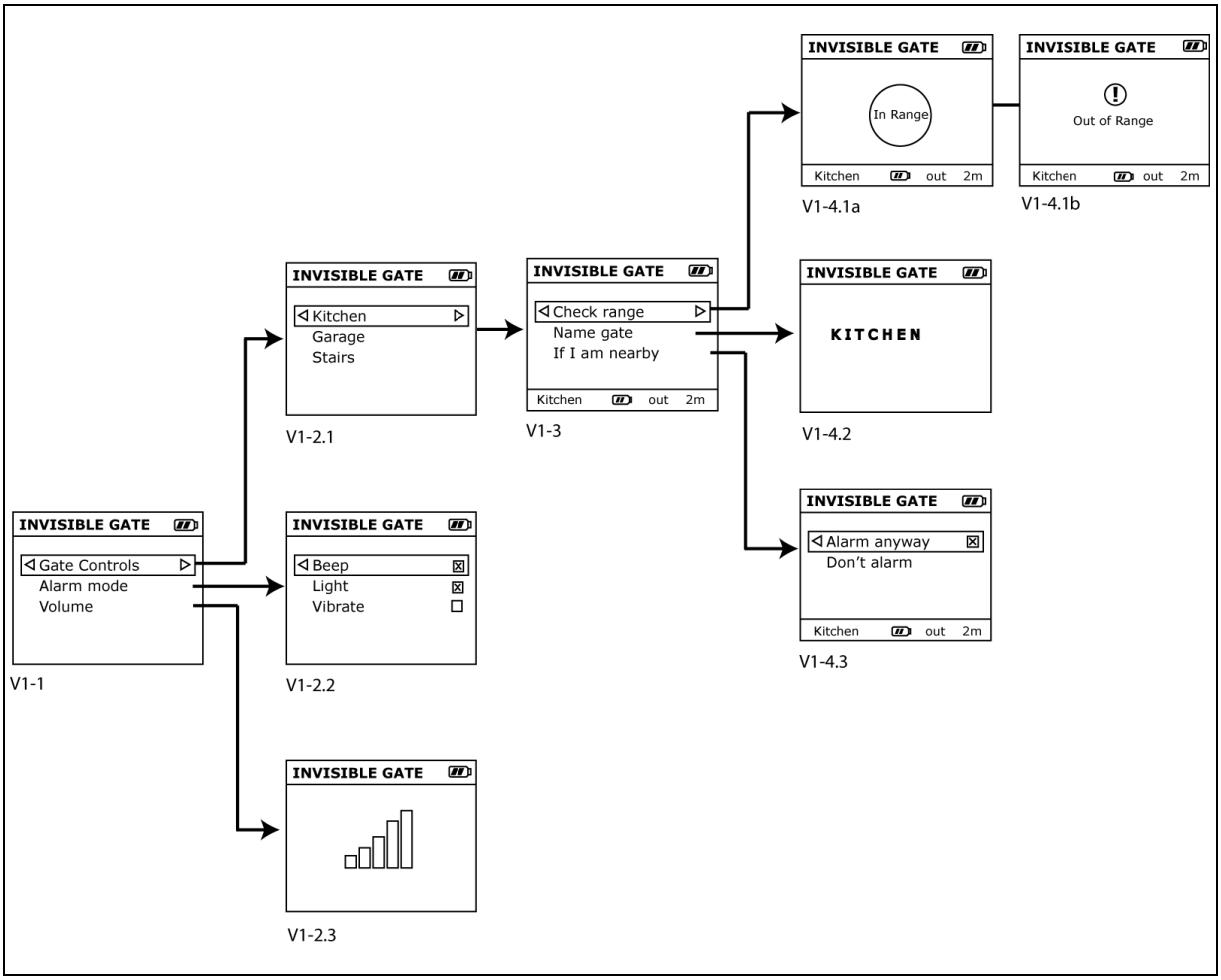


Figure 20. Navigation structure of the parent's unit with screenshots (inverted colors): 1st prototype

5.3 Evaluation of 1st design iteration

The first design iteration was evaluated by child safety specialists (access to product's conceptual design and documentation) and usability specialists (access to the first prototype). The results of those evaluations and their impact in the second prototype are in the next sections.

5.3.1 Usability Inspection

Based on the assumption that possible user interface issues of the prototype might bias the user's opinion about the product, a usability inspection was carried out. The inspection helped ensuring that serious usability matters will not be experienced by the users during the final evaluation of the concept.

The usability inspection was held in the Demolab of the Human Centered Solutions group, Philips Applied Technologies, in 13th June. Each inspection took 30-50min to be completed. Six usability specialists working in groups throughout Philips volunteered to participate. Two participants were woman, and none of the participants have kids. The average age of the participants was 28 years old. The average working experience with user-centered design was 3,5 years, and all participants declared to have previous experience performing usability inspections.

The participants received an explanation about the product concept and the design requirements. Then, the participants were invited to interact with the prototype by following a pre-determined set of tasks. The participants were invited to verbalize any comments they might had during the interaction. After finishing all the tasks, the participants filled in the inspection sheet, composed by eight questions concerning their experience with the prototype. The participants rated every item as: (a) no problem; (b) minor problem; (c) major problem; (d) do not apply, and justified each answer. This technique was borrowed from Nielsen's guidelines (1993) to apply heuristic evaluations in *websites*. Because the prototype was an appliance, and since no reliable guidelines t apply heuristic evaluations in appliances was found in the literature, Nielsen's method was adapted, as shown in Appendix 5.

The majority of the problems detected by the participants were rated as minor problems. Usability problems were concentrated in the labels chosen for the product's functionalities, and the information architecture of the parents' unit menu. The comments were consistent between usability inspectors. Table 3 summarizes the main usability problems detected, and how they were solved in the second prototype.

	FUNCTIONALITY IN 1ST PROTOTYPE	USABILITY PROBLEM DETECTED IN 1ST PROTOTYPE	RESPONSE TO PROBLEM IMPLEMENTED IN 2ND PROTOTYPE
RF Transmitter (RF)	Keep child *inside* or *outside* range (**A, B**[13])	In/out are arbitrary → meaning can be swapped: **in** as *alarm when child is in* and **out** as *alarm when child is out* range.	Rename *in* and *out* as *playpen* and *gate* → became 2 SEPARATED PRODUCTS.
	1-3m RF range (**C**)	- If device must be in the ceiling, 1m and 2m is not enough. - More flexibility may be needed.	*Boundary markers* introduced to gather requirements on size and shape of area to be covered by RF range.
	On/off switch and battery case behind the device.	- If in ceiling, difficult access.	*On/off switch and battery case put in front of the device, facing the floor.*
Parent's unit (P.U.)	By approaching P.U. and R.F., user triggers process to add a new gate to the network.	Process was *too intuitive.* Could lead to adding gate undesirably.	Make adding new gate procedure explicit and systematic.
	After adding a new gate, P.U. requests user to name it (**V1-4.2**[14]).	- Request not clear. - Users able to skip the procedure by mistake	- Clearly declare naming procedure. - Insert screen to prevent this error.
	RF's *in/out* function (**1,2**) confused with PU's check range function (*in range / out range*) (**V1-4.1**).	Ambiguous labels.	PU's check range function renamed
	Information bar of current gate displayed in bottom (**V1-3.1.** and further).	- Information imperceptible for some users. - Too much text in the bar	- Put information bar of current gate in top. - Some information regarding the gate not displayed anymore.
	Home menu (**V1-1.1**)	- Incoherent information structure mixing the control of gate settings with alarm settings[15]. - Not clear where home menu is.	- navigation re-architecture separating "gate settings" from "alarm settings"; - distinctive home menu features.
	Volume control (**V1-2.3**)	- Bars growing in horizontal were not coherent with up/down keys on the navigation control.	- Bars rotated 90 degrees.

Table 3. Design evolving from Prototype 1 to Prototype 2 based on usability inspections

5.3.2 Evaluation by Child Safety Specialists

Three child safety specialists working in The Netherlands were interviewed about the product concept. The specialists had access to the product's documentation[16].

CONSUMENTEN VEILIGHEID

Two specialists of the Consument Veiligheid (http://www.veiligheid.nl/) were interviewd. This organization is responsible for the safety of products released in the Dutch market. The specialists

13 A and B are referring to functionalities of the first prototype, as showed in Figure 20.

14 V1-4.2 is referring to screen of 1st prototype's navigation structure, as showed in Figure 23

15 Incoherence verbalized by inspectors and observed in the patterns of navigation gathered by logging the interaction process in the server.

16 The Product documentation was composed by drawings and storyboards that illustrates and justifies the product concept.

were the consultant Ine Buuron and the researcher Dr. Chantal van Aken. Both specialists provided interviews by phone after analyzing the documentation.

According to Buuron, the product could generate two contradictory reactions in the parents: lax of vigilance due to a false feeling of safety, or panic due to false alarms. The false feeling of safety would be also triggered by pool alarms, a category of safety equipment that she considered similar to the proposed design concept. According to Dr. van Aken, the danger of supervision relax pointed out by Buuron might also be present in products such as baby monitors. If used in combination with supervision, however, the product could be useful for parents teaching children about danger.

Indeed, Dilillo and Tremblay (2001) support that parents tend to reduce vigilance after installing *any* safety equipment, effect known as *behavioral compensation* or *risk homeostasis*[17]. For this reason, manufacturers of safety equipment are obliged to print "never leave your child unattended" on the products' wrapping. There is no evidence in the literature that alarm systems augment the behavioral compensation when compared with other safety equipment.

The use of the term "fence" or "gate" by the product was not recommended, since these terms imply a physical barrier that the product does not support. This might lead to a false assumption that the product substitutes conventional safety gates that can avoid the child's access to a danger even without supervision.

PROF. MARIANNE JUNGER, UTRECHT UNIVERSITY

The interview with Prof. Junger occurred in person during one hour. Professor Junger studies non-compliant children and adolescents, as well as the correlation between delinquency and cultural background with accidents.

In Professor Junger's opinion, the product has great opportunities as a monitoring tool. The design could help families in Parent-Child Interaction Therapy (PCIT), a technique used by cognitive psychologists to treat difficult-to-manage children. When asked if the Product should include an alarm to be received by the child, Prof. Junger pointed out the difficulty of stating a position without any supporting experimental research, and demonstrated interest to run a experimental trial to answer such question.

5.4 Conclusions

The evaluation of specialists led to the following design decisions:

- avoid associating the product with terms such as gate or fence;
- the product's defence against false alarms became a design priority;
- the navigation of the parent's unit was restructured and label ambiguities removed (Figure 24);
- a more flexible alternative for the fixed RF range was considered;
- the child alarm should be the subject of further user studies before its implementation.

17 As discussed in the review of the literature.

6 Second Design Iteration

In the second iteration, the lessons learned in the first prototype's evaluation were implemented. First, the two use cases of the product (*keep child inside* and *keep child outside* range) were separated into *two distinct products*. Only the product referring to *keep the child outside range* was implemented, being finally named as the **Safe Spot**.

All commands available in the fist prototype's RF transmitter migrated to the parent's unit of the **Safe Spot**, in order to avoid the need to manipulate the RF transmitter after it is installed in the ceiling. As a result, the design concept shown in Figure 21 was developed. Still in the parent's unit, the user interface changes proposed by the usability inspectors (described in Table 3) were implemented, leading to the navigation structure shown in Figure 23.

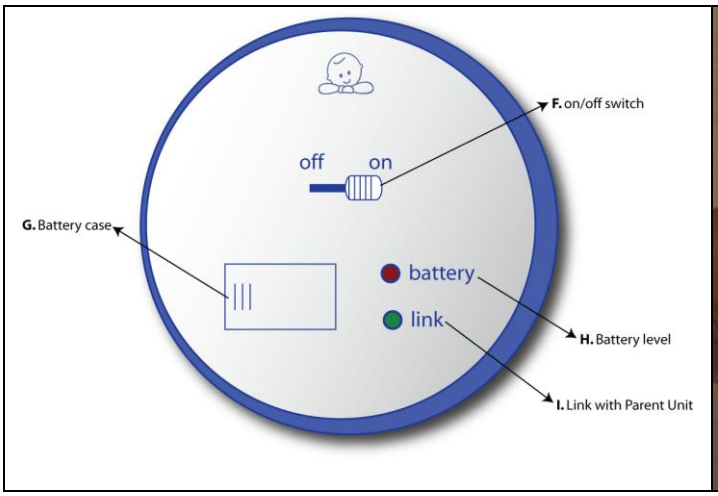


Figure 21. Conceptual model of the RF Transmitter: 2nd prototype

Figure 22. RF transmitter in the second prototype

The insufficient flexibility provided by the RF technology supposed to the first prototype (RF beamer and passive RFID tags), led to a search for a more robust solution to the problem of identifying the child in the dangerous area. That solution did not precise the size and shape of the covered area nor considered the differences in home layouts. Therefore, it was decided to work with the assumption that a highly customized solution could be implemented – while still simple enough to be installed in less than 5min by parents in their properties. Currently, RF *time-of-flight ranging* technology is a strong candidate to provide such customization, although it demands active RFIDs as the child's unit.

To realize the customization of an area to be covered, the *markers* were introduced in the second prototype as part of the installation process. To define the area to be covered by the **Safe Spot**, the parents set the markers in the ground, so it can be *mapped* by the RF transmitter. After the area is mapped, the parents can remove the markers from the ground. The user guide for the installation process is shown in Figure 24.

(Figure 23 here)

Because the **Safe Spot** is highly unobtrusive, it lets parents certify that it is covering the right area. To do so, the parents chose the option "check coverage" in the parent's unit. The **Safe Spot** will feedback the messages *area covered* or *area not covered* depending on the position of the parent in the room, giving this user a mental model of the invisible borders that the RF transmitter is providing (as shown in Figure 23, V2-41a and V2-41b).

In order to avoid false alarms, the **Safe Spot** allow parents choosing not to receive the alarm if the one porting the parent's unit is inside the area covered by that **Safe Spot**. The assumption is that the caregiver would, in this situation, be visually monitoring the child, so the **Safe Spot** would not be needed. This solution was presented in the final user test to understand the size and shape of the areas parents would like to cover in their houses, since such requirements were not clarified in the previous studies. A screenshot of such function can be seen in Figure 24, V2-3.4.

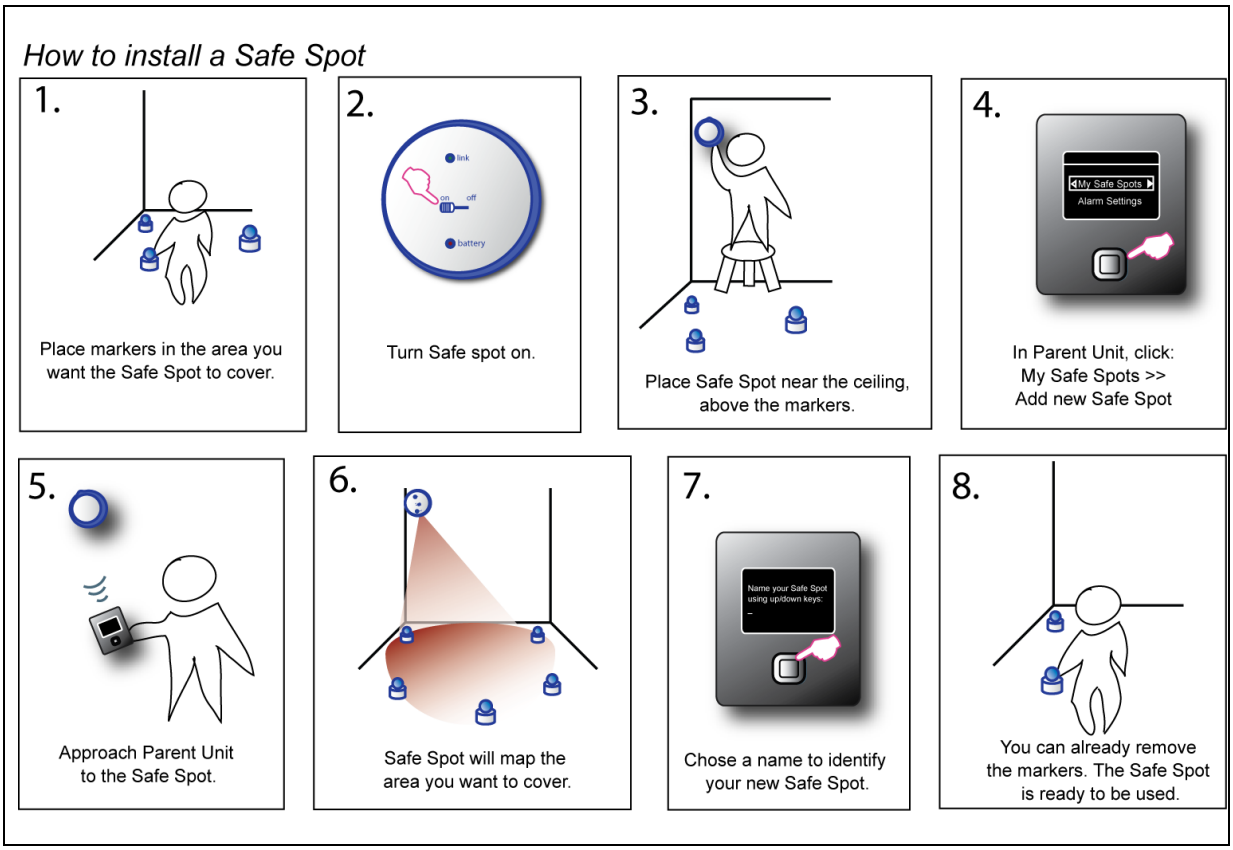


*Figure 24. User installation guide of the **Safe Spot***

6.1.1 The second prototype

To realize the second design iteration, a new prototype was made. The parent's unit continued to be mimicked by a HTC touch smartphone with the aid of a wizard-of-oz java application. The RF transmitter was handcrafted in a wooden box (Figure 22) with remote-controlled LEDs. To represent the child's unit, a pacifier clip was used as an instance of the possible accessories that parents could wear in their children.

6.2 Final Evaluation

The second prototype was used to perform a final user study aiming at evaluating the **Safe Spot** among parents. The study aimed at answering the following questions:

- Would the **Safe Spot** be used by parents in daily life?
- What is the size and shape of the areas parents need to cover with the **Safe Spot**?
- What is parents' opinion about providing an alarm for the children as well?
- How parents would experience monitoring more than one area with the **Safe Spot**?
- How the **Safe Spot** should support parents in supervising multiple children?
- How should the child's unit be?
- What alarm modes should the **Safe Spot** support?
- Do parents feel like they could intervene in time while using the **Safe Spot**?

6.2.1 Method

Five mothers (M1-M5) of children fitting the user group of the **Safe Spot** volunteered in participating in the study. The average age of the mothers was 35 years old. Two of the mothers held undergraduate degree and three of the mothers held a Master's degree. Considering the children's age, M1 had a 6 months old girl; M2 and M3 had 18 months old boy and girl, respectively; M4 had a 12 months old girl; M5 had a 3, 5, and 8 years old boys. Therefore, only one of the families visited had multiple children.

The mothers received the researcher in their houses. The visit took, in average, one hour. All participants signed a document containing an informed consent and a non-disclosure agreement. The participants filled in a background information questionnaire about age and higher education received. The researcher presented an introduction about the **Safe Spot**'s concept with a similar sketch as presented in Figure 14. Then, parents were invited to try out the prototype, guided by a list of tasks suggested by the researcher. The trial started by installing the Safe Spot using the user guide shown in Figure 24. After experiencing the **Safe Spot**, the researcher followed a semi-structured questionnaire (Appendix 6) aiming at obtaining answers to the study's questions. In the end of the visit, the researcher explained to the mothers the *wizard of oz* setting used to run the prototype. All participants received a *VVV-IRIS Cheque* of 20 euros in gratitude to their participation.

6.3 Results

6.3.1 Concept Acceptance

Four of five mothers declared that they would use the **Safe Spot** to help monitoring their children's whereabouts when inside their houses. According to the participants' opinion, the **Safe Spot** would enhance their ability to monitor their children when they and their children are in different rooms. As highlighted in the previous user studies, the mothers never leave their children in a different room for more than 5min. Current reasons for leaving the child unattended are when going to the laundry room or garage, or for a short task upstairs. The mothers also stated that the **Safe Spot** could help caregivers supervising more than one child at the same time, since sharing the attention among more than one child may lead to supervision slips *even if the caregiver is in the same room as the children.*

6.3.2 Installing a Safe Spot

The installation process was considered *very easy* for all the mothers. The RF transmitter took in average 3min30s to be installed, overcoming the 5min. goal defined in the requirements. The setting was considered *above the participants' expectations*. The mothers spontaneously referred to the need of transporting the **Safe Spots** among different properties that their children visit without having to remap the areas covered in each house – a feature not currently implemented.

On installing multiple **Safe Spots** in the house, none of the mothers previewed difficulties in managing them with the current user interface of the parent's unit. However, two of the mothers expected that a same RF transmitter could cover different areas. It seemed more intuitive to have only one device centralizing all mapped areas. In the participant's opinion, centralizing all areas in one box could also reduce the possibility of the safe areas intersecting with each other.

6.3.3 Reusing the baby monitor

Reusing the parent's unit of the baby monitor to control the **Safe Spot** was highly appreciated by all mothers. However, the mothers were not enthusiastic about using the caregiver's mobile phones for this application: only one of them perceived additional value in this option. Although all the participants still use the baby monitor, they believed that the parent's unit could concomitantly serve the baby monitor *and* the **Safe Spot** without losing performance.

6.3.4 Size and shape of area to be covered

Figure 25 shows how the participants positioned the markers (blue dots) when installing the **Safe Spot**. The areas the mothers wanted to be avoided by their children are the dashed lines. The red titles show the name typed by the participants in the parent's unit when mapping that area. As it can be noticed, all mothers chose to install the **Safe Spot** at least in the kitchen.

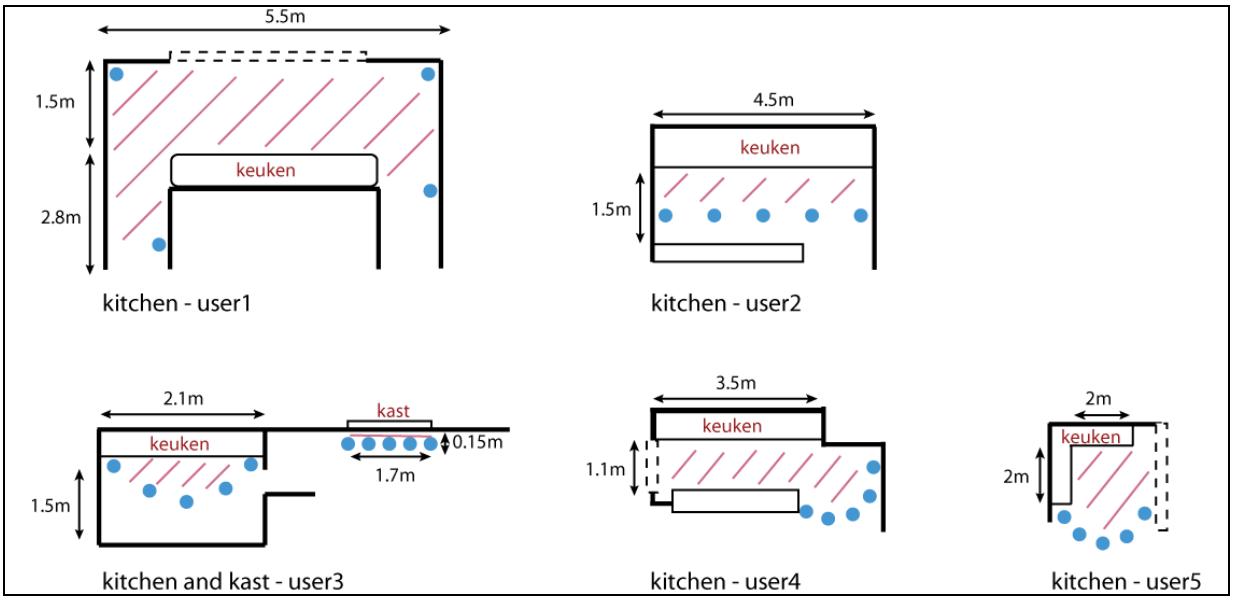


Figure 25. How parents positioned the markers *in the areas to be covered by the* ***Safe Spot****.*

Figure 25 shows that, except by user 1, the participants saw walls and furniture as natural barriers that the **Safe Spot** would consider when mapping the area to be covered. This result shows the need to provide a visual feedback linking the markers when mapping the area, in order to help parents forming a polygon-like area.

6.3.5 Intervening in time

After installing a second **Safe Spot** to mark off her cupboard (*kast*, Figure 25), the user 3 realized that that 15cm area would not be enough to prevent her daughter to interact with the furniture. She mentioned that such a small area would not give her enough time to stop her daughter to interact with the cupboard, and cancelled the installation. As this mother, all participants questioned if the areas they chose would be wide enough to allow them intervening in time, considering the current motor development of their children. A general conclusion was that the **Safe Spot**'s range should cover room areas, and not furniture spots. According to the mothers, a long-term trial with the product in their houses would be necessary to test its efficacy.

6.3.6 The child's feedback

Four of the five mothers were against the introduction of a feedback for the child. These mothers considered that a child's feedback could be disturbing and even traumatizing. They also pointed out that the child's alarm could be used by their children as a game or to call the mother's attention. In this sense, the child's feedback takes away **Safe Spot**'s invisibility, the most liked feature of the product.

The mother in favour of the child's feedback suggested its implementation as a message that she could record reprehending the child to enter in the area. The message would go off when her child enters the area covered by the **Safe Spot**, giving the mother time to arrive and guarantee that the child had or not obeyed the instruction. In this sense, the child's feedback would help parents in reinforcing rules.

6.3.7 The child's unit

The participants suggested the underwear as the best place for the child's unit. Other ideas to implement the child's unit were in the shoes, in accessories such as earrings, and in disposable adhesives to be glued in the clothes. Again, two of the participants showed concern about high electromagnetic field in contact with the child's skin.

Some mothers were concerned that their children could remove the child's unit, since toddlers commonly remove their clothes and accessories. Forgetting to make the child wear the child's unit was also a concern. To solve this problem, the mothers suggested that they should be alerted by the system if the child is not wearing the child's unit when the **Safe Spot** is in use.

6.3.8 Supported alarm modes

Considering the three alarm modes supported by the prototype (beep, vibrate, and light), the parents preferred the beep and the vibration, which provide faster decision making without having to look at the parent's unit. The vibration was considered essential in noisy environments, and would require a good clip in the parent's unit. The current baby monitor clips do not support the use of dresses and were considered not comfortable to wear.

Different ring tones could also be used to represent different areas, like the mothers already experience with their mobile phones. The drawback of ring tones is that they are arbitrary codes that are not easily shared with other caregivers using the **Safe Spot**. Another alternative would be a recorded message. The parent could record the name of the area to be covered when installing the Safe Spot, and then chose to listen to the recorded message when the alarm goes off.

6.3.9 The different caregivers

When asked if the other caregivers that take care of their children would be adepts of the **Safe Spot**, the opinions were split. Mothers that count on the children's grandparents considered that those elderly users would not be enthusiastic in introducing the **Safe Spot** in their routine. According to the mothers, those same grandparents did not adapt to using baby monitors. However, when their children are supervised by young nannies or elderly persons who already use mobile devices, the mothers believed that those caregivers would not experience usability problems.

6.3.10 Pros and Cons

When asked the main quality of the **Safe Spot**, all parents pointed to out its unobtrusive yet efficient way to prevent children to assess a dangerous area inside the house. The Safe Spot was seen as a *friendly manner* to keep children safe, without taking away their freedom, *and still keeping the parent in control.* Another strong point is that the **Safe Spot** can be installed in all home layouts without introducing physical barriers in the house.

The mothers pointed out that a weak point of the **Safe Spot** was its potential to be misused by irresponsible parents. The mothers feared that some parents could leave their children alone in the house and make the **Safe Spot** ruling as *the nanny*. The mothers compared this risk to the baby monitors, which provide a coverage range of kilometers in some models even though parents should never leave their children unattended.

6.3.11 The Playpen use case is back

Interestingly, the mother of the only infant in the pool spontaneously suggested that the **Safe Spot** could also be used as stated in the *playpen* use case (Figure 16), reinforcing the need to perform extra assessments to this idea.

7 Recommendations

Based on the lessons learned with the second design iteration, the following recommendations are suggested to the continuation of the project:

7.1 Guidelines to the next design iteration

7.1.1 Child's alarm feedback

It is still not clear if such an alarm will be beneficial or not. Experimental trials must be performed with parents and children. Prof. Marianne Junger (currently at Twente University) demonstrated interest in participating in these trials.

Although stimuli such as the *Mosquito* sound was considered to this purpose during the research, the opportunity to record a message with the parent's voice to be triggered when the child approaches a danger might provide better pedagogical outcomes and fits better the Avent brand. To the moment, without further studies, the implementation of the child's feedback alarm in the **Safe Spot** is not recommended.

7.1.2 Area mapping

The final evaluation showed that the majority of the parents will consider walls and furniture as part of the barriers when shaping the markers to map the area to be covered by the RF transmitter. A technology that allows a fast and intuitive mapping is the *key* to the success of the product (Figure 28). A user interface solution might be to provide a visual link between the markers, to help parents understanding the need to put them in the shape of a polygon. X-ray light is also a good option to provide visual cue during the installation.

7.1.3 Acting time

Because the final evaluation was not a longitudinal observation, it was not possible to test if parents will be able to arrive in time to stop the child in entering a dangerous area. A longitudinal study is the next step in studying the viability of the concept. Based on such study, it must be recommended a minimum area to be covered by the RF transmitter to guarantee enough time to act. It should be emphasized that the product is not recommended to fence off only an appliance (such as only an oven) but *room areas* (such as the kitchen). Also, the **Safe Spot** should not be used to substitute the top-stair gates if children did not master mobility yet (around two years old).

7.1.4 Child's unit

The types of child's unit that could be used must be further explored in a next user study. This user study should consider the following information:

- the child's unit should be made available in at least three models that can serve an infant, a toddler and a preschooler;
- the child's unit should not be visible or easy to reach and remove; embedded in the child's underwear clothes, shoes, or earrings, are better options;
- it is not clear if parents will forget to make the child wear the child's unit. If the child's unit is released hidden in clothes or accessories, the system should alert the caregiver if it does not recognize it in the child's body (an accelerometer in the child's unit might solve the problem).

7.1.5 Focus on multiple children

Parents with multiple children younger than five years old tend to appreciate more the concept. These parents experience the difficulty of having to share attention, and the growing risks that it brings while watching children. This tendency is already clear and should be exploited in the next consumer studies ran for the product concept.

7.1.6 Reuse the baby monitor

Reusing a mobile device that parents already have to run the parent's unit is a strong point of the concept. The baby monitor is the best option for this role, presenting two benefits: (a) it reinforces the choice for the choice for the brand when buying the monitoring category; (b) it reduces the production costs and let a better margin to achieve the 150 euros mothers are willing to pay for a kit with one RF transmitter and one child unit (one starting kit).

7.1.7 Regulation

The **Safe Spot** should be categorized as a toy, which will avoid the need to run clinical trials and ease the release of the product in the market. Currently, the European Union is the strictest in regulating the production of toys, so it should serve as the baseline when defining the product's technical requirements. Consider, for instance: the *European Standard EN-71 (Safety for Toys)* and the *ISO 8124: International Regulation for Children's Products.*

7.1.8 Communicating the product

The Safe Spot will demand strong communication strategy with health advisors, starting by the midwives. As the user studies show, parents rely on trustworthy sources of information. In countries where official safety policies are not strong, specialized baby shops and Internet are the main sources of information. Extra communication effort is also needed with distribution channels. The shops visited during the review of current solutions in the market normally do not have special place for safety products – and this is also true for online stores. If the parent does not know what products exist to each solution, it is difficult to find.

7.1.9 The Playpen

The second design iteration concentrated in the use case *keeping the child outside* the RF transmitter's range to give focus to the final evaluation. Therefore, the use case *keeping the child outside the range*, illustrated in Figure 16 as the ***Playpen***, was left behind. However, the Playpen has potential to be developed as part of the **Safe Spot** family. Instead of an RF transmitter, the Playpen can be an interactive play mat with a *piezo* foil underneath. Implementing the idea already generated in AppTech by Sima Asvadi's group, the Playpen could react to the child's movements to propose entertainment games that can stimulate the cognitive and motor development of **infants**. As the infant leaves the mat, it reports to the parent's unit as part of the Safe Spot network of fenced areas. Figure 26 presents a sketch of the idea.

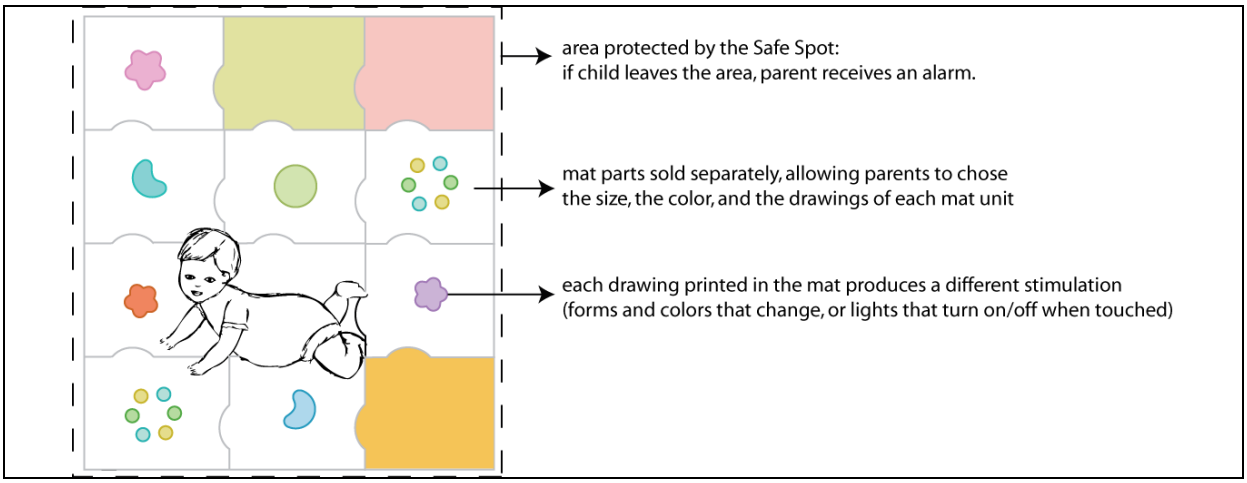


Figure 26. Sketch of the Safe Spot used as a play mat

7.2 Next Steps

1. Run an experimental trial to asses if the child's feedback should be implemented or not;

2. Define the RF technology that could be used (since it will impact in the customization of the area to be covered during installation and the use or not of active RFID in the child's unit;

3. Run a longitudinal study with 10 parents (preference in more than one locality) to assess:

- acceptability and comfort of the child's unit for different age groups;
- parent's ability to guarantee that the child is using the child's unit every time the parent wants to make use of the Safe Spot;
- how the concomitant use of the baby monitor and the Safe Spot in the parent's unit work for families that still rely on both products at the same time;
- how parents deal with monitoring multiple children and multiple RF transmitters in the house;
- finally, asses parent's subjective perception if the Safe Spot actually improved their ability to monitor their children in situations that requires attention sharing.

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World Health Organization – Regional Office for Europe. http://www.euro.who.int/violenceinjury

9 Appendices

9.1 Appendix 1. List of current solutions in the market analyzed in the review

Current Solutions by Risk Type			
Risk	**Solution**	**Description**	**Comments**
Fall and other mechanic accidents	Harnesses	Use in highchair	
	Stair Gates	Placed between stairs	- Child can open it around 14 m.o. - Child can can climb it around 2 years old
	Corner protectors	Placed in edge of furnitures	Change the appearance of furnitures
	Anti-slam doorstop	Avoid finger squeezing	Inexpensive, but require set in and out
	Impact absorbing	Diminish fall impact while playing	
	Low-wattage night lights	Avoid trips during the night	
	Safety glass and safety film	Prevent glass crash if the child fall against it	Require installation
	Window locker and safety netting	Avoid falling from windows	Require installation and change window's layout
	Playards	Restrict small children's area for playing and ease supervision	
	Stationary play center	Substitutes the walkers	Walkers are banned from Canada due to falls
Fire-related injuries	Plug socket covers	Avoid electrical shock	New plug sockets are very safe, so the product is becoming obsolete
	Cooker, Oven, and hob guards	Avoid access to cooking places	They change the look of appliances and are difficult to remove afterwards
	Fireguards	Avoid access to fireplaces	They are big and change the room's appearance
	Smoke and CO detector	Help parents to evacuate from home in time	New versions allow parents to record a message in case of emergency, since children do not respond promptly to alarms when sleeping

	Anti-scald devices	Control bathtub's water temperature	
Access to dangerous materials	Locks and latches	Avoid access to cabinets, drawers, appliances, toilet.	- Children can learn how to open plastic lockers by imitating parents - New versions use magnets to unlock the door.
	Door knob covers and door locks	Prevent access to a room with a closed door	- Children can learn how to open it by imitating parents - New versions have release in the top of the door, where children cannot reach
	Door gates	Avoid access to a dangerous room	Pressure-mounted, easy to install and remove
Drowning and Airway-Obstruction	Pool alarms	Activated when child or pet falls in the water	Forgetting change battery is common problem
	Cordless phone and safety cord shorteners	Avoid strangulation by the phone or curtain tassels' cords	
	Bathtub anti-slip and bathtub float cushions	Avoid drowning in the bathtub	A float cushion can be dangerous for newborns if it flips when the caregiver is not supervising.
	Baby monitors	Help supervision during nap and sleep time	AngelCare model provides movement sensor that tracks breathing signs. Very well received by parents fearing SIDS
	Anti-suffocating mattress	Allow the baby breathing even in the prone position	Very well received by parents fearing SIDS
	Baby Sacks	Reduce child's mobility in the crib and avoid suffocation by soft bedding	Safety standard for bedding in Europe.

9.2 Appendix 2. The 5-days tasks proposed in the Diary Study

DAY 1: Monitoring safety

How do you monitor your child to ensure that he/she is not exposed to a risk?
Consider the following situations as examples:

- during the night when you are sleeping;
- while your child is having his/her day naps;
- while you are bathing your child;
- while you are cooking;
- while you are doing the housework.

Take pictures that show how you monitor your child's safety in situations that are typical for you.
Think about objects, rules, places, persons, etc.
To summarize your comments, you can also write or make drawings.

DAY 2: When it didn't work well

Yesterday you reflected about how you monitor your child's safety in different situations.
Now, recall an occasion when you felt that your supervision was not enough. For example, when your child was exposed to a risk or injured him/herself.
Describe how you felt and how you managed the situation by drawing or writing.
You can also take pictures that help to describe that situation.

DAY 3: Facing your fears

What makes you feel anxious and fearful when thinking about your child's safety and wellbeing?
Describe three objects, situations, adjectives, places, persons, or anything that makes you feel anxiety and fear.
Why do you think these three things make you feel anxiety and fear?
You can take pictures, write, draw, etc.

DAY 4: Peace of mind

Peace of mind is the feeling that everything is well and under control, so you can relax.
Anxiety and fear are opposite feelings of peace of mind.
Describe three objects, situations, adjectives, places, persons, or anything that brings you peace of mind when considering your child's safety and wellbeing.
Why do you think these three things bring you peace of mind?
You can take pictures, write, draw, etc.

DAY 5: The high-tech house

Imagine that your house was selected to become the first accident-proof house in the world.
The company responsible for the prize will install high-tech equipment that will protect your child from the hazards that you fear the most.
The solutions are so comfortable and discrete that they fit perfectly into your house's size and style.
What do you think these solutions would be? What do you think they would look like? How do you think they will work?

9.3 Appendix 3: Semi-Structured Questionnaire used during the first visit to Parents in the Diary Study

1.) Background information: nationality; child's age, name, etc.

2.) Child's temperament

3.) Common daily activities of child (kindergarten, nursery, nannies, parents' routine, etc).
4.) How long and when child is alone at home?

5.) Common concerns about safety:

- Safety equipments and modifications done;
- Any other equipment/modifications in mind?

6.) Previous accident

- how was it?
- was it here? describe situation.

7) Travel constantly?

- how without home's infrastructure?

9.4 Appendix 4. Semi-structured questionnaire used to moderate the Creative Workshops

Always Around

1. What would you like to know about your baby when you are not with him or her?
2. Is there any situation where this sensor would not be helpful?
3. Would you like the baby sensor to be worn by your child?
4. How should the parents' unit look like? (give woman's sketch)
5. After this discussion, do you think this device would fit your lifestyle?
    a. If it is not for you, would you recommend it to someone else? Who/ what is the difference between yours and this other person?
6. What could make you stop using this device?
7. How much would you pay for this device?

More Supervision Control

1. In which situations this sensor could be helpful?
2. Is there any situation where this sensor would not be helpful?
3. How should be the signal provided to you about a dangerous situation in order to make your response fast enough to avoid a danger?
4. Should the device also inform the child that he/she is near a danger? Why/How?
5. What features in the device could make it motivating for the child to wear it frequently?
6. What is the best body location for this sensor to be worn by your child? (based on toddler sketch we will provide) - comfort, ability to take it out, etc.
7. How should the parents' unit look like? (give woman's sketch)
8. After this discussion, do you think this device would fit your lifestyle?
    a. If it is not for you, would you recommend it to someone else? Who/ what is the difference between you and this other person?
9. Until what age you would use it in your child? Why?
10. What could make you stop using this device?
11. How much would you pay for this device?

9.5 Appendix 5. Tasks and questions used in the Usability Inspection

Tasks to experience the prototype

1. Install a new gate.
2. set range to cover the area suggested;
3. set to keep child out.
4. Certify that the gate is covering the right area.
5. Choose an alarm mode that can help you notice an eventual alarm if you are receiving friends in your house;
6. Choose a volume for the alarm;
7. Set this gate not to alarm when you are nearby;
8. You will receive an alarm.

Questions

1. Did you feel confident that the gate's range you set was covering the right area?
2. While configuring the gate, did you feel reassured that the system was keeping it the way you wanted?
3. While using the parent's unit, was it easy to form a general impression about all its available functionalities?
4. Were the words, phrases and concepts used by the system clear for you?
5. Did you have a clear idea about the system's status during all the interaction?
6. Was it easy to retrieve information that you needed?

7. Did you experience problems recovering from an action you wanted to undo?
8. Did the system respond according to your intentions while you were performing the tasks?
9. Please comment on any part of your experience using the system that was not covered by the above items.

9.6 Appendix 6. Tasks and questions used in the Final Evaluation

Tasks to experience the prototype

1. Install gate in a place where you consider dangerous for your child (based on installation guide, Figure 22).
2. Certify that Safe Spot is covering the right area.
3. Chose if you would like the Safe Spot to alarm when you are inside the area or not.
4. Experience alarm (researcher put baby unit in the area).
5. Change alarm settings.
6. Researcher put baby unit in the area to experience alarm again.
7. Is it clear the way the product works?
    a. Want to start over? Want to install somewhere else?

Questions

1. Was it easy or complicated to configure the Safe Spot? Why?
2. Did you feel confident that the Safe Spot you configured was covering the right area?
3. Is it a good idea to use the parent's unit of the baby monitor for this application, or you would prefer a separated device?
4. Do you think the Safety Spot would enhance your ability of monitoring your child(ren)? How?
5. Considering your child's mobility and the way the Safe Spot alarms, do you think you could stop your child to interact with something hazardous in time?
    a. Which situations would not be preventable?
6. Would the option *not alarm when I am nearby* effectively avoid false alarms?
    a. How else could the Safe Spot avoid false alarms?
7. In this prototype only you receive an alarm. However, some parents think that the child should also be warned when he/she is in a dangerous area to reinforce teaching about dangerous things. Would you like your child to receive a warning as well?
    a. IF YES: how would it be? (visual/tactile/auditory?); social weight (for you and for the child)
    b. IF NO: Why?
8. Think about all the persons that take care of your child for you.
    a. Would you encourage them to use the Safety Spot?
    b. Pros and cons of other caregivers using the Safe Spot.
9. Can you think of a house where you could not use the Safety Spot? Why?
    a. Would you like to use the Safe Spot in your house in a way that is not possible?
10. If you needed to protect more than one place in your house, you would need more to install than one Safe Spot.
    a. Would it be difficult to control all Safe Spots with the parent's unit?
    b. Explore challenges of multiple Safe Spots.
11. How would it be to use the Safe Spot to protect more than one child?
12. Would you/other caregivers have problems remembering to make your child wear the baby unit everyday?
    a. Would it stop your child to play or sleep comfortably?
    b. Where would it be the best place to wear the baby unit?
13. What would be other options to identify the area that the alarm is relating to in a fast way? (explore pictures if in PDA/smartphone, voice, tones).
    a. How much more value it would add to the product?
14. Identify a weak and a strong point of the Safe Spot
15. Would you buy the Safe Spot for yourself or recommend it for other moms?