

Opportunities for Technology to Support Healthy Sleep Behaviours in Children

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ABSTRACT

Persuasive technologies that successfully change behaviours, especially in the quest for a healthier lifestyle, have become a recent trend in HCI research as well as in commercial products. A lot of these studies and products focus on a healthy diet and physical activities. Sleep is also an important part of a healthy lifestyle, but very few HCI studies have looked at this behaviour. Healthy sleep behaviours in children are important as they will allow a satisfying development to adulthood. Currently, behavioural treatments have a low rate of adherence and do not support the intention of sleep behaviour change into a long-term habit formation.

This paper investigates opportunities for technology to support healthy sleep behaviours in children aged 4 to 12. Three studies were conducted. The first used semi-structured interviews with parents to explore what sleep disorders their children were experiencing, how they deal with them and what their opinions on children and technology in general was. The second study used the same method, but was conducted with paediatric experts to find out how behavioural treatments are applied in practice, what gaps exist for sleep technologies to fill as well as what their opinion was on children and technology. The third study used participatory design workshops to generate functional and design requirements from the participants' explicit and latent needs.

Findings showed a gap for technology to educate and help families about healthy sleep behaviours as well as complement existing behavioural treatments. It also supports the statement that persuasive technologies should implement the three principles of captology to keep children motivated through the process of habit formation

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NOTE BY THE UNIVERSITY

This project report is submitted as an examination paper. No responsibility can be held by London University for the accuracy or completeness of the material therein.

[39].

This study has identified design recommendations for children sleep technologies to complement existing behavioural treatments as well as encourage children to self-control their sleep patterns. Those recommendations could support the design of prototypes to be empirically evaluated in future work.

Author Keywords

Persuasive Technology; Behaviour Change; Habit Formation; Dyssomnias; Children.

ACM Classification Keywords

H.5.m. *Information interfaces and presentation* (e.g., HCI): Miscellaneous.

MSc Contribution Type

Empirical.

1. INTRODUCTION

Recently, there has been an increased interest within the HCI community around persuasive technologies to track and change behaviours about health and wellbeing. Several studies have successfully documented and implemented technologies to support healthy behaviours in areas such as eating, exercising, smoking cessation and mental health [17, 18, 19, 24, 37, 43]. Regarding technology for children, there also has been some extensive studies on how technology can support healthy habits in eating, exercising or even brushing teeth rather than sleeping [14, 27, 32, 38, 61].

Additional to a healthy diet and regular physical activity, sleep is also an important component of a healthy lifestyle. There has been little research in HCI around technologies that support healthy sleep behaviours. Choe et al.'s [15] research is the first to look at opportunities for technology to support healthy sleep behaviours and to offer a design framework for sleep technologies. Furthermore, Choe et al.'s [15] paper as well as other technologies developed within the HCI field like SleepTight [16] and ShutEye [8] tend to only focus on adults. Sonne et al. [20] are the first within the field to be investigating opportunities for establishing sleep routines for children with ADHD to improve sleep behaviours. To date, there has been no empirical evidence regarding opportunities of sleep technologies for neuro-typical (NT) children. The aim of this thesis will be to address this gap.

Sleeping is a physiological and basic need [45], which means that without sleep humans would not be able to survive. Children need more hours of sleep than adolescents or adults for a healthy development [23]. Previous research has shown that poor sleep quality in children, most commonly caused by late bedtimes and frequent night wakings, is the reason behind behavioural and cognitive difficulties [20, 23]. Poor sleep quality is shown to negatively impact daytime sleepiness, learning, memory processes, and cognitive behaviours [20]. Bedtime resistance, difficulties to fall asleep and frequent night wakings were found as the most common sleep disorders for children aged 5-12 [9, 21]. Those sleep disorders are classified as dyssomnias [26], which most often originate from a poor sleep hygiene (see Section 2.2) [9]. Research has shown that dyssomnias in childhood can impact the child's cognitive development to adolescence as well as to adulthood [21, 25, 28].

Until now, it is mostly the medical community that has been looking into solutions for dyssomnias in children. Several studies have focused on behavioural treatments such as consistent bedtime routines, graduated extinction, etc; while some other studies have been looking at positive and negative impacts of pharmacological treatments [35, 40]. Those treatments will be further discussed in Section 2. Poor parental adherence to those behavioural and pharmacological treatments have been observed [13], which is why there is an opportunity for persuasive technology to cater for that issue.

This study aimed to address the following research questions:

- How can technology complement existing treatments for dyssomnias by encouraging habit formation?
- How can technology help children become more independent in controlling their sleep patterns?

The overall structure of the study takes the form of 8 sections including this introductory section. Section 2 provides a brief background on children's sleep and discusses behaviour change, habit formation and persuasive technologies. Section 3 outlines and justifies different methods used for the three different studies that investigated the research questions of this thesis. Section 4, 5, and 6 present those studies:

- Study 1: semi-structured interviews with parents.
- Study 2: semi-structured interviews with experts on paediatric sleep.
- Study 3: participatory design workshops with families.

In those sections, findings are analysed and introduced. They will be then discussed in Section 7. Finally, Section 8 gives a brief review of the study.

The thesis provides new insights within the field of HCI into how persuasive technology can support and implement healthy sleep behaviours in children.

2. BACKGROUND AND RELATED RESEARCH

In this section, we will first provide a background introduction to the paediatric sleep domain. After that, we will present research on persuasive technologies for behaviour change and habit formation from the HCI domain as well as related technologies to the domain of sleep.

2.1 Understanding Paediatric Sleep

Before diving into current treatments that cater for children's sleep problems, it is important to have background information on what is normal sleep for children as it may inform the nature of possible sleep problems [23].

The different stages that comprise normal sleep are: Non-REM sleep (Non-Rapid Eye Movement) and REM sleep (Rapid Eye Movement). Non-REM sleep corresponds to a quiet and deep sleep where heart rate and breathing have a regular pattern, which provides sleep's restorative properties. REM sleep coincides with an active and light sleep; it is the stage in which most of the dreaming will happen, and the heart rate will change irregularly [23].

In a normal and non-disrupted sleep cycle, children will achieve deep sleep within a few minutes. In the first part of the night which corresponds to three or four hours, children will be in very deep sleep (non-REM sleep) and difficult to wake. At the end of this cycle, they will enter a stage of REM sleep, known as light sleep, children might wake up briefly but will normally fall back asleep quickly. Then, for the rest of the night will follow a series of non-REM (deep sleep) and REM (light sleep) sleep and it is particularly in those transitions that wakings accompanied by sleeplessness occur [23].

2.2 Sleep Hygiene for Children

Circadian rhythms are changes in our biological systems that will control sleep and wakings. It is important to understand them and to understand how they can be maintained in harmony through good sleep hygiene. Circadian rhythms will be repeated every twenty-four hours. For example, light is an external factor that will set circadian rhythms. When it is dark, it induces sleep while when there is light people will tend to wake up or will have trouble falling asleep. Body temperature is also an external factor, as we will fall asleep faster if the body temperature is low and wake up when body temperature starts rising [23].

To avoid disrupting circadian rhythms, it is recommended to follow a healthy sleep hygiene, especially for children, to prevent sleep disorders and their consequences. Recommendations for good sleep hygiene in children are as follows [12, 23, 25]:

- Regular bed and waking times;

- Consistency regarding the amount of time spent in bed;
- No food or drink prior to bedtime;
- Rational bedtime routine (getting in pyjamas, tooth brushing, bath time, story time, etc.);
- Exercise during the day;
- Appropriate napping time according to the age range;
- No stimulating activities before bedtime.

2.3 Sleep Disorders in Children

Davis et al. [21] have defined paediatric sleep disorders as: “any sleep patterns that interferes with the child obtaining the optimal amount of sleep required for normal growth and development, emotional and psychological health, and proper immune function”.

There are two main categories of paediatric sleep disorders: dyssomnias and parasomnias (see Table 1). Dyssomnias refer to sleep disorders that make it difficult to fall asleep or to remain asleep as well as induce excessive sleepiness during the day. Parasomnias allude to sleep disorders in the form of nightmares, sleepwalking and night terrors that will happen during sleep.

In this study, we will be focusing on types of dyssomnias (Obstructive Sleep Apnoea Syndrome (OSAS) will not be taken into account as it is a medical condition that often requires surgery to be treated [21]), rather than types of parasomnias.

For the purpose of better understanding sleep disorders in children we will briefly define each type of dyssomnia (except for OSAS):

- Sleep-Onset Association Disorder: children will wake up in the middle of the night and will not be able to self-soothe if they are not in the same condition as when they went to sleep, e.g. presence of their parents.
- Limit-Setting Sleep Disorder: the child will demand many things, such as more stories, and then water, etc., this disorder can also be called bedtime resistance. It will occur if parents have not set limits to the child.
- Inadequate Sleep Hygiene: we have seen previously what consists a good sleep hygiene, the lack of it will disturb the child’s sleep pattern and will generate sleepiness during the day.
- Insufficient Sleep Syndrome: consequence of poor sleep hygiene where the child will repeatedly not get enough sleep that will increase sleepiness during the day.

DYSSOMNIAS	PARASOMNIAS
Sleep-Onset Association Disorder	Confusional Arousals
Limit-Setting Sleep Disorder	Sleepwalking

Inadequate Sleep Hygiene	Sleep Terrors
Insufficient Sleep Syndrome	Nightmares
Obstructive Sleep Apnoea Syndrome (OSAS)	Rhythmic Movement Disorder

Table 1. Types of dyssomnias and parasomnias.

2.4 Current Treatments for Dyssomnias

For the purpose of this thesis, it is important to have an overview of current treatments to be able to understand how persuasive technology can complement them. We will first look at behavioural treatments and then we will present pharmacological treatments.

2.4.1 Behavioural Treatments

The table below (see Table 2) provides a review of all current existing treatments for dyssomnias in children [2, 30, 35, 34, 40, 41, 42, 49]

Behavioural Treatment	Description
Extinction	Parents will put the child to sleep at a set bedtime and then ignore the child (even if crying) until the next morning at a set time. Parents will not be allowed to stay in the bedroom.
Graduated Extinction	It is the same as extinction except that they will ignore the child only for a period of time. When checking on the child for comfort, it should not be more than 15 seconds. Parents will have to decrease the number of times they check on the child over time.
Extinction with Parental Presence	It is the same as extinction except that parents can stay in the bedroom, but they still have to ignore the child.
Positive Routines	Parents will develop a relaxing bedtime routine that the child will enjoy.
Bedtime Fading	Parents will set the initial bedtime treatment when the child is most likely tired and then successively set it earlier each day until reaching the desired bedtime.
Response Cost	If the child does not fall asleep, parents will remove him from bed for a certain

	amount of time. This is based on the belief that keeping a child awake is unpleasant.
Positive Reinforcement	Giving rewards to the child every time he goes to bed on time and/or sleeps through the night.
Sleep Scheduling	Setting regular sleep and wake times as a strict contract between the parents and the child. Even during the weekend.

Table 2. Summary of existing behavioural treatments.

2.4.2 Pharmacological Treatments

Pharmacological treatments are often prescribed as complements to behavioural treatments, especially if the sleep disorder is severe and parents experience extreme frustration and are looking for a rapid solution [48]. The most common treatments are [35, 48]:

- Antihistamines that are highly sedating. Research has shown that they produce short-term improvements such as quicker sleep onset, decreased crying, and lowered parental anxiety.
- Chloral hydrate which is often prescribed to children with insufficient sleep syndrome.
- Benzodiazepines are used to control parasomnias.
- Melatonin is the most prescribed treatment that will improve the child’s sleep overall.

2.4.3 Critique of Current Treatments

The least accepted and most criticised treatment is “extinction”, it has been found to be stressful on parents, and often they will not be able just to let their child “cry it out”. This means that parents will try to adapt the treatment in a way they think is best, and the treatment will fail accordingly [40, 42]. This kind of situation also happens with other treatments. Sometimes, parents will not see rapid results and therefore will think that it is not functioning for their child and will abandon or change the treatment [42].

Kuhn & Weidinger [35] argued that pharmacological treatments are only temporary and would not treat the child properly in the long-term. They also stated that those treatments might create non-desired side effects and could also endanger the child’s life. For example, chloral hydrate might cause sleep apnoea and potential accidental overdose.

Poor adherence to those treatments for children’s sleep disorders gives an opportunity for persuasive technologies to form healthy sleep behaviours in children and complement those treatments where they are currently failing.

2.5 Behaviour Change, Habit Formation and Technology

In this study, we want to look at how technology can support healthy sleep behaviours in children. To do so, it is important first to understand that habit formation is an important part of behaviour change and then look at how behaviour change and habit formation have been implemented in HCI, especially in sleep technologies.

2.5.1 From Behaviour Change to Habit Formation

When people execute a certain behaviour repeatedly within the same context, associations will be created between both. At some point, behaviours will automatically be triggered by the context without the need for a conscious effort: this is when it will be considered a habit [36]. In the long term, the new behaviour turns into a habit and becomes automatic. This is what previously stated behavioural treatments for children sleep disorders are aiming for. For example, in graduated extinction, parents’ behaviour will be to ignore the child gradually in time until it becomes a habit for the child to fall asleep alone and self-soothe during night wakings. However, it has been proved that habits are resistant to change, especially when it comes to changing an existing habit rather than creating one, which is also a reason why the implementation of some behavioural treatments has been difficult [58, 60]. For example, parents have the intention of telling their children to go to sleep with a robotic voice, but it might not turn into a habit because they will give up as they might not be able to handle external factors such as the child crying.

2.5.2 Applying Habit Formation to HCI

Stawarz et al. [56] research is one of the first in HCI to support the idea that habit formation is key to long-term behaviour change. They suggest that no existing behaviour change apps currently support habit formation. Instead, they are focusing on the first steps of behaviour change by giving users the opportunity to self-track their activities. For a new behaviour to become an automatic habit in the long-term, habit formation apps are needed as they will support the repetition of the new behaviour in the same context until it is unconsciously adopted by users [56].

So far, regarding sleep technology, academic research, and commercial products have been created towards an understanding and a tracking of sleep rather than towards forming long-term healthy sleep habits. SleepTight [16] an easy-to-use self-tracking system, will allow its users to collect and reflect on sleep behaviours. Results showed that users better understood their sleep patterns and how external factors were related to those patterns. ShutEye [8] a mobile and peripheral display, shows its users how activities they did during the day affect their sleep quality. Results of the study indicated that ShutEye increased its users’ awareness of healthy sleep habits. Sleep Cycle [2] is a commercial product that allows its users to track sleep and thus uncover eventual existing sleep disorders. Sonne et al.’s work [20] is one of the first in HCI to focus on children’s sleep technology with the MOBERO app for

families and children with ADHD. MOBERO offers bedtime and morning routine activities for both children and parents. Upon completion of their activities, children will receive rewards. The purpose of the app is to encourage children with ADHD to become more independent with their routines, and reduce parents' levels of frustration.

2.6 Persuasive Technologies for Children

Persuasive technologies are the means through which behaviour change and habit formation will be delivered. It is important to understand what their role is in HCI as well as to see how they have been applied for children. Fogg is a pioneer within the HCI community as he was the first to study computers as persuasive technologies that can stimulate or discourage behaviours. This phenomenon is also called 'captology' [24]. Persuasive technologies are advantageous in the sense that they will reinforce the willingness to change behaviours. Persuasive technologies for wellbeing are also beneficial as the long-term goal is to improve health and prevent disease [31].

Pollak et al. [44] demonstrated advantages of persuasive technology for children's health with "Time To Eat", a mobile game that encouraged children to eat healthier by giving them rewards to evolve and raise their virtual pet every time they would eat something healthy. The persuasive element was the relationship built by the game between the child and the pet in order to increase the desire to eat healthy. They have also found that children were showing emotional attachment to their pet, which is key in motivating kids to change their behaviours. Pollak et al. [44] argued that emotional attachment would be faster and easier if the new technology is implemented to something children already have and know. It should be noted that no intervention from parents was required.

Another persuasive technology, Papelucho [39], was created for children between 8 and 11 years old to motivate them improve their reading and writing skills. Papelucho gives indication on how to use three principles of captology to keep children motivated in achieving goals. The first principle is similarity, for the children to identify with the technology and trust it rapidly, Papelucho has the same age range and nationality as them. The second one is tailoring, in the case of Papelucho, language is tailored to the children so they can pay more attention. The last principle is credibility; Papelucho has been around for fifty years which gave it enough time to build its credibility in the eyes of children. Lucero et al.'s [39] research results show the importance of integrating those three principles from captology when designing persuasive technologies to achieve motivation in children.

3. METHODOLOGY

This section will give an overview of the different methods used in this thesis as well as justify why they were chosen.

3.1 Choice of Participants

Kelder et al.'s [32] study concluded that to effectively implement a behaviour change in the long-term, the habit should be implemented before the child is 12, which is before behavioural patterns become resistant to change. Children usually stop napping between 3 and 4 [23]. The transition from napping to not napping anymore can also be at the origin of some sleep disorders. This study has been approved by the UCL Research Ethics Committee as Project ID Number: UCLIC/3923/002 to work with children from 4 years old onwards. For all the reasons cited above, the researcher has chosen to focus on children aged between 4 and 10.

3.2 Semi-Structured Interviews

Semi-structured interviews were used to conduct the first study with parents and the second study with paediatric sleep experts. The purpose of the first study was to find out what kind of sleep disorders participants' children are experiencing, what solutions they have adopted to cater for those disorders and what their thoughts were on sleep technology and technology in general for their children. When interviewing paediatric sleep experts, we aimed at better understanding what were current treatments and their limitations as well as their thoughts on sleep technology to support healthy sleep behaviours in children. Semi-structured interviews were considered as the best technique for this exploratory work as they will allow the topic to be explored in detail, help to understand situations that were never experienced by the researcher as well as understand different perspectives [11, 50]. Some questions were pre planned to guide the conversation to then prompt participants in getting more information [7]. The researcher was careful to not introduce any bias when prompting participants [46].

3.3 Participatory Design Workshop

A participatory design workshop was chosen as a method for study 3 to uncover unexplored directions as well as widen the possibilities for design (functionality and aesthetics) for technologies to support healthy sleep behaviours in children. Parents and children were considered as informants. This means that they helped the researcher discover things rather than confirm what the researcher already knew [53].

Projective expression was chosen as a technique for the first exercise of the workshop because it would allow participants to express their tacit (needs they are aware of but cannot express with words) and latent needs (subconscious needs) [59]. Images and words were given to participants and they needed to answer specific questions from the researcher by doing collages (see Images 2 to 11). Stappers & Sanders [55] have defined collaging as a great technique for prompting memories and emotional responses, which is useful in an early generative session. Visual stimuli are also considered a good technique to obtain participants' tacit and latent needs on a certain topic [51]. Those scenarios highlighted three main sleep

problems that have been discussed in Section 2 and studies 1 and 2: bedtime resistance, delayed sleep onset and night wakings. Collages helped getting a genuine account of parents and children’s needs and feelings regarding sleep. Children, especially at a young age, might have limited vocabulary and conceptions of needs and feelings. Soliciting simple imaged answers from simple questions such as: “what makes you happy?” was considered the most appropriate technique.

In the second exercise, the technique of flowchart mapping with post-it notes was used with parents to draw out patterns from requirements found in studies 1 and 2. This technique enabled participants to represent their ideas and unmet needs [59].

Drawing was chosen as a technique in the third exercise because children might better elucidate their ideas through them rather than through their limited writing and verbal skills [29].

3.4 Thematic Analysis

Thematic analysis was used to identify and generate key themes from studies 1 and 2. The analysis followed Braun & Clarke’s six-stages of analysis [10]:

1. Familiarising with data, especially when transcribing and reading the transcriptions;
2. Generating initial codes, which means coding the whole data set;
3. Searching for themes, by regrouping codes into potential themes, making sure the data is relevant to the theme;
4. Reviewing themes and mapping the analysis.
5. Defining and naming themes, refining definitions and names for each themes and subthemes;
6. Producing the report, which can be seen in Section IV and V under findings.

QCAmap [3] is the software that was used for the coding of the data and creation of themes. An inductive approach was used, which means that coding of the data set was used to identify patterns to then build a theory; even though, it does not mean that the researcher did not use existing theory to formulate the research questions that are investigated [52].

3.5 Workshop Analysis

The researcher followed Visser et al.’s [59] three-phase structure for data analysis of the workshops:

1. “Fixate on the data”: the researcher got familiar with the data by being present and writing everything down during the sessions, and by transcribing the recordings made;
2. “Search and be surprised”: the data set was searched for interesting, unexpected and novel findings;
3. “Find patterns and create an overall view”: comparisons between findings from both

workshops allowed to draw patterns for functional and design requirements.

4. STUDY 1: PARENTS INTERVIEWS

4.1 Methods

4.1.1 Participants

Seven out of eighteen respondents were recruited on social media (Facebook and Twitter). The researcher designed a screener that was communicated through Google Forms (see Appendix 1) to make sure the right participants were recruited. The main criteria was to have a child aged between 4 and 10, which corresponds to age range defined for this study. Table 3 provides details about each participant regarding gender, age, number of children and age of the children. The participating parents were between 27 and 41 years old (mean = 34.1), and their children were between 3.5 and 9.5 years old (mean = 5.2). They were from various countries: UK, Australia, New Zealand, Brazil and France. Informed consent and information sheets (see Appendices 2 & 3) were drafted and distributed to participants before the beginning of each session to be signed. There were no vulnerable participants (all parents were under the age of 18 and there was not any disabled participant). Privacy and confidentiality were maintained by referring to participants as P1, P2, P3, etc. A summary of the results will be sent to participants. A £10 incentive was initially planned for each participant for a maximum of one hour of their time.

<i>Participant ID</i>	<i>Gender</i>	<i>Age</i>	<i>Number of children</i>	<i>Child age</i>
<i>P1</i>	Female	28	1	- 4.5
<i>P2</i>	Female	35	2	- 9.5 - 7
<i>P3</i>	Male	38	1	- 4
<i>P4</i>	Female	27	1	- 3.5
<i>P5</i>	Female	41	2	- 7 - 4
<i>P6</i>	Male	32	1	- 4
<i>P7</i>	Female	38	2	- 3.5

Table 3. Participants for study 1.

4.1.2 Design/Materials

The interviews were semi-structured. Ahead of the sessions, an interview script was drafted with a specific set of questions to direct the conversation (see Appendix 4). During the sessions, the interview script was used to follow steps in order. Although, unplanned and prompting questions came as needed during the conversation.

Interviews were conducted remotely by using Skype and on the researcher’s laptop: MacBook pro Retina 13” with the OS X El Capitan software.

An instruction sheet was used to make sure no important information was forgotten.

Sessions were recorded with the use of a recording application on an iPhone 5S. Participants were aware that they were recorded and agreed with it by signing the consent form. A notebook was used to take notes in case the recorder would fail.

4.1.3 Procedure

Participants were contacted via email to organise a day and time. To accommodate everyone's availability the interviews were spread over one month. The informed consent and information sheet were sent one day before the interview with a reminder and confirmation email giving the Skype username. Before the interview started, the researcher looked back to the screener to note down what sleep issue(s) the child was having, level of frustration of the parent and what technologies were in use at home to orientate questions according to this information.

Once the Skype call started the participant was asked for oral confirmation to record the session with the recording application. Questions from the script were asked and prompting questions came as needed according to what the participant was saying. Once all questions were answered, the participant was asked if there was anything else relevant regarding their child's sleep that they did not mention or something they thought was important to mention. This technique was used to make sure all valuable data was mentioned. While the participants were talking, notes were taken in case the recorder would fail, this was also to facilitate later coding in data analysis.

At the end of the session none of the participants wanted the incentive instead they wanted to be sent the results of the project when ready. After each interview, a thank you email was sent to participants while confirming that they would get a summary of the results in September.

4.2 Findings

Five main key themes were identified through thematic analysis [10], as stated in Section 3:

1. Encountered behavioural sleep disorders
2. Sleep environment
3. Solutions adopted by parents
4. Sleep hygiene
5. Children and technology

4.2.1 Encountered Behavioural Sleep Disorders

All participants had children with sleeping disorders as it was a criterion in the recruiting screener. Two types of behavioural sleep disorders came out from the interviews. This theme aligns with the literature's statement that bedtime resistance, delayed sleep onset and night wakings are the most common sleep disorders in children. This finding is important as it shows what issues future sleep technologies can solve.

Difficulties to go to bed

When talking about difficulties to go to bed, it was observed that the most cited issue relates to the limit-setting disorder. P1 and P4's children have a tendency to call for their parents to come back various times after being put to bed. P4 mentioned that her child will continuously call her to ask for more stories, water or toys that are not in her bed. If they start ignoring them, the children will get upset. P7 justified with separation anxiety the fact that her twins cannot fall asleep without her presence, as it occurred around the same time she went back to work, "*But now I think it has to do with me going back to work, they've taken a step back and they don't allow, their father used to be able to put them to bed and just close the door but they don't allow their father to do that anymore. We actually have to stay with them until they fall asleep*" (P7). P2's children sleep in the same room and in the same bed and they will talk to each other past bedtime which is something that their mother would like to control more.

P3's child will be troublesome to put to sleep if she goes to bed after 9pm, it happens when parents are coming home later than usual from work, which means that the bedtime routine is delayed. In that case they will need to lay down with her until she falls asleep, "*There's a few times when it took her one hour to get to sleep, but it's rare. Usually that happens when she goes to bed after 9 because normally she goes to bed between 7 and 7:30*" (P3). This shows how inadequate sleep hygiene can negatively impact a child's sleep pattern.

An implication for technology in this situation would be to motivate the child to go to bed and to fall asleep independently. The technology could also educate parents on how to set limits to the child without upsetting the child.

Night Wakings

Participants with children between 3.5 and 4.5 years old were the ones observing frequent night waking (66.7% of the total of children). P2 has children aged 7 and 9.5 and mentioned that when they were younger, around 5 years old, they used to frequently wake up at night, "*I can relate to when they were younger, about 5 years of age, then my sleep wasn't that good because they were young and they kept on disturbing me and woke up normally many times in the middle of the night*" (P2).

Other parents stated that when their children wake up during the night they will go to their beds and sleep with them until morning (P3).

Reassurance was mentioned as a factor for children wanting to sleep with their parents, "*She has been doing that since we got back from England, it was a radical change, we had to come back because my mother got seriously ill and a lot happened, so I think she needed reassurance*" (P4). "*I think she needs company; she needs to see someone when she opens her eyes in the middle of the night*" (P2).

We can assume that the issues mentioned above pertain to sleep-onset association disorder. In the previous subtheme it

was found that most participants stay with their children until falling asleep, since this is the context they go to bed in, when they wake up in the middle of the night they will then typically look for their parents. In this case, technology could take the form of a companion offering them reassurance so they are able to self-soothe when waking in the middle of the night.

4.2.2 Sleep Environment

Elements of the sleep environment were mentioned either as help to cater for or as factors of behavioural sleep disorders. Below is an account of those elements.

White Noise

Five out of seven participants said that they use white noise to cancel out other noises and relax the child to ease the transition to sleep. One participant has been using the sound of a waterfall since her children were babies and they now recognise it as the signal that it is time to go to sleep, *“...it’s also a sound that they’ve known since they were really young. The sound of water. And it does calm them and it is their cue to go to sleep”* (P7). We can see that white noise became a habit for her children as it automatically triggers sleep when they hear the white noise. The white noise will not be left on during the whole night but only for a certain period of time from when the child goes to bed. In general, the pattern in the sound of white noise will help children relax and fall asleep faster. Also it will allow parents to talk, watch TV or do activities that require some noise without disturbing their child’s sleep.

Light

Most participants talked about the fact that their children were afraid of the dark and thus had a night light in the bedroom, a star projector light or would simply leave the light on in the corridor until the child falls asleep. The presence of light has been indicated as an element of reassurance for the children, *“...little projector that shines stars onto the ceiling, she likes it and sometimes complains that it’s too dark still. So I might leave the lights on in another room”* (P3). Some participants mentioned that darkness could be a reason why their child goes to their bed when they wake up in the middle of the night as they will feel alone and scared in the darkness of their bedroom.

Parental Presence

As mentioned in the previous theme, children need the presence of their parents for reassurance. It should be noted that none of the parents mentioned the presence of their children’s favourite toys as something that reassures them when they wake up alone in their bedroom. In addition, P5 pointed out that even if her daughter sleeps with her older brother in the same room, she will still come to her parents’ bedroom when waking up in the middle of the night.

From these findings it can be stated that to help children become more independent in controlling their sleep, white noise, light and presence of a reassuring element should be included in the bedroom environment. These three elements

can also be covered by sleep technologies for children. More details and discussion on how they could be incorporated can be found in Section 7.

4.2.3 Solutions Adopted by Parents

None of the interviewed participants have sought for professional help regarding their children’s behavioural sleep disorders. Reasons for that are they do not think that their children are in such a bad situation that they would need professional help. Instead, they are trying to find “homemade” solutions that come naturally to them or that might have been recommended by family members or friends.

Co-Sleeping

Participants who have more than one child (P2, P5 and P7) have all adopted co-sleeping settings to try to cater for bedtime resistance and night waking issues.

Both P2 and P5 have decided to put their children in the same bedroom/bed for the youngest ones to feel reassured by the presence of the older sibling, especially when waking up during the night. P2 changed the setting from bunk beds to a double bed, *“Then I realised she might be a bit scared or she wants some company so I changed the beds from bunk bed to a normal double bed”* (P2), while P5 went from separate bedrooms to the same bedroom with bunk beds but it did not work as her youngest still goes to the parents’ bed when waking in the night, *“We moved them because I thought it might help the younger one, that she would feel less alone at night, but it didn’t make any difference at all”* (P5). Co-sleeping did not work as a solution for P2 either since that she recognised because her children sleep in the same bed, they tend to talk to each other more which delays their bedtime. P7 has young twins (3.5) and has adopted co-sleeping with parents and children in the same bed. *“We all sleep together at the moment because it’s the only way I can manage the night waking because I work full time as well”* (P7).

For other participants, co-sleeping only happens after the child wakes up in the night and comes to the parents’ bedroom where he or she will stay until morning. Participants said they would not bother carrying their children back to their bedroom by fear of waking them up again and starting a negative spiral.

Those findings, once again, highlight and reinforce the need of parental presence for children in the prevalence of sleep-onset disorder. An issue on which future technologies should primarily focus on, by educating parents on appropriate techniques and by giving reassurance to the child to allow self-soothing.

“Cry-It-Out”

To let a child “cry-it-out” or as formally known, the extinction technique, was only mentioned by one participant. P4 uses that technique when she is tired and frustrated after trying repeatedly to put the child to sleep and encountering strong resistance from the child. *“She will*

start yelling, crying and I would leave her just like that. I will wait for her to calm down. I am more patient than my partner as he will rush to her bedroom if he hears crying". It should be noted that P4 is applying that technique unconsciously as it was not recommended by a specialist to her. This emphasises the levels of frustration parents can get from their child's bedtime resistance.

"Outgrowing" Sleeping Disorders

Most participants with younger children think that their child will "outgrow" being difficult to fall asleep or waking in the middle of the night. Which is also one of the reason why they will not seek for professional help as they think that it will change with their child becoming older.

One participant who has older children (P2) has attributed the fact that they do not wake up at night anymore to that: *"They grew out of it. Because they are older they can have a long sleep without being disturbed"* (P2).

It has also been cited as the most common advice from family members as well as friends, *"I just talk to my family and my family members all say that this is something that you know as the children get older they will outgrow it. Sometimes I think it's age-related"* (P7).

Some parents will look for answers on forums or existing online discussions that will have the same advice, *"Sometimes I look at forum discussions, but mostly it says that it will pass, she will grow out of it"* (P1).

This shows a lack of awareness from parents regarding solutions to their child's sleep disorders. In this case, technology could replace the belief that the child will "outgrow" sleep disorders by raising parents' awareness of existing solutions.

4.2.4 Sleep Hygiene

Bedtime Routine

All participants follow a bedtime routine for their children, which is an essential part for a good sleep hygiene as seen in Section 2. Stages have been the same for all:

1. Dinner;
2. Shower or bath;
3. Get in pyjamas;
4. Brushing teeth;
5. Story time (maximum of 2);
6. Kiss good night;
7. Lights off.

Usually, the bedtime routine will be respected and accepted by most children until stage 6 where some of them will start crying and calling their parents to come back to the room (P1, P3, P4, P6, P7). P2 described the bedtime routine of her daughters as being very slow and delaying the time they should fall asleep, *"They are giving me some trouble. They are taking time to do everything, even brushing teeth."* This might be happening because of the lack of a set bedtime, which is also a basic for good sleep hygiene.

An implication for technology here would be to educate parents and children on implementing and sticking to an appropriate bedtime routine to prevent sleep disorders.

Sleeping Times

Some participants thought that their children were falling asleep later than they should and that it happened because of their reluctance to fall asleep, *"By 8pm he should be sleeping like his sister, but it looks like he is not tired and I don't know why"* (P5). During weekends the bedtime routine changes and parents are more flexible with the time children should go to sleep, which brings issues when starting the school week again: children go to bed later and thus are difficult to wake up earlier on Monday morning, *"The bedtime routine changes over the weekend, they go to bed quite late because they wake up later also, one hour late. It affects Monday mornings, it's always difficult to wake them up on Monday. Even if I try to put them to bed early on Sunday night they're still a bit lazy"* (P2).

In this situation, technology could help create a sort of contract between parents and children for a set bedtime that would also be kept consistent during the weekend.

4.2.5 Children and Technology

Regarding participants and their opinions towards the use of technology by children an interesting pattern emerged from the findings: participants working in the Information Technology (IT) industry seemed to be more open to have their children use technology compared to participants not working in the IT industry.

Technology Use in the Context of Sleep

When P5's eldest child does not want to go to sleep she allows him to play on the iPad or watch TV. She is not happy with that solution and would like to find a healthier solution than screen time. P5 also used "Gro-Clock" (a sleep trainer alarm clock) [57] when her son was younger, but she said that it did not work and she did not use it in the long-term. However, she suggested that audiobooks might help, *"...I have wondered whether if I put on some sort of audiobook and he can listen to that, then it might be more relaxing than reading"* (P5).

These findings allow the identification of various applications of technology for the benefit of sleep, such as screen time being an issue, the non-adherence to a sleep technology designed for children as well as new suggestions.

Control of Technology Use

Being able to control their children's use of technology is one of the main concerns amongst participants, *"So I think it's good but it needs control. Kids absorb easily games, interactions, and all information that's surrounding them and we need to take care of that. We need to moderate. Use technology with moderation."* (P6).

Every participant mentioned that controlling the amount of time and type of technology their children use is essential.

Their main fear is that the children will isolate themselves and become addicted to technology and will not learn social norms properly. *“...when the kids come home they’re always watching TV, playing on screens, in the morning and in the evening and then we’ve noticed the children screaming very often, and being impolite on occasions and parents tell us they have problems with the children”* (P3).

Another participant said that she had to stop allowing her child to use a children’s tablet because she would get quite upset as soon as they would remove it from her (P4).

This means that allowing parents to control the device and technology that support their children’s sleep as well as the amount of time they spend with it would be an important factor.

Moments of Technology Use

All participants were against children using technology after stage 1 (dinner) of the bedtime routine considering it was not appropriate, *“They use it when they come home from school until tea time at 6-ish, but once dinner is over no, because it is time to get ready for bed”* (P5). This finding helps understand in what context sleep technology for children would be most likely used. Reasons on why they are against allowing their children technology in bed can be found below in the last subtheme.

Educational Technology

When participants let children play games on tablets or phones, they want to make sure that what they are doing is educational so it will add benefits to their development, *“I try to make her play games that are a little bit more educational. With numbers or whatever, puzzle games, trying a bit of thinking rather than just looking at a screen”* (P3). This finding indicates that parents need to be reassured by knowing that their child is using technology for their own benefits in terms of brain development.

Opinion on Children, Sleep and Technology

Most parents were against the idea of letting their child use a phone or a tablet in bed. The blue light was brought up as an element that would stimulate the child’s brain when they should be relaxing, *“I would be really against giving her a device if she is in bed. I noticed when my wife uses her phone when she goes to bed and takes ages to go to sleep, I think it is because of the light of the screen, it keeps her awake, whereas I rarely touch my phone and go easily to sleep”* (P3).

Another participant mentioned that the device was not the issue but the activity was, depending if it is relaxing or stimulating, *“The least relaxing in devices, I think it has to do with the activity on the device rather than the device itself”* (P5).

Health consequences were brought up by a participant who stated that it would damage her children’s eyesight to have a device with a screen in bed, (P2).

In general, having a device in bed was considered as a negative thing that would rather create the opposite effect of what parents are trying to accomplish through the bedtime routine, *“It is bad to use tech in bed. Tech has a lot of interactions and it is too stimulating. Before going to bed they can’t be stimulated. The bedtime routine is supposed to create an atmosphere to prepare the child to sleep”* (P6). *“You know they talk about how when they overstimulate them they can’t rest and they can’t sleep. For children like ours that would be really a big worry. Because it overstimulates them and it has a negative effect”* (P7).

What can be concluded from these findings is that parents believe that the blue light from the device’s screen and the activity executed on it are elements that would stimulate their children instead of relaxing them at bedtime. These are important elements to take into account when thinking of designing sleep technologies for children.

8. STUDY 2: PAEDIATRIC EXPERTS INTERVIEWS

5.1 Methods

5.1.1 Participants

Six paediatric experts on children sleep disorders were contacted and recruited through a web search on Google and exchange of emails. The researcher looked for children sleep disorder specialists in the UK and found the contacts of E1, E2 and E3 who were then reached out to by email. E4 was recommended by E3 and was contacted by email. E4 helped recruiting more participants by contacting fellow professionals and tweeting regarding the need for participants for this research. This is how E5 and E6 were recruited. Table 4 provides details about each participant regarding gender, specialty and place of work. The participants were based in London and Edinburgh. Informed consent and information sheets (see Appendices 2 & 3) were drafted and brought on the day of the interview and distributed prior to the beginning of each session to be read and sign. Privacy and confidentiality were maintained by mentioning participants as E1, E2, E3, etc. A summary of the results will be sent to participants to maintain trust and for their own interest.

Participant ID	Gender	Specialty
<i>E1</i>	Male	Consultant in Paediatric Respiratory Medicine at Royal Brompton Hospital
<i>E2</i>	Female	Physiologist at Evelina London Children’s Hospital Sleep Centre

E3	Male	Principal Clinical Physiologist at Evelina London Children's Hospital Sleep Centre
E4	Male	Sleep Counselling Coordinator at SleepScotland
E5	Female	Clinical Psychologist
E6	Male	Neurology Social Worker at SleepScotland

Table 4. Participants for study 2.

5.1.2 Design/Materials

The interviews were semi-structured. Ahead of the sessions, an interview script was drafted with a specific set of questions to direct the conversation (see Appendix 5). During the sessions, the interview script was used to follow steps in order. Although, unplanned and prompting questions came as needed during the conversation.

Interviews with E1, E2 and E3 were conducted in-person at their place of work. Sessions were recorded with the use of a recording application on an iPhone 5S.

Interviews with E4, E5 and E6 were conducted on the phone with the interlocutor being on speaker for the purpose of recording with QuickTime Player from the laptop.

In all interviews, notes were taken on a notebook in case the recorder would fail.

5.1.3 Procedure

Before beginning each interview, the researcher made sure that questions from the interview script were adapted to the role and functions of the participant. The purpose of the study was explained and room was left for eventual questions. Once all questions had been answered participants were asked if there was anything they wanted to add that they felt would be important to highlight for the research or that was not mentioned to ensure all important data was gathered.

Questions were sent beforehand to E4 after his request to prepare answers for the interview. The interview script was not sent beforehand of the interviews to the rest of the participants.

All participants were interested in receiving the results of the research. After each interview a thank you email was send while confirming that they would get the results in September.

5.2 Findings

Before presenting the results of the second study, it should be reminded that this paper focuses on behavioural sleep issues rather than medical ones. Three of six participants in the second study are specialised in paediatric respiratory medicine, thus their knowledge is more extended to medical sleep disorders rather than behavioural ones, although thanks to their training and experience they were able to comment and give insights on behavioural sleep disorders. Four main themes emerged from the thematic analysis [10] done on the dataset and are accounted for below:

1. Causes for behavioural sleep disorders
2. Treatments for behavioural sleep disorders
3. Paediatric expert opinion on technology for sleep
4. Consequences of behavioural sleep disorders

5.2.1 Causes for Behavioural Sleep Disorders

This paragraph will relate causes for behavioural sleep disorders that were stated by paediatric experts in the interviews as well as act as support to the theory affirmed in Section 2.

Poor Sleep Hygiene

A poor sleep hygiene translated by an inconsistent bedtime routine has been defined by paediatric experts as a primary cause for behavioural sleep disorders.

"We have a lot of children who have bedtimes where they just fall asleep on the floor or 2 years old coming in and their parents say their time is at 11pm and these are the ongoing issues" (E3).

"Lack of a consistent bedtime routine and stimulating activities prior to bedtime are usually at the origin of sleep issues" (E5).

Separation Anxiety

Quite often sleep-onset association disorder is caused by separation anxiety coming from the child. Interestingly this was also mentioned by one of the participants in the first study. Separation anxiety means that the child will feel stressed and anxious when being kept away from his parents. When parents leave the bedroom, stress hormones will start to increase and as a consequence the sleep hormone, melatonin, will decrease and the child will have troubles falling asleep and might cry. If this situation happens repeatedly then the child will start associating bedtime with being alone, stressed and anxious, *"It becomes almost a vicious circle, mum says time to go to bed, the child's stress goes to the roof and the child won't go to bed because the melatonin is low because of stress and then the child will just lie in bed awake and will begin to associate bed as a bad place"* (E4).

E6 highlighted that parents are also likely to experience separation anxiety which would then be felt by the child and it might enhance anxiety for both parties.

Implications for technology in this case would be to try to break the vicious circle of anxiety by reassuring children as

well as motivating them to become more independent in their sleep patterns.

Sleep Environment

Co-sleeping with siblings has been identified by E3 as not ideal because children might have a different bedtime routine or because of their age difference one sibling might need less sleep than the other. This gap can disorientate one sibling's routine and might develop sleep disorders.

“The main thing about bedroom environment is that it should only be for sleeping, if they have all their toys in the bedroom they will associate it with playing and it might be difficult to get them to sleep in this environment, they are not making the association between bedroom and sleep” (E4). The bedroom should be arranged and used in a way where the child only associates it with sleep.

Findings in the first study indicate that a lot of parents actually use co-sleeping as a technique to treat their children's sleep disorder, but in this study it has been suggested by experts that it is actually a cause.

One of sleep technologies' aim could also be to better inform parents on appropriate techniques to cater for behavioural sleep disorders.

5.2.2 Treatments to Behavioural Sleep Disorders

Behavioural and pharmacological treatments mentioned by paediatric experts during the interviews support a strong link between practice and theory (see Section 2).

Behavioural Treatments

Graded exit: this technique is to help cater for sleep onset association disorder. In order to not stress the child, one of the parents will sit on a chair in the bedroom until the child falls asleep. Every night the parent will move the chair closer and closer to the door until it is not in the bedroom anymore and the absence of the parents does not cause stress to the child. The child will then be able to go to sleep without associating it with stress and if he wakes up during the night he would not be looking for his parents and will fall back asleep easily. This technique is closely related to “extinction with parental presence”.

Robotic voice: when the child comes to the parents' bedroom in the middle of the night, parents will have to adopt a robotic voice, stop the child from going into their bed and redirect the child to the bedroom by repeating with a robotic voice “time for bed”. E4 recommends to do this every time the child tries to go to the parents' bed even if it is several times during the night “*Parents should not give in or it might get a lot worse*” (E4).

When it is bedtime, parents should stick to this robotic voice so children understand bedtime is different from daytime, “*It's almost a good cop/bad cop situation*” (E4). Children will scream and cry at the beginning as they are not used to it but if parents keep consistent with this voice for 2-3 weeks the results will be there. This technique can help with “limit-setting” disorders.

Reinforcement: it is important to praise children on their progress with getting better at sleep by giving them rewards, “*A lot of parents use sticker charts so the child will get stickers as they go on and if they get ten stickers they get a prize, this will motivate them to continue with the new routine*” (E4). This will reinforce positive behaviours. “*Set a sleep program that involves the child with a reward system is a technique that I give parents to help them change their child's sleep behaviour*” (E6). This is linked to the positive reinforcement treatment seen in Section 2. Sonne et al. [54] also used positive reinforcement in the design of the MOBERO app for children with ADHD, which was valued by both parents and children, however it seemed that children preferred physical rewards rather than virtual ones.

Cognitive Behavioural Therapy: The objective is to change a behavioural pattern, which is the way people react to things, it is almost like conditioning. You change the behaviour by changing the pattern. “*If the child is seeking parents' attention at bedtime what we try to do is to get parents to redirect the times when they give the child attention so that it is not when it is time to go to bed*” (E6). “*A child knows that if they call out from their bed in the evening mum will come, we are trying to change that pattern, so every time the child calls out mom doesn't come and they accept it*” (E4). This is an important finding as it links directly to behaviour change and habit formation theories previously stated in Section 2, which will be the purpose of future sleep technologies for children.

Consistent bedtime routine: it has been acknowledged in theory and in practice that a poor sleep hygiene is one of the causes of sleep disorders in children. Participants gave some of their best recommendations on how to implement a consistent and healthy bedtime routine as they all agreed on the fact that there is no standard routine. The ideal would be to have dinner two hours before going to bed. Followed by relaxing activities such as drawing or reading, even playing Legos. One hour prior to bedtime the child should take a bath and not a shower “*... because in a shower the water splashes on the nerves. A hot bath will help raise the body temperature very high and as soon as the child steps out of the bath his body temperature would plummet, mimicking what body does naturally when going to sleep*” (E4). The bath should be followed by brushing teeth. Parents can read a story or talk about what the child did during the day before kissing him good night, turning the lights off and leaving the room. E5 encourages parents to have their children exercise after school to make sure they get tired, and to increase the chance of melatonin release one hour before bedtime. This recommended treatment is also what is called “positive routine” in literature.

The MOBERO app [54] supports and recommends healthy bedtime and morning routines for children with ADHD to trigger self-management of their sleeping patterns.

From the literature reviewed in Section 2 and the findings from the interviews in the first and second studies, it has been established that parents are not aware of the existing techniques and treatments, which gives an opportunity for technology to step in as a complement to raise awareness and fasten recovery from sleep disorders.

Pharmacological Treatments

Melatonin has been cited by four participants as a sleep enhancer and a medication that would be prescribed to support behavioural therapies, it is considered a short-term solution, which confirms theory's statement that medical solutions should be temporary. Usually it is given to children who have severe delayed sleep onset, "We may give medication such as melatonin or a sort of sleep enhancing drug to help get them off to sleep and maintain sleep" (E3). "You can be prescribed melatonin, as a way of improving your sleep patterns, as a temporary measure" (E1).

5.2.3 Paediatric Expert Opinion on Technology for Sleep Existing Technology for Children Sleep

Some participants mentioned existing technologies that support sleep in children. Suzy Snooze (see Image 1) [4], was developed by a paediatric expert. It comprises a relaxing night light that will help increase the child's melatonin and at the same time records the child and sends the recordings to the parents' mobile phone. It also helps keep the child in bed: when the object's "hat" comes up it means the child is allowed to get out of bed otherwise it means that he needs to stay in bed and go back to sleep. It mostly helps with sleep-onset association disorder and participants were seduced by it because it does not have a screen.



Image 1. The Suzy Snooze device.

Challenges of Using Technology to Support Healthy Sleep Behaviours

The blue light that comes from the screen of any device was mentioned by participants as the most negative aspect of technology when it comes to sleep.

The blue light will suppress melatonin and confuse circadian rhythms as it mimics daylight. Because it prevents sleep from happening, participants recommend their patients to get technology out of the bedroom especially in the last hour before bedtime.

"Screen time is an issue that we face with almost every single child that comes through our service" (E5). This is a very important finding that supports theory as well as findings in the first study. The issue of blue light has to be considered when designing sleep technologies.

5.2.4 Consequences of Behavioural Sleep Disorders Consequences on Children

E4 used the model of reciprocal relation [33] to explain a vicious circle that happens as a consequence of poor sleep in children. If a child does not sleep well at night, the next day behaviour issues will probably be experienced, the child might act out and feel more stressed than usual. Behaviour issues at school will cause poor performances which means poor grades. The child will come home with poor grades that will cause family stress which will then prevent the child from sleeping, "It becomes a circular causality eventually" (E4).

One consequence of poor sleep that a lot of parents ignore is the appearance of lack of confidence in children. It has been observed by specialists that children with sleep disorders will most likely take fewer risks than others, "If they are not used to taking risks they can become young adults that are too frightened to step outside of their comfort zone" (E6). This shows how sleep disorders can have later consequences in adulthood.

Consequences on Parents

E4 mentioned that the model of reciprocal relation [33] also applies to parents. Parents will feel fatigue and stress because they will not be sleeping properly either. This will generate stress and arguments between parents. The child assisting to the arguments will be stressed by it and the vicious circle of poor sleep begins again.

It is important to understand consequences of poor sleep on children as well as on their families as they are the problem sleep technologies will try to solve or prevent.

6 STUDY 3: PARTICIPATORY DESIGN WORKSHOP

6.1 Methods

6.1.1 Participants

Two workshops were conducted with two families (see Table 5). In the first workshop the family consisted of a mother and her two children: a 7-year-old boy and a 4-year-old girl. In the second workshop, both parents were present

with their two daughters (9.5 and 7). Both families (parents) had taken part in the first study (parents interviews) and were selected to participate in the workshop as both families were located in London (physical location of the study). Informed consent and information sheets (see Appendices 2 & 3) were drafted by the researcher and distributed to participants prior to the beginning of each session. Privacy and confidentiality were maintained by describing new participants as F1, F2, F3, etc. Participants who already took part in the first study were identified with their given participant ID from that study. A summary of the results will be sent to participants to maintain trust and for their own interest. A £40 Amazon voucher was given to each family to compensate for their time.

<i>Participant ID</i>	<i>Gender</i>	<i>Age</i>	<i>Workshop ID</i>
<i>P5</i>	Female (Mother)	41	1
<i>F2</i>	Male	7	1
<i>F3</i>	Female	4	1
<i>P2</i>	Female (Mother)	35	2
<i>F5</i>	Male (Father)	42	2
<i>F6</i>	Female	9.5	2
<i>F7</i>	Female	7	2

Table 5. Participants for study 3.

6.1.2 Design

Three exercises formed the main body of the workshops. Parents and children were separated into two different groups; thus an assistant was needed to facilitate the sessions. Below is a detailed description of each exercise.

Exercise 1: Projective Expression

We have discussed in Section 3 what projective expression is and why it was chosen. 150 words and images were randomly chosen and printed for this exercise. Both groups had the same images and words to choose from. Participants were then asked to answer questions by doing collages of images and words that would best represent their answers. They were also asked to think-aloud and explain to facilitators their choices. Questions were representative of current and ideal situations, however they differed according to the group. The comparison between a current and ideal situation is important in that it will best reveal tacit and latent needs [51].

Example of questions asked to parents:

- How do you currently feel when your child does not want to go to sleep?

- How do you feel when your child goes to bed without fuss?

Example of questions asked to children:

- How do you feel when you wake up in the middle of the night?
- What would you like to see around you when you wake up in the middle of the night?

A full list of questions can be accessed in Appendix 6.

Exercise 2 (parents): Classification of functional requirements

In this exercise parents were responsible for classifying functional requirements. Requirements were written on post-it notes ahead of the sessions. They were chosen according to findings from the first and second studies. Participants were then asked to classify those requirements against a positive, neutral and negative categorisation. Facilitators told them that they could modify post-it notes if needed or add new requirements that were not in the initial list. This was made to ensure the expression of all explicit needs [59].

Sample of requirements (a full list of requirements can be accessed in Appendix 7):

- Mobile app
- Website
- Digital games
- Physical device without a screen
- Self soothing device for children
- Parents' help needed
- Music

Exercise 3 (children): Gathering of design requirements

Children were given 3 scenarios on which to draw. The first scenario was for them to imagine an object that would motivate them to go to sleep and help them fall asleep quickly. In the second scenario the facilitator asked them to draw interaction that would happen between the child and the object. In the last scenario they were asked to draw how the object would interact if they woke up in the middle of the night and they were not able to call for their parents or go to their parents' bedroom.

After each exercise children were asked to "show and tell" their parents what they have done previously. Parents were not asked to do that because some answers to questions in exercise 1 might have made them feel uncomfortable and the researcher thought that it might be boring for children to hear about functional requirements.

In Table 6 you will find an account of the workshop with allocated timeslots and specified activities.

Duration	Activity
5 minutes	Welcome presentation
10 minutes	Warm-up/Ice breaker

20 minutes	<u>Exercise 1: Projective Expression</u>
15 minutes	Exercise 1 “show & tell” for children
10 minutes	Break
20 minutes	<u>Exercise 2 (parents):</u> Classification of functional requirements <u>Exercise 3 (children):</u> Gathering of design requirements
15 minutes	Exercise 3 “show & tell” for children
5 minutes	Wrap up

Table 6. Outline of the flow of the workshops.

6.1.3 Materials

A room was booked in advance on UCL Campus. The room was needed for two hours, even though the workshop was planned to last one hour and forty minutes. This was made in case the workshop lasted longer than initially planned. The room needed to accommodate at least six people (two facilitators and families of maximum four). Two tables were needed as there were two different groups working on different exercises.

Snacks and drinks were offered as the workshop was long and for breaks. It was also used as a motivator and as an ice-breaker. The researcher asked parents about dietary requirements, food and drinks preferences in advance of the workshop. Snacks and drinks were made available for the whole duration of the workshop.

For the first exercise, 75 images were randomly chosen from a free stock photo website and then printed [5]. 75 words were chosen from a list of positive and negative emotional words [1], and then printed. Since we were asking participants how they felt about something this was considered as the best option by the researcher. Each question of the first exercise was written on an A4 sheet of paper that was then displayed on the tables. Participants were collaging images and words on each pieces of paper.

For the second exercise, functional requirements were written on post-it notes. Participants had access to unused post-it notes as well as sharpies to write down new requirements. The classification occurred on an A1 sheet of paper that was attached to the wall.

In the third exercise, children were given A4 sheets of papers with felt pens and sharpies to complete their drawing tasks.

Stickers were given to children when they finished one task in each exercise to keep them motivated. This initiative was very well received.

An iPad with the CBeebies [6] game downloaded was arranged in case children would get bored or finish before their parents.

The camera of an iPhone 6S was used to record what participants did (collages, drawing, post-it notes). Sessions were recorded with the use of a recording application on an iPhone 6S. Participants were aware that they were recorded and agreed with it by signing the consent form. Notes were also taken on a notebook in case the recorder would fail.

6.1.4 Procedure

One day prior to the workshop, an email was sent to participants to confirm their presence and remind them about the workshop. Directions to go to the location of the workshop were given as well as indications on how to get there. Snacks and drinks were bought the day before the workshop and thirty minutes of preparation was allowed before the arrival of the participants.

Once the participants arrived they were told to help themselves to snacks and drinks followed by a 5-minutes welcome presentation where facilitators would present themselves, explain why they were conducting this workshop as well as an outline of the activities in which they would be involved. Once the presentation was done, the facilitators gave the information sheet and consent form to one of the parents to be read and signed before starting.

A 10-minutes ice-breaker allowed participants and facilitators to talk to each other about random topics in order to make them feel more comfortable. Participants were then asked if they were ready to start the first exercise and facilitators went with their respective groups. Participants were told one more time what their tasks were.

During the first exercise facilitators asked questions to make sure participants were explaining why they would choose a certain image or word to answer a particular question. At the end of the first exercise, the children presented what they did to their parents which prompted more explanations on why they did so. This was helpful when a child was too shy to tell the facilitator why they chose an image or word particularly.

A 10-minutes break was then announced where participants had snacks and drinks and could also talk further to facilitators about the exercise they had just finished.

When starting exercises 2 and 3 the facilitators went with their respective groups and reminded participants of their tasks. Facilitators tried to prompt participants again by asking questions on why they were putting a post-it in the negative column (exercise 2) or what they were drawing exactly (exercise 3). Once the last two exercises were finished, children were asked to show their drawings to their parents and explain to them what they were seeing. This also allowed more data to be collected for this exercise.

The workshop was concluded with a 5-minutes wrap-up where participants were thanked for coming, children also got more stickers and participants were asked if they had more questions regarding the research or what they did during the workshop.

A follow-up email was sent to participants to thank them as well as their incentives.

6.2 Findings

Findings from both workshops were compared against each other. This technique allowed patterns to be identified that are discussed in Section 7. It is important to note that in the first workshop, the children were quite young and the 4-year old (F3) did not feel well that day and thus did not participate much. Also, F3 was always choosing her images after her older brother (F2) had chosen his.

6.2.1 Exercise 1: Projective Expression (children)

Need for Motivation to Go to Bed

Children from both workshops seemed to associate going to bed with happiness, “I chose the jumping people because I’m having lots of joy because I want to go to sleep. I like to go to sleep because I can have a rest from a busy day” (F6). F2 mentioned that he felt confident when going to bed and that “I chose the swimming children because they look happy swimming, I love playing in the pool” (F2).

F7 picked the teddy bear because “it looks sad and sometimes I don’t want to go to bed. Yesterday I didn’t really want to go to sleep and it annoyed me”. But sometimes she said that she feels happy to go to bed which is why she also chose the laughing little girl.

From this scenario we can see that children associate going to bed to happiness and sometimes sadness, thus the importance for the technology to motivate them to go to bed (see Image 2).



Image 2. Scenario 1.

Need for Reassurance and Familiarity

A feeling of reassurance, relaxation and familiarity are what come out of the second scenario (see Image 3). The design of future sleep technologies for children should reflect and enhance those feelings for the child to fall asleep faster and without parental presence.

F2, “I feel like being in space because I like science and I want to learn about space”. He also chose the word

“surprised” because he expressed that he would feel surprised if he was dreaming about being in space.

F3 chose the teddy bear because she feels reassured when going to bed with her toys.

F7 also chose a toy “because it looks happy and sometimes I like going to bed because it feels warm”.

F6 associated the palm trees to calmness because she feels calm and relaxed before falling asleep.



Image 3. Scenario 2.

In the fourth scenario and from both workshops, food emerges as an essential element for children to feel happy. We can also see the re-emergence of pictures that were used in a different scenario by different participants. For example, in this scenario children from the first workshop used palm trees to express their feeling of happiness as it reminds them of their summer holidays, while F6 from the second workshop used the same picture to express the feeling of calmness she experiences before falling asleep. Likeability, reassurance and familiarity are feelings that emerge once again from this scenario (see Image 4).



Image 4. Scenario 4.

When asked about what would make them not feel afraid anymore, children from the first workshop chose images that reflect brighter colours with a dominance of blue and green and that also represent nature.

It is interesting how in the second workshop, F7’s image that would make her feel not afraid anymore is the same image that F2 chose to represent his feeling of sadness. F7 explained her choice by saying, “before it was scary and gloomy but then you find out that sunshine is coming out and then you start to feel happy again because sunshine is coming”. F6 chose the child and the father walking in the sunset as something that inspires her reassurance. F6 justified her choice by saying, “the little girl is with her

dad, it makes me feel not afraid anymore because my dad is there for me all the time”.

Again, we encounter the feeling of reassurance, familiarity and presence of light as a solution to the fear of darkness (see Image 5).



Image 5. Scenario 7.

Ownership and Trust

In the third scenario what is interesting is how the picture with the pony toy came up in both workshops in the same scenario. F3 chose it in the first workshop but did not really give an explanation on why she chose it, while F6 chose it in the second workshop and said that it inspired her trust because the little girl is giving it to someone that she trusts to take care of it. F2 chose the Halloween pumpkins and fireworks because he said that he loves it. The squirrel was chosen by F3 but she gave no particular reason for it.

This shows that children might tend to trust things that they appreciate and own. The feeling of familiarity appears once again and this finding reinforces [39] and [44]’s argument that a persuasive technology will be efficacious in children when it is implemented in something children are already attached to.



Image 6. Scenario 3.

Fear of Darkness and Loneliness

What is interesting in the fifth scenario are the similarities in the colour schemes. Children were asked to choose pictures that represent fear to them and from both workshops the dominant colour schemes are red, like fire, and a dark/gloomy ambiance.

F3 did not explain why she chose the picture of a child with a dad walking in the sunset as something that scares her but in this case we could assume that she chose it because of the colour scheme relating to the image of fire that her brother previously chose.

F7 said that she chose fire because *“it might be so big that you just want to run away from it.”* F6 chose the storm because she defined it as something dangerous and scary that makes you wonder what will happen next.

The dark/gloomy ambience being something scary for children reinforces what was found in the first study where parents said that their children needed some kind of night light to help them sleep otherwise they feel scared in the dark. And that it also might be a reason why children come to their bedroom at night. It highlights the importance for sleep technologies to take the light factor into account.



Image 7. Scenario 5.

The first reaction from participants in the sixth scenario was that none of the pictures made them feel sad but by prompting them a bit to have a better look at the pictures they chose images with colour schemes that remind the colour scheme addressed in the previous scenario: dark/gloomy ambience. F6 said that she chose the boy in the sea because *“it looks like the boy looks sad that he doesn’t know how to surf so it makes me feel sad that he can’t do it”.*

Scenario 5 and scenario 6 are very similar in terms of findings and reinforce the importance of catering for children’s fear of the dark in sleep technologies.



Image 8. Scenario 6.

In the eight scenario, F2 chose words instead of images because he found ones that were expressing exactly how he felt when waking up in the middle of the night, *“I feel a bit annoyed because I can’t go downstairs and play or watch TV. I also feel tired and alone”* (F2).

F3 chose the picture of the fire with the firefighters to represent how she feels when waking up in the middle of the night but did not want to comment it. From the first study, we know that P5 is F3’s mother and that she has

been struggling with her daughter’s night wakings. Once F3 chose the picture F2 agreed that he felt the same.

F6 and F7 chose those images because when they wake up in the middle of the night usually it is dark and cold and they do not feel reassured.

We can observe the choice of the same colour schemes as when they were expressing feelings of sadness and fear. Once again, feelings of reassurance and familiarity come out as being overriding when it comes to children sleep.



Image 9. Scenario 8.

6.2.2 Exercise 1: Projective Expression (parents)

Findings from this exercise showed how important healthy sleep in children is for parents as it will help them feel relaxed and refreshed. On the contrary, when their children do not want to go to sleep or wake up multiple times during the night, frustration and desperation came out as predominant feelings from both workshops.

In the second study, experts explained how a vicious circle of unhealthy sleep can be created from parents’ fatigue and frustration. These findings show the opportunity for children sleep technologies to support self-soothing and self-control of their sleep patterns that will relieve parents and break the vicious circle of unhealthy sleep. Image 10 and 11 are examples to support this statement.



Image 10. Scenario 3

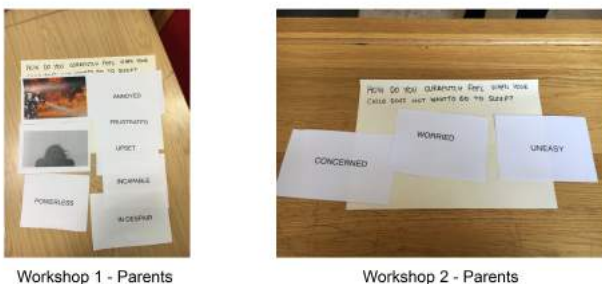


Image 11. Scenario 5.

6.2.3 Exercise 2 (parents): Mapping of functional requirements

Table 6 provides a summary of the mapping of requirements by parents. (O) means that the requirement was originally written by the researcher. (P) means the requirement was added by the parents. (W1) means that the requirement was classified into the related section only by P5 in the first workshop. (W2) meant the requirement was classified into the related section only by P2 and F5 in the second workshop. Requirements in bold in Table 6 represent ones that are the same but that were classified in different sections.

Stimulating or Relaxing Activities

All parents were against sleep technologies for children with stimulating activities. P5 said she observed that when her children watch TV or play with the iPad before going to bed they become hyperactive and it is difficult to put them to sleep.

Gamification was also considered too stimulating and not helpful in relaxing children before sleep. Bedtime stories were viewed as entertaining and relaxing and considered important in putting children to sleep.

P2 suggested an interactive device that would talk to the children, giving them answers if they have questions, or telling them bedtime stories.

P5 thought that it would be positive if the device offers educational options but P2 and F5 mentioned that if it is educational there is a chance their daughters would not be interested and as a consequence they would not stick to it.

Parental Intervention

P5 thinks that if parental help is needed to use the device then it defeats the purpose of the children becoming independent with their own sleep. P2 and F5 said that it is important for them to control the technology but they also want their children to be able to use it without help. P5 supports that requirement by saying that the device should be password protected to facilitate parental control.

Sharing

Sharing was considered positive if done nicely (P5), but in the second workshop parents said that sharing the device would only bring discord between the children and delay even more sleep onset.

P5 highlighted the fact that age difference also makes it difficult to share. For example, her son can read but not her daughter yet. Which is why she suggested the device to be adjusted to different age ranges.

Screen or No Screen

All parents had a neutral opinion on digital screens and it seemed like they were not aware of the consequences of blue light on melatonin and sleep as well as not aware of the benefits some current technologies bring by turning the screen to a warmer colour at night time.

However, they considered a physical device without a screen positive because parents believed that bedtime should be a moment to feel relaxed and not one to stare at a screen. It was also viewed as helpful as it would be able to reassure the children without needing parental presence.

Mobile App or Website

P5 stated that she would consider a mobile app more than a website because the screen focuses on one task while on the website there are many other options available on the same screen and it might induce her children to error or do something else than what they are supposed to do.

P2 and F5 have a neutral opinion regarding a mobile app saying that it depends on the activity, if it is stimulating or not.

Sleep Environment

Evaluating the bedroom environment was viewed as patronising by P5 and the only time she would consider it is as a new mum who does not know much about children's sleep environment.

However, in the second workshop, it was considered as something positive that would help parents and children better understand what external factor might be impacting their sleep.

Bedtime Routine Help

Sleep technology as a bedtime routine helper was considered a good thing for new mums by P5 but she said that she would not need it as her children have a well set routine already.

P2 and F5 considered a bedtime routine helper as beneficial, as it would help their daughters switch from one mode to another.

Music and White Noise

They were not against music but all of them said that it would depend on what type of music and if it is relaxing or not. Which is also why they all thought integrating white noise to a sleep technology for children would be a good idea.

Device Practicality

P5 said that she would like the device to have a battery for an easier mobility, if it needs to be plugged in when utilised it could become complicated. She also added that it would be nice if the device would turn off on its on so she does not need to go to their bedroom to turn it off and risk to wake them up.

Positive	Neutral	Negative
Emotional companion (O)	Digital screens (O)	Stimulating (O)
White noise (O)	Purely functional device (no emotional)	Gamification (O)

	attachment) (P)	
Ability for parents to control device (O)	Sharing between siblings (depends how nicely they share) (O) (W1)	Stimulating entertainment (O)
Relaxing / Soothing (O)	War (red/orange) light (from screen) (O)	Need for the parent to turn off the device (P)
Self-soothing device (O)	Blue light (from screen) (O) (W1)	In-App purchase (P)
Physical device without a screen (O)	Bedtime routine helper (O) (W1)	Sharing between siblings (O) (W2)
Device turns itself off after a certain time (P)	Website (O) (W2)	Parents' help needed (O) (W1)
Good battery life vs plugging frequently (P)	Educational technology (O) (W2)	Website (O) (W1)
Adapted to different ages (P)	Music (O) (W2)	Evaluate bedroom environment (light, noise, temperature) (O) (W1)
Emotional encouragement (P)	Parents' help needed (O) (W2)	
Read a book in a tablet (P)	Mobile app (O) (W2)	
Mobile app (O) (W1)	Interactive device that talks to children, answers their questions and read stories (P) (W2)	
Relaxing entertainment (read a story) (P)		
Music (O) (W1)		
Educational technology (O) (W1)		

Evaluate bedroom environment (light, noise, temperature) (O) (W2)		
Blue light (from screen) (O) (W2)		
Bedtime routine helper (O) (W2)		

Table 6. Summary of requirements mapping.

6.2.4 Exercise 3 (children): Gathering of design requirements

In this exercise, all children drew their favourite toy as the object that would motivate them to go to sleep and reassure them when waking up in the middle of the night. When asked how the object would interact with them, the objects became “alive”. For example, F2’s toy was Hedwig, the owl from Harry Potter, (Image 12) and the owl was able to fly to him to play if he woke up during the night. For F6 her object was her pillow (Image 13) and she drew arms that would hug them when she feels sad or scared or does not want to sleep.

This once again reinforces the need for an emotional companion as well as the idea of implementing the technology into something children are familiar with and attached to.

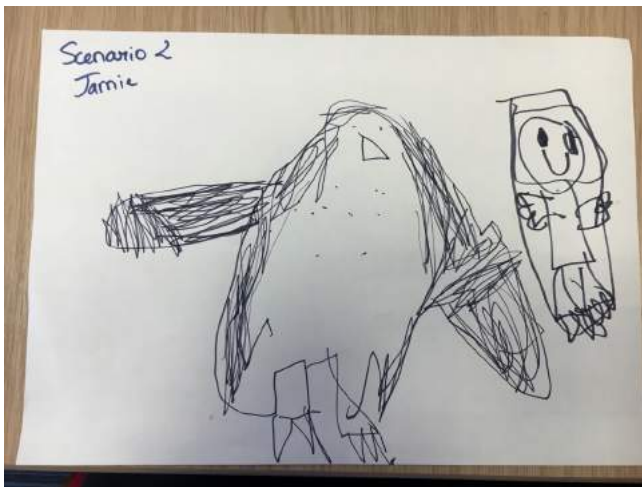


Image 12. Drawing of F2 representing Hedwig the owl in Harry Potter.



Image 13. Drawing of F6 representing her pillow.

6.2.5 Summary

Overall, findings from this study mostly reinforced theories from literature as well as data from the first and second studies.

There is a clear opportunity for technology to support children in becoming more independent with their sleep patterns as parents expressed feelings of frustration and despair when asked how they felt about their child not wanting to go to bed or waking them up during the night.

Parents in the first study assumed that their children were calling for them when waking up during the night because they needed to be reassured. Findings from both exercises with children confirmed parents’ assumption and highlighted the gap in existing behavioural treatments as they do not cater for reassurance.

One interesting finding was the neutral opinion parents had regarding mobile apps as a sleep technology. It shows parents’ lack of awareness about children’s healthy sleep behaviours. If a child wakes up in the middle of the night and starts using a mobile phone, there will be direct exposure to blue light and instead of self-soothing the child it will suppress melatonin and prevent the child from falling back asleep.

7 GENERAL DISCUSSION

This study’s aim was to investigate opportunities for technology to successfully support healthy sleep behaviours in children aged 4 to 12. The discussion below shows what was learned about possible uses for sleep technologies and how findings help understand how to build those technologies.

7.1 Technology as a Complement to Behavioural Treatments

Verplanken et al. [58] as well as Webb & Sheeran [60] demonstrated that habits are resistant to change especially when creating a new habit rather than changing one. This was confirmed in our findings by the need of familiarity the children expressed in the third study. It would therefore be

interesting to see a technology that acts as an emotional companion to the child while complementing a prescribed treatment. In the case of sleep-onset association disorder, the companion/technology could potentially emotionally replace the parents.

Separation anxiety has been quoted as a cause for sleep disorder by some parents and experts in the first and second studies. Interestingly, it is not quoted as such in the literature. However, separation anxiety might be one of the underlying cause for sleep-onset association disorder and limit-setting disorder. The literature's solution to those disorders involve treatments that could enhance separation anxiety rather than resolve it. For example, the extinction technique implies parents to ignore the child until morning even if there is crying happening. This is the gap in behavioural treatments that technology could fill by offering an emotional companion to children. It has been proved [39, 44] in the literature and confirmed in the third study that children need to have a feeling of familiarity with the persuasive technology they use to successfully change a behaviour as well as implement a habit. Mindell [40] and Owens et al. [42] stated that parents will tend to adapt the treatment to their child if they are encountering difficulties such as tantrums, which can lead to the failure of the treatment. In the third study, children drew their favourite toys as objects that would support their sleep patterns, which reinforces this need for personalisation of the treatment. This is why it would be important to incorporate the technology to something they already own or that takes the form of something they can easily relate to.

7.2 Technology as a Motivation for Self-Soothing and Self-Control

The objective of behavioural treatments is to, at some point, create independency in the child to go to bed as well as be able to self-soothe during night wakings. We have just discussed that technology might be an ideal complement to those treatments. But this research also showed that technology could act as a motivation to achieve this objective. For example, it could take the form of a social companion that children would bring to bed with them and it could play a lullaby or read stories for them to fall asleep. It could also operate as a night light and if they wake up during the night they would be able to find it and reach for it to feel reassured without needing to call for their parents or go to their bedroom.

What is novel about this research is that children were involved as informants in the process of expressing needs and generating ideas for opportunities to support healthy sleep behaviours. Current behavioural treatments have been researched without asking children's opinion. However, as Druin [22] demonstrated it, children should be treated as any other user when gathering requirements, especially to ensure that what will be designed will answer their needs and be appealing to them.

Light came as an essential implication for a children's sleep technology. In the first study, parents were assuming that their children were coming to them in the middle of the night because they felt scared and alone in the darkness of their bedroom. This assumption was later confirmed by children in the third study during projective expression. Additionally, experts have recommended an existing technology, Suzy Snooze [4] that can generate a light at bedtime that will help produce melatonin, the sleep hormone. As seen in the literature [35, 48], melatonin is sometimes prescribed in severe cases of behavioural sleep disorders. Those findings give two important functionalities for future sleep technologies:

- Act as a night light to reassure children when they fall asleep and if they wake up during the night;
- Help produce melatonin to help the child fall asleep faster.

7.3 Technology to Educate

Findings in the second study are quite consistent with the paediatric sleep literature. This shows a good application of theory into practice. However, findings in the first study are not consistent with the ones in the second study nor with paediatric sleep literature.

In the first study, parents showed that solutions they apply to cater for their children's sleep disorder are somewhat different from the treatments found in literature as well as recommended by experts in the second study. This difference shows that they are unaware of existing treatments recommended by experts that could help them and their child. When asked, parents said that they do not look for professional help and there were two main reasons for this:

- They do not think their child has a severe enough case of sleep disorder to consult experts;
- They think their child will "outgrow" the sleep disorder.

Those beliefs can become an issue as the longer the disorder is not treated, the greater the consequences [20, 25, 28].

Those situations clearly show the importance for parents to be more aware about causes for children's sleep disorders as well as aware of available treatments according to what their children are experiencing. Currently, the only way to find this information would be on the internet or by consulting a professional. But as we have seen in the first study, parents are not doing that. This leaves a great opportunity for technology to fill that gap of raising parents' awareness on children sleep disorders and existing treatments by creating a digital aid that would make access to that kind of information easier and more visible.

7.4 Design recommendations

According to the literature review, findings from the studies and previous discussion, there are a number of design

recommendations for technologies to support healthy sleep behaviours in children:

- Personalisation: the technology should represent a familiar object to which the child has some attachment. The technology would interact with the child to create a sense of reassurance according to what kind of behavioural treatment is needed.
- Emotional aspect: to help cater for separation anxiety.
- Parental control: parents need to be able to control the use their children make of the technology.
- White noise: this is a feature that the technology could have, it would help children fall asleep faster by associating bedtime to the noise
- Light: the importance of light is discussed in 7.2.
- Absence of a screen: it is seen as stimulating and parents were against their children using devices with screens after dinner until bedtime. No screen means no blue light, which suppresses melatonin and thus delays sleep onset.
- No stimulating activities.
- Independent use: parents would not need to be present for the child to use it. The device would turn off itself automatically after some time without parents having to do it themselves.
- Positive reinforcement: to keep children interested and motivated.
- Credibility: parents need reassurance that their children are using technology for their own benefits and not without a clear purpose.

7.5 Limitations and Future Work

After discussing the findings of the study, we will look at limitations as well as possibilities for future work.

One limitation would be that the participants in this study were not diagnosed with behavioural sleep disorders but parents suspected it in their children. It would be interesting to see if design recommendations for this group of users would be the same as the one from this study.

It is interesting to see how positive reinforcement was found ineffective in Stawarz et al.'s study [56], while being considered an effective treatment in the paediatric sleep literature as well as in the expert interviews from the second study. In addition to that, Sonne et al.'s [54] study showed that there was a preference for physical rewards rather than digital ones. Further research might explore sleep technologies that implement positive reinforcement, with two conditions: physical or digital rewards, and evaluate its efficacy in a longitudinal study. In fact, Lally et al. [36] stated that it takes 66 days to form a habit, although it depends on how complex that habit is.

Another direction for future work would be to include the design recommendations into a prototype and evaluate its use with a diary study.

8 CONCLUSION

The purpose of the current study was to uncover opportunities for technology to support healthy sleep behaviours in children aged 4 to 12.

Findings have shown three roles in which technology could help children maintain healthy sleep behaviours. The first one is as a complement to existing behavioural treatments in the form of a sleep companion that would be tailored to the child's needs and bring an emotional aspect that currently does not exist in behavioural treatments. The second one is as a device that would motivate children to become more independent with their sleep patterns especially regarding bedtime and night wakings. The device would offer the children reassurance and familiarity which are important elements which accommodate for the separation anxiety they feel when their parents are not present. An interesting finding defined the last role technology could fulfil as a tool to educate parents and children on healthy sleep hygiene as well as healthy sleep habits to adopt. In the findings it came out clearly that parents had a lack of awareness regarding causes for sleep disorders and existing treatments or solutions.

The research contributes to prior work in HCI on sleep technology by defining a design framework that supports a healthy sleep habit formation in children. The thesis concludes by making design recommendations for the building of prototypes and suggests future research directions with this study as a starting point to be explored.

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APPENDICES

Appendix 1: Screener for study 1 participant recruitment



Technology support to children bedtime routine

Hi everyone!

My name is Sophie and I am a Master student in Human-Computer Interaction at UCL in London. I am currently working on a project to research opportunities for technology to support healthy sleep habits in children.

Purpose: to uncover existing issues parents encounter when putting their children to bed or talk about existing solutions that they apply
Duration: between 30 minutes and 1 hour
Location: in a cafe in London or remotely via Skype
Incentive: £10 for your participation.

Please fill in the following details to confirm eligibility for participation:
If you have any questions, feel free to drop me a line at: cochette.sophie@hotmail.fr

***Obligatoire**

What is your age range? *

18-25
 26-30
 31-35
 36-40
 41-45
 46-50
 60+

What is your gender? *

Female
 Male
 Other
 Prefer not to say

If other, please specify:
Votre réponse _____

How many children do you have? *

1
 2
 3+

How old is/are your child/children? You can choose more than one answer. *

Less than 4 years old
 4 - 10 years old
 More than 10 years old

What electronic device(s) do you own? You can choose more than one if needed: *

Laptop
 Desktop
 Smartphone
 Tablet
 None of these
 Other

If other, please specify:
Votre réponse _____

Do your child/children have access to some or all of the devices listed? *

- Yes
- No

If yes, please specify which device(s) your child/children use: *

- Laptop
- Desktop
- Smartphone
- Tablet
- None of these
- Other

If other, please specify:

Votre réponse

How frequently would your child/children use electronic device(s) *

- Not at all
- Occasionally
- Frequently

How difficult is it to put your child/children into bed? *

- 1 2 3 4 5
- Not at all Extremely difficult

Do your child/children wake up at night? *

- Yes
- No

If yes, how many times approximately?

Votre réponse

Do you consider your child/children to have sleep disorders? (you can answer yes even if only one of your child/children has sleep disorders): *

- Yes
- No

If yes, could you please give us more details about what kind of sleep disorder is/are affecting your child/children?

Votre réponse

How does the quality of sleep of your child/children impacts your personal well being? *

- 1 2 3 4 5
- Poor Excellent

Appendix 2: Information Sheet Template Used in the Study

Information Sheet for Participants in Research Studies

You will be given a copy of this information sheet.

Title of Project:

This study has been approved by the UCL Research Ethics Committee as Project ID Number: UCLIC/3923/002

Name, Address and Contact Details of Investigators:

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, please read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

Insert Details of Study

(outline the purpose of the research and the participants' participation in it, including the expected duration of participation, any foreseeable risks or discomforts and any benefits).

It is up to you to decide whether or not to take part. If you choose not to participate, you won't incur any penalties or lose any benefits to which you might have been entitled. However, if you do decide to take part, you will be given this information sheet to keep and asked to sign a consent form. Even after agreeing to take part, you can still withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.

Appendix 3: Consent Form Template Used in the Study

Consent Form for Participants in Research Studies

(This form is to be completed independently by the participant after reading the Information Sheet and/or having listened to an explanation about the research.)

Title of Project:

This study has been approved by the UCL Research Ethics Committee as Project ID Number: UCLIC/3923/002

Participant's Statement

I

agree that I have

- read the information sheet and/or the project has been explained to me orally;
- had the opportunity to ask questions and discuss the study; and
- received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my rights as a participant and whom to contact in the event of a research-related injury.

I understand that I am free to withdraw from the study without penalty if I so wish, and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Investigator's Statement

I confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date:

Researcher notes, optional clauses:

- I understand that my participation will be taped/video recorded, and I am aware of, and consent to, any use you intend to make of the recordings after the end of the project.
- I understand that I must not take part if (insert exclusion criteria) _____
- I agree to be contacted in the future by UCL researchers who would like to invite me to participate in follow-up studies.
- I understand that the information I have submitted will be published as a report and I will be sent a copy. Confidentiality and anonymity will be maintained, and it will not be possible to identify me from any publications.

Appendix 4: Semi-Structured Interview Script for Study 1

1.0 [PREAMBLE]

Hello [PARTICIPANT'S NAME], I'm Sophie and I am a master student at UCL conducting this research for the purpose of my dissertation on opportunities for technology to support healthy sleep habits in children.

Thank you very much for agreeing to meet with me. I would like to talk to you today about sleep habits and behaviours of your child/children to help me better understand and identify what current issues are and what possible solutions technology could bring.

The whole session should take about 45 minutes. Is this ok? Do you have any questions so far?

2.0 [REQUESTING RECORDING]

It would be very helpful if I could record our conversation today so I can then focus my attention on speaking with you.

Is this OK? We would like to record with this microphone here (point to the microphone).

[2.1]

[IF THEY DO AGREE TO RECORDING]

Thank you. First of all I'd like you to read this consent form. Please read it and then sign the bottom.

If you have any questions about it please let me know.

[GIVE THEM 30-60 SECONDS TO READ THE FORM]

[2.2]

[IF THEY DO NOT AGREE TO RECORDING]

That's not a problem. I will make extra notes to make sure I have gotten all your feedback.

During the rest of the session, I'll be working from a script to ensure that my instructions to everyone who participates in the study are the same.

3.0 [CONTEXTUAL INTERVIEW IF ANSWERED YES TO SLEEP DISORDER]

[3.1] In the survey you said that your child/children has a sleep disorder, do you know what factors might have triggered that in your child/children?

[3.2] Do you seek help, information and/or advice regarding your child/children sleep disorder? If yes, could you give me details about where and how?

[3.3] Do you have solutions/treatments in place to cater for your child/children sleep disorders?

[3.4] Do(es) your child/children have a bedtime routine?

[3.4.1] If yes, could you please describe it to me?

[3.4.2] If no, what do(es) your child/children usually do before going to bed?

[3.5] In the survey you said that your child/children use(s) (mention device) (occasionally/frequently), could you please tell me what they most frequently use it for?

[3.6] Do you use any form of technology to cater for your child/children sleep disorders? If yes, could you please elaborate?

[3.7] What is your opinion as a parent on children using technology (digital or physical) in general?

[3.8] What is your opinion as a parent on children using technology (digital or physical) to have healthier sleep habits?

[3.9] In the survey you said that the quality of sleep of your child/children affected your well being in a negative way, could you please tell me what it is affecting exactly?

[3.10] How do you cater for that issue? How do you try to make it better?

4.0 [CONTEXTUAL INTERVIEW IF ANSWERED NO TO SLEEP DISORDER]

[4.1] In the survey you said that your child/children is difficult to put to bed and/or wake(s) up at least once at night, do you know what factors might trigger that in your child/children?

[4.2] Do you seek help, information and/or advice regarding this issue? If yes, could you please give me details about where and how?

[4.3] Do you have solutions/treatments in place to cater for your child/children sleep issues?

[4.4] Do(es) your child/children have a bedtime routine?

[4.4.1] If yes, could you please describe it to me?

[4.4.2] If no, what do(es) your child/children usually do before going to bed?

[4.5] In the survey you said that your child/children use(s) (mention device) (occasionally/frequently), could you please tell me what they most frequently use it for?

[4.6] Do you use any form of technology to cater for your child/children sleep issues? If yes, could you please elaborate?

[4.7] What is your opinion as a parent on children using technology (digital or physical) in general?

[4.8] What is your opinion as a parent on children using technology (digital or physical) to have healthier sleep habits?

[4.9] In the survey you said that the quality of sleep of your child/children affected your well being in a negative way, could you please tell me what it is affecting exactly?

[4.10] How do you cater for that issue? How do you try to make it better?

5.0 [END OF INTERVIEW]

Thank you [NAME] for taking part in our research. I have no more questions to ask. Do you have anything else to tell us? Thank you very much for doing this and I will let you know about the progress of this research if you are interested.

Appendix 5: Semi-Structured Interview Script for Study 2

1.0 [PREAMBLE]

Hello [PARTICIPANT'S NAME], I'm Sophie and I am a master student at UCL conducting this research for the purpose of my dissertation on opportunities for technology to support healthy sleep habits in children.

Thank you very much for agreeing to meet with me. I would like to talk to you today about sleep habits and behaviours in children aged 4 to 10 to help me better understand what the current issues and solutions are.

The whole session should take about 45 minutes. Is this ok? Do you have any questions so far?

2.0 [REQUESTING RECORDING]

It would be very helpful if I could record our conversation today so I can then focus my attention on speaking with you.

Is this OK? We would like to record with this microphone here (point to the microphone).

[2.1]

[IF THEY DO AGREE TO RECORDING]

Thank you. First of all, I'd like you to read this consent form. Please read it and then sign the bottom.

If you have any questions about it please let me know.

[GIVE THEM 30-60 SECONDS TO READ THE FORM]

[2.2]

[IF THEY DO NOT AGREE TO RECORDING]

That's not a problem. I will make extra notes to make sure I have gotten all your feedback.

During the rest of the session, I'll be working from a script to ensure that my instructions to everyone who participates in the study are the same.

3.0 [CONTEXTUAL INTERVIEW]

[3.1] What do patients most frequently consult you for?

[3.2] What are sleep disorders for which you consult the most for children aged 4 to 10?

[3.3] When is it considered a sleep disorder?

[3.4] What are factors that most commonly trigger sleep disorders in children aged 4 to 10?

[3.5] What are different consequences of sleep disorders on children aged 4 to 10?

[3.6] Are there also consequences on parents and/or the family (siblings)?

[3.7] If yes could you please elaborate?

[3.8] What are the most frequent treatments/solutions that you recommend to parents?

[3.9] Do you use any form of technology (digital or physical) when recommending treatments/solutions to parents? If yes, could you please elaborate?

[3.10] What is your opinion as paediatrician on technology (digital or physical) helping children with healthier sleep habits?

[3.11] How do you describe a healthy bedtime routine?

[3.12] What do you usually recommend parents when implementing a healthy bedtime routine in the life of their children?

4.0 [END OF INTERVIEW]

Thank you [NAME] for taking part in our research. I have no more questions to ask. Do you have anything else to tell us?

Is there anyone you know that you would recommend me to talk to for my research? Thank you very much for doing this and I will let you know about the progress of this research if you are interested.

Appendix 6: Questions from Projective Expression Exercise

Parents

1. How do you currently feel when your child does not want to go to sleep?
2. How do you currently feel when your child wakes up in the middle of the night and do not go back to sleep?
3. How do you feel when your child goes to bed without fuss?
4. How do you feel when you get a full night's sleep?
5. How do you feel when your child is asleep?
6. Could you describe their current bedroom environment?
7. What would the ideal bedroom environment look like?

Children

1. How do you feel when dad and mum tell you it's time to go to bed?
2. How do you feel before falling asleep?
3. In all these pictures and words can you please tell what do you trust?
4. What makes you sad?
5. What makes you happy?
6. What makes you scared?
7. What makes you not afraid anymore?
8. How do you feel when you wake up in the middle of the night?
9. What would you like to see around you when you wake up in the middle of the night?
10. What do you need with you or in the bedroom when going to bed?
11. What would you like to add to your bedroom environment for a better sleep?

Appendix 7: List of Requirements for Parents' Mapping Exercise

1. Mobile app
2. Website
3. Digital screens
4. Digital games
5. Physical device without a screen
6. Self soothing device for children
7. Parents' help needed
8. Educational technology
9. Music
10. White noise
11. Ability for parents to control the device
12. Blue light (from the screen)
13. Warm (red/orange) light (from the screen)
14. Relaxing
15. Stimulating
16. Entertaining
17. Bedtime routine helper
18. Sharing between siblings
19. Evaluate bedroom environment (light, temperature, noise)
20. Emotional companion
21. Purely functional device