A Walk on the Child Side: Investigating Parents' and Children's Experience and Perspective on Mobile Technology for Outdoor Child Independent Mobility

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ABSTRACT

Technology increasingly offers parents opportunities to monitor children, reshaping the way control and autonomy are negotiated within families. This paper investigates the views of parents and primary school children on mobile technology designed to support child independent mobility in the context of the local walking school buses. Based on a school-year long field study, we report findings on children's and parents' experience with proximity detection devices. The results provide insights into how the parents and children accepted and socially appropriated the technology into the walking school bus activity, shedding light on the way they understand and conceptualize a technology that collects data on children's proximity to the volunteers' smartphone. We discuss parents' needs and concerns around monitoring technologies and the related challenges in terms of trust-control balance. These insights are elaborated to inform the future design of technology for child independent mobility.

KEYWORDS

Independent mobility, walking bus, children, parents, privacy, surveillance, trust.

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1 INTRODUCTION

Children's independent mobility has been shown to have a positive impact on their well-being and development, with both short and long term benefits arising from greater levels of physical activity and higher levels of sociability, resulting in improved conflict resolution skills and mental well-being [15, 25, 28]. Despite this, growing restrictions are placed on children's independent mobility, especially in urban areas, due to parents' feelings of insecurity and their perception of the outdoor space as dangerous for their children. One of the main motivations of parents for giving a smartphone to their children is the perception of risk and consequent need for monitoring and tracking their location and activities [1]. The age at which children receive their first smartphone is lowering worldwide: in 2017, children owning a smartphone were 45% in US (age 10 to 12), 51% in Germany (age 6 to 13) and 72% in South Korea (age 11 to 12) [14]. Besides smartphone apps for location tracking [30], commercial wearable devices for tracking child location are also growing. This technological surveillance is often promoted as a responsible response to everyday risks [23].

However, research has argued that parental monitoring could change the way children relate to others and face the surrounding environment [18, 27]. For example, Rooney [27] showed that increased surveillance may hinder children's development and experience of trust.

Figure 1: Children and volunteers (with the yellow vest) walking together to school in a walking bus.

In this study, we leverage the experience of walking buses that have been promoted by the Municipality of Trento, Italy for several years in the primary schools of the city and surrounding areas (Figure 1). A walking school bus, or simply a walking bus, is a form of alternative mobility in which children gather at designated places (walking bus stops) and, under the supervision of an adult volunteer, walk to school together [16]. The experimentation involved the deployment of a simple, custom technology supporting the walking bus practice: children received a Bluetooth Low Energy (BLE) device whose proximity to the volunteer's smartphone is registered by a custom smartphone app, indicating that the child is ready to "board" the walking bus.

We conducted a field study with adults and children, carrying out participant observations, interviews and workshops, to examine how the technology was appropriated into the walking bus practice by volunteers, parents and primary school children. We exploited this experiment as a probe to trigger participants' reflection on the use of technology to support independent mobility and their expectations for further improvements and extensions. Specifically, we investigated the following research questions:

- *Interaction patterns with technology*: how did adults and children interact with the proximity detection device? How did they understand the functioning of the technology? What are children's and adults' values, representations and mental models related to data acquisition and usage?
- *Attitudes toward monitoring and autonomy of children*: which are the perspectives of parents around tracking their children's presence? Which concerns do parents have toward mobile devices meant to support child autonomy?

We report how the technology, disappearing into the background, was socially appropriated into the daily walking bus experience and was positively evaluated by parents as an appropriate technological compromise balancing their need of control and trust related to child independent mobility. These insights are further elaborated to inform the future design of mobile presence-based technology for child independent mobility. Our findings contribute to the ongoing debate on safety, control and autonomy of children and the role technology could play. While a growing number of papers explore the use of smartphones and GPS location trackers by parents for monitoring child mobility [11, 18, 23], our work provides a novel contribution concerning a simpler technology: proximity detection meant not to track child movements but to check their presence in selected contexts. Moreover, our study considers a largely unexplored age range, 6 to 10, with most papers focusing on older children or teenagers [1, 4, 18].

We start by introducing the research lines that inspired our work, then outline the field study and the methodological approach exploited to engage both adults and children. We proceed with the analysis and results from the field study, discussing insights that can drive the future design of mobile presence-based technology for child independent mobility.

2 RELATED WORK

Increasingly technology offers parents mechanisms to monitor children. Growing attention in the HCI research community, outlined here, addresses the use of mobile technologies for tracking and their effect on family relationships [1, 4, 18, 27].

Location Tracking and Family Relationships

With the growing availability of location tracking systems, research addresses the impact on family relationships. In a survey of commercial tracking systems, Vasalou et al. [30] found that parents using them were driven by values such as security, peace of mind and the need to reduce uncertainty. Non-users considered tracking a threat to relationships and self-direction, and valued trust as a reliable strategy to manage uncertainty and to sustain individual growth.

Boesen et al. [4] studied the impact of location-based services on family relationships and found that they were primarily used for digital nurturing, e.g., digital parenting (a mother tracking her children) or adult-caretaking (a nephew tracking an older uncle). However, these technologies often replaced trusting interactions, reducing opportunities to maintain and display trust, and thus undermining the initial caring intention to ensure safety. Similarly, Mancini et al. [18] conducted a qualitative study with two families who used a custom-built tracking application. The authors found that tracking technology strongly affected social contracts within the families by generating anxieties and conflicts, even in close relationships. As noted by Hasinoff [11], these technologies first provoke anxiety, then offer location data as a way to overcome it.

Tracking: Trust and Surveillance

Issues raised by tracking strongly affect the discourse on trust and surveillance. Rooney [27] highlighted that increased child surveillance may deny children opportunities to trust and to be trusted, suggesting that in the negotiation of trust and surveillance, children should be considered as "dialogical partners" rather than passive objects of remote control. There is growing attention in HCI research on how parents monitor the online activities of their children, both in relation to parenting styles [2] and the use of parental control applications to monitor smartphone use [7, 31]. For example, an online survey by Ghosh et al. [7] in the United States with 215 parents and their children aged 13-17 found that low autonomy granting parents (i.e., authoritarian or neglectful parents) were most likely to use monitoring applications and these parenting styles were associated with teen online victimization and peer problems. This confirms previous findings linking low autonomy granting parenting styles to negative outcomes for children such as behavioural problems or poor mental health [24, 29]. However, in the investigation of parenting styles and child development, one must acknowledge the complex interplay of parenting styles, ethnicity and cultural contexts and their effect on developmental outcome. For example, Greening et al. [10] investigated the moderating effect of parenting styles on 6 to 12 years old's suicidal behavior, finding that a positive relationship between depressive symptoms and suicidal behavior in young children was attenuated by authoritarian parenting styles for African-Americans but not for Caucasians.

Oostveen et al. [23] conducted a content analysis of 40 websites of GPS location trackers targeting children and teenagers in the US and UK. They found that, even if price levels and technical device capabilities were the same in both countries, features varied by social context. For example, in the UK consent by children was the norm while in the US parents were allowed to secretly track children. Interestingly, the issue of trust versus surveillance is a key point in the commercial messages of location tracking providers. For instance, providers suggest that monitoring will increase independence, using terms such as "supervised independence", and claiming that GPS monitoring will build a stronger trusting relationship between parents and children [23].

Children and Tracking Technology

Children have increasingly become the target of new technologies, and research on children's interaction with them is growing. Studies are identifying strategies employed by children to both resist the surveillance and the restrictions on their mobility, e.g., avoidance strategies, and negotiation of the monitoring boundaries [1]. Further, as suggested by Rogers [26], the move to the so-called calm computing, with its invisible and embedded nature, poses a number of challenges, especially when vulnerable people are involved: while motivations "behind such projects are altruistic they can also be naïve, overlooking how vulnerable people's privacy and self-respect may be being violated" [26, p. 410]. With respect to privacy, Nissenbaum's theory of "Contextual Integrity" [22] argues that privacy is contextually grounded, governed by cultural, ethical or moral norms and values. In this respect, studies show how children's privacy should be considered in relation to evolving needs and relationships between parents and children [5, 20], as well as the evolving nature of privacy boundaries that adults and children set. Ghosh et al. [6] analyzed comments left by children aged 13 to 17 about apps for parental control and found that they rated these apps significantly lower than parents revealing their belief that parental control apps are overly restrictive and invasive of their privacy, and that they negatively affect the relationships with parents [6]. Children's perspective has also been taken into account in co-designing activities targeting less invasive mobile online safety applications [5, 21].

While past research has primarily addressed the negative consequences of GPS location tracking, it is of growing interest to investigate how technology could instead effectively support child independent mobility while respecting people's values and children's rights. Our work provides an account of adults' and children's reflections on a proximity detection technology, contributing to further explore tensions around monitoring and balance between surveillance and trust concerning outdoor mobility. To do so, we involved parents and children ages 6 to 10, a range that has not received significant attention but represents an important phase in the development of autonomy and independence.

3 FIELD STUDY

Our work focuses on children's and parents' experience with a technology deployed for one entire school year to support the walking bus. We conducted field observations, semi-structured interviews with parents and separate workshops with parents and children.

Fieldwork Setting

This work is part of a larger living lab initiative focused on child independent mobility. The main goal of the initiative is to foster sustainable and active mobility by leveraging the daily journey to school as part of a collaborative educational experience (www.smartcommunitylab.it/climb-en/). The living lab has been running since 2016 and involves many primary schools in Trento, Italy. While the project comprises multiple activities, we focus here on the Smart Pedibus (Italian for Walking Bus), which aims at supporting the daily walking school bus with technology specifically developed to this end. Across three schools, 60 volunteers

Figure 2: The proximity detection BLE device given to children (left), which connects to the mobile application installed on the volunteer's smartphone (right).

and 130 children ages 6-10 have participated in the Smart Pedibus.

Walking School Bus A walking school bus involves adult volunteers, often parents or grandparents, escorting a group of children to school. Similar to a traditional school bus, it follows a timetable along a planned, safe route with a number of stops. Walking bus initiatives are commonly associated with a shift away from cars for the daily commute [16], with improved physical and mental well-being [15].

The Technology Our Smart Pedibus is supported by the combination of two technologies developed at our research center: a Bluetooth Low Energy (BLE) beacon device given to each child and an app running on the volunteer's smartphone, as seen in Figure 2. The app detects the proximity of the BLE devices carried by the children to the phone carried by the volunteer, automatically registering that a child is "ready to board" the walking bus [8]. Each BLE device contains a Bluetooth transmitter that periodically sends the unique id associated to a specific child. It is powered by a small, coin battery, designed to last the duration of the school year, avoiding the need to recharge the devices and the corresponding need for a charging port. The BLE device has neither a display, LEDs, nor buttons and is, by design, minimal and simple. Before the introduction of the technology, walking buses were supported by pen and paper, i.e. the volunteers registered the presence of a child on a piece of paper by checking the corresponding name on a list. The technology was designed to support the management of the walking school bus by automating the registration of children and thus letting the volunteers focus on the children instead of the paper registration.

Methods

Participants Our study involved the parents and children of two public primary schools in two different neighborhoods of Trento, Italy: Vela, where the Smart Pedibus had been active since the 2016-17 school year, and was well-established as part of the daily commuting routine, and Cognola, where the Smart Pedibus was first introduced in February 2018. This allowed us to observe the technology adoption process. Between February and May 2018, three methodologies were used to focus on increasingly specific research questions: *i)* participant observations, *ii)* semi-structured interviews, and *iii)* workshops. First, we observed volunteers and children in the actual practice of the walking school bus. We then discussed and identified a set of topics to be explored through semi-structured interviews. Finally, we organized three workshops to address specific research questions. We followed an iterative approach, meeting at each step to discuss significant aspects that we deemed important to analyze. We describe the methods used in each phase in the following.

Table 1: Overview of study participants.

Method	Participants	Gender	Age range
Observations	61	-	6-40
Interviews	11	9F, 2M	30-40
Parent workshop	5	5F	30-40
Children workshop 1	4	1F, 3M	6-8
Children workshop 2	5	2F, 3M	9-10

Observations We conducted seven observations of the walking bus experience. Vela has three different walking bus routes and in April 2018, we observed each. Cognola has only one route and, between February and March 2018, we observed this route four times, at distinct moments in its evolution: before the introduction of the technology (when it was still based on pen and paper), on the day the technology was introduced, after one week, and after one month.

In this way, we observed first-hand both the adoption process and how the use of the technology by volunteers and children evolved. In this phase, we based our work on contextual inquiry [13], focusing our observations on participants roles and organization of activities, on the artifacts used, on the interaction with the environment and on cultural and social aspects. The field observations allowed us to identify a set of topics that we further explored with individual semi-structured interviews with parents.

Interviews Interviews were conducted in April and May 2018. After collecting informed consent forms for audio registration, we interviewed eleven parents (see Table 1), asking predetermined but open-ended questions, e.g., *i)* values underlying the walking bus, *ii)* attitudes toward the technology of the Smart Pedibus, *iii)* perspective, as parents, toward the monitoring of children and their autonomy, and *iv)* how children related to the technology. Interviews were transcribed for analysis.

Workshops Finally, in May 2018 we conducted three separate workshops with nine children and five parents (who were also volunteers of the walking bus) to elaborate on the main themes that consistently emerged from participant observations and interviews. We combined different techniques to elicit children's and parents' mental models about the technology, and to examine their attitudes toward the conflicting balance between monitoring and autonomy. The workshops were conducted simultaneously but in three separate rooms, each with two researchers.

Workshops with children: We intentionally chose to involve children in workshop activities rather than in individual interviews to promote greater elaboration of ideas [12] and to limit the drawbacks of direct interviews with children [32]. The participating children were divided into two groups according to age: four children from 6 to 8, and five children from 9 to 10 (see Table 1). During the workshop, we asked them to draw *i)* a typical morning with the walking school bus, *ii)* how the technology works, *iii)* what the technology knows about them, and with whom it shares this information, and finally *iv)* what they would like it to do. At each step, we prompted children to describe and discuss their drawings to foster the elicitation of their mental models in the context of a teach-back interview [19].

Workshop with parents: the drawing tasks were combined with a scenario-based discussion. After collecting informed consent forms for audio and video registration, we asked parents to draw a typical morning with the walking bus, describing the most salient aspects of their experience. We then asked them to describe and elaborate their drawings, highlighting the most important aspects. Then we prompted a scenario-based discussion to elicit parents' attitudes toward monitoring and autonomy using two hypothetical scenarios.

Scenario 1. Edda, a mother who has recently moved with her family to a new city, must to be at work at 8 a.m. and cannot chauffeur her children to school. She must decide whether or not to leave her two children unattended for a few minutes at the walking bus stop while they wait for the volunteers to arrive.

Scenario 2. Edda must decide whether to let her 8-year old child walk with a group of schoolmates to the gym after school, with no adult supervision but with the use of proximity-based technology.

For both scenarios, we first asked parents to individually produce as many ideas as possible on post-its eliciting the conditions under which Edda would: *i)* leave her children alone at the waking bus stop in the morning, or *ii)* allow her 8-year old son to go to the gym after school without adult supervision. Then, we used the post-its to prompt a discussion on the balance between monitoring and autonomy, discussing the positive and negative aspects of each idea.

Data Analysis We used a grounded theory approach to analyze our data and iteratively elaborate a set of key themes [9]. We collected the data from field observations, transcribed the interviews and reviewed the videos from the workshops. Four researchers independently coded all the data, each individually developing an initial coding scheme. As analysis proceeded, we iteratively discussed to reach consensus on the final codebook. Finally, we categorized data into subgroups based on their relationships to the broader themes we identified using the affinity diagram technique [3, 13].

For the analysis of children's and parents' drawings, we adopted a qualitative approach inspired by educational and pedagogical research [17]. The approach provides guidance for the interpretation of iconographic categories of graphical data, focusing on the thematic analysis of children's drawings using quantitative and qualitative observations.

4 RESULTS

We report our findings, organizing them around two macrothemes: different visibility levels of the technological components and the balance between monitoring and trusting. We then synthesize these findings into recommendations.

Visibility levels of technology

First we focus more on the technological components of the system, reporting how adults and children interacted with both the Bluetooth-based device and the related app installed on adults smartphone. We report how their experience evolved over time and their representations and mental models of the functioning of the technology, with attention to how data is collected and shared.

A Disappearing Technology Children participating in the walking buses received the BLE devices with a lanyard (Figure 2, left). In both schools the device quickly became invisible, "disappearing" into the children's backpacks. The field observations conducted as a first step in Vela (in which the experimentation was well established) revealed that the BLE devices were already "hidden" in the children's backpacks and that children never interacted with the device, neither during the walking bus journey nor in other moments.

This disappearance into the backpack was encouraged by parents. As a father explained: *"when we gave the 'microchips' to children we told them: 'make sure to put it in the backpack and forget about it'. We told them this because at the beginning they asked if it was a game"* (Parent - P1). In Cognola, we were able to follow more closely the process of adoption since we observed the transition from a pen-and-paper walking bus to the one supported by technology. We witnessed that initially the BLE devices were worn around the necks. Nevertheless, after only a few days, the devices migrated into the backpacks. Interviews with parents and volunteers highlighted a number of motivations behind this choice.

First, parents thought it was preferable to have an "invisible" device, to avoid diverting the children's attention from the pleasure of walking together to school with other

schoolmates to the device and the technology. As one parent explained *"(my son) completely forgot about it... and that's right, I like it. He never touches it, he never interacts with it"* (P2). A mother explained *"by now it's part of the backpack, it is at one with the backpack"* (P3). Overall, parents valued the simplicity of the sensor and the absence of interactive elements, such as buttons, LEDs or screen, *"otherwise children would be attracted to it and I don't see the need for this"* (P4). In fact, during interviews, parents (6 of 11 parents) actually stated their preference for a device that would not be seen by children as a game or gadget.

During the workshops, drawings were used to investigate participants' view of the experience and their representations of the technology supporting it. The first drawing task was to represent "a typical morning with the walking school bus". Although we expected to collect drawings depicting the BLE beacon and/or the smartphone, none of the children visually represented either (see for example Figure 3), and only one parent drew the smartphones used by the volunteers (Figure 4). This reinforces the disappearing nature of the technology. Table 2 summarizes the graphical data in the drawings related to the first task.

Valuing the Social Side of the Experience Technology was not perceived as the key aspect for the walking bus, with drawings always prominently depicting the human part, i.e. children and volunteers going together to school (see Table 2). All interviewed parents considered this a successful aspect of the technology, which is able to support the experience without becoming the focus of the attention and in fact "disappearing" into the background.

The importance of the presence of adult volunteers is mentioned by all parents, for instance *"The assurance that at the walking bus stop there's an adult who walks the child to school, that they are not alone, for me it's important"* (P5). With regard to technology, it was clear that all parents relied more on the human part of the system *"The technology is useful, but we live in such a small neighborhood: we all know each other, we are all friends [...], I'm sorry but I wouldn't exclusively rely on this [the BLE device]. My eyes and my head are the technology"* (P2), and another parent: *"The responsibility is on the parent, not the sensor, it's not the sensor that provides security, it's not the sensor that makes the difference. It's the volunteer that sees if the child is there or not"* (P11). However, parents (7 out of 11) also observed that the technology allows them to speed up the presence tracking process, having more time for social interactions and hence support social values such as interacting with other children and adults: *"The technology provides a faster registering of the children. In this way there's more time for example to text other moms of the walking bus route to see if their child who has not arrived yet is sick or just late, or to talk to the children, ask 'Where do you live?' and get to know each other"* (P6).

Table 2: Contextual elements in workshop drawings. Task "draw how the technology works".

Category	Element	Children	Parents
People	Children	6	5
	Adults	6	3
	Volunteers	5	5
Technology	BLE device	0	0
	Smartphone	0	1
Environment	Lane	1	2
	Elements of nature	7	1
	School buildings	7	1
	Home buildings	6	0
	Other buildings	3	1
Objects	Walking Bus stop	8	4
	Schoolbag	1	0
	Schoolbus	2	0
	Cars	3	1
	Animals	0	1

Figure 3: A child's workshop drawing. Task "draw a typical morning with the walking school bus".

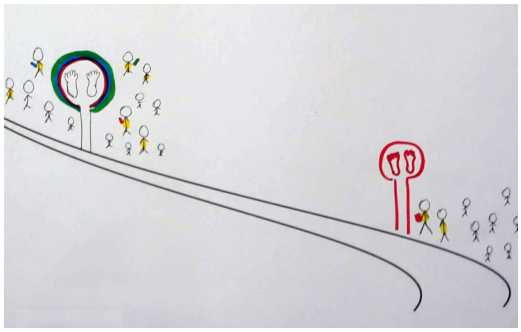

Figure 4: The only drawing by a volunteer depicting the smartphones.

The App on Volunteers' Smartphones Attracts Children The second key component of the Smart Pedibus is the app installed on the volunteer's smartphone. While there must be at least two volunteers on each walking bus line, the app is used by only one volunteer. Often, but not always, the volunteer held the smartphone with the app open during the walk. Field observations revealed that children engaged frequently with the app, especially when the volunteer was their parent. We observed collaboration between parents and the children especially before the group started walking.

During one observation in Cognola, we noted that the smartphone was always held by the volunteer's daughter, from arrival at the walking bus stop up to arrival at school. When prompted about it, the volunteer affirmed that her daughter was *"much better at technology than me"* (P7).

The children's interest in the app emerged also during the workshop. In particular, when we asked them to draw the technological components, almost all of them (8 out of 9 childrens) were able to draw the interface of the app with many details (see two sample drawings in Figure 5 in comparison with a picture of the interface in Figure 2). They were also able to precisely describe the interface elements of the app. Children reported some short sentences in their drawing such as: *"At each stop, it [the BLE device] sends the children's name on the smartphone and you press 'Next'. [...] The school is the last stop where you press the button 'Send' and then we go in class"* (Child - C1), *"It [the BLE device] is used to check if the children are at the stop or not. The smartphone displays the name of the children at the stop"* (C3).

In general, children liked the idea of helping volunteers, and were especially interested in verifying on the app the automatic detection of the children joining the walking bus. The interest of children in the app was reported, for example, by a mother: *"Children are attracted and want to participate actively as main characters. Those [children], who are very interested in technology, help in checking, in verifying ... they ask 'where am I? Am I in there?' [...]"* (P6). At least in part they are attracted because they see their names on the smartphone *"The smartphone shows my name"* (C4), *"The system knows my name and it appears in the volunteer's phone"* (C6). They ask *"'Where am I?' because they think their position (in the list) means something... and so they want to check if they are above or below the other children ... it is a game for them"* (P3).

Regarding the engagement of children with the smartphone, parents had mixed feelings. Just as they liked the sensor because it is able to support the practice while disappearing in the backpack, they had some concerns about the children being attracted by the app. When asked if her son was interested in the smartphone, a mother said: *".. yes, he wants to start the app, select the walking bus line, he is very curious about it. But I don't always let him do it, because in that moment he is privileged, to respect other children. But he is attracted, yes"* (P8).

Figure 5: Two children's drawings depicting the smartphone app (Task "draw how the technology works".

Representing the System Functioning and Data Acquisition, Usage and Storage During interviews and focus groups we investigated how children and adults understand the functioning of the technology, in particular, their mental models about data acquisition, usage and storage. Collected data about walking bus attendance go to a server in our research institute when the volunteer communicates through the app that the journey is finished. Interviews with parents showed a partial understanding. A mother said: *"Maybe these parents participate rarely to meetings and they don't know. Sometimes parents don't read the information sent home. With the doubt 'but you gave a microchip to my child'. We, humble parents, don't know if you, researchers, can find them with another system. This is what created doubts for some parents"* (P1).

Drawings by children on how the technology works (second task, see Figure 5) often contained both the BLE device and the app and hinted at an overall good understanding of the functioning of the technology. More specifically, drawings about what the technology knows about them, and with whom it shares this information (third task). This turned out to be mainly written content and the task was only performed in the workshop with older children. Results highlighted the big picture of how the technology is supposed to work, e.g. *"It [the BLE device] brings up the name of the children to the volunteer's smartphone"* (C1), *"It [the BLE device] is used to show who is and who isn't on the walking bus. It is connected to the phone and can do a sort of roll call"* (C2), and *"It [the system] collects our names and send it to a secure place"* (C4). Nevertheless, children sometimes exaggerated the capabilities or overestimated functionality, e.g. *"The sensors calculate our steps and know where we are"* (C5), *"The sensor knows our names, when we were born, where we live and which walking bus line we take"* (C3).

It is worth noting that the partial awareness about data collection modalities was not perceived as an issue by adults

in Vela, where the living lab had been active for several years. In this context, participants explained that even if they did not understand exactly the way the BLE devices and apps collect and send data, they trusted the overall context of the living lab in which the experimentation was running.

Balance Between Monitoring and Trusting

A main goal of our study, identified by the second research question, was to exploit the walking bus experiment to trigger reflection on the role technology could play for supporting child independent mobility, exploring parents' attitudes and concerns toward child safety and autonomy.

Parents' Attitude Toward Autonomy During interviews and workshops, parents' reflections on the importance of carefully balancing parents and children needs was central. The need to protect children and at the same time the will to gradually let them experiment with autonomy was considered one of their main responsibilities as parents. Many interviewed parents (8 out of 11) clearly stated that children need to learn autonomy and independent mobility. They also observed that achieving full autonomy is a process that needs to be encouraged and sustained, also accepting that children need to make mistakes in order to learn from them. As a parent explained, trust is central in this process: *"Children need trust and self-esteem, they need to feel big and responsible [...], it's important for them to have moral support and to know that we believe in them"* (P3).

Parents also agreed that when it comes to independent mobility, children's autonomy is only possible in a protected and controlled environment. During the workshop an interesting conversation arose between parents with children aged 10-11, who the following year would be going to the secondary school by public bus. They discussed how they were dealing with their children's independent mobility, and one parent reported the conversation with her son: *"he told me 'How will I be able to take the bus?' because he's never taken the bus alone [...]. And I told him 'we'll try and take the bus together, even at 7:10, the very bus you will get to go to school, we'll get off together, we'll try and get off at the previous stop, then at the following stop, we'll get some experience'"* (P3).

Too Much Monitoring Means Lack of Trust In general, parents considered monitoring as a manifestation of a lack of trust in their children: *"But this is not for controlling, it's important to show that we trust them"* (P3). Trust was perceived as having an educational value, which, however, comes with a price and requires significant effort by the parents who must accept a certain degree of risk. As one parent said: *"Now, with all the children abductions you worry, but again, we must rely on trust and on the close relationship with the child"* (P9).

In the focus group, parents recognized their crucial role to teach children to rely on their own skills to cope with daily issues. Related to this, parents repeatedly expressed concerns about an overuse of technology and reflected on the potential negative impact on self-confidence if technology is used to monitor children. Reflecting on the differences between proximity devices and the use of GPS, a mother noted: *"Keeping her monitored all day... I wouldn't, not me. It's too much, I find it unfair"* (P9). Another mother, referring to GPS tracking technology: *"This is a trend I don't like, it's a trend in which technology can be manipulated". She added "I'd like to gain the trust that allows me to give autonomy, not to give autonomy because I have a tracking technology"* (P10).

In this process of learning autonomy, parents observed that the particular way in which technology is employed can either hinder or sustain children's path to independent mobility. In a lively discussion during the workshop, parents evaluated advantages and disadvantages of giving smartphones to their children and the risk associated with relying on technology instead of relying on their own skills to cope with possible risky situations: *"There's the risk that by completely trusting technology, one isn't able to manage the little everyday problems, that not having the technology to help you right away could lead to some sort of personal insecurity. You always have to rely on a tool, you're not able to rely on yourself and sharpen your mind"* (P11). Another mother agreed: *"Technology can sometimes be unreliable, so one must be able to manage the problems without an emergency technology"* (P3).

Comparing the proximity based technology with the use of smartphones, all parents agreed that a unobtrusive device like the one used for the walking bus can better support the journey toward autonomy because is not visible and can disappear, i.e. children forget they have it and must take care of themselves without it. *"The possibility of a silent tool, unobtrusive, as opposed to a mobile phone doesn't raise certain issues. I mean that when the child begins to go to middle school, the parent who is a little anxious gives her/him a mobile phone... but this opens the gates to other [problems], so you, to satisfy your need for some peace of mind, have opened a world in which s/he will spend 24 hours a day... [...] In other words, the sensor can save the parent the purchase of a mobile phone for their children, which brings an access to the Internet, WhatsApp groups, and bullying"* (P6).

Monitoring and Trusting: an Evolving Balance The discussion during the workshop focused also on the changing needs of parents and children and their relationship. This was especially noted by parents with children in the last year of primary school. A mother, when asked if always knowing where her children were could be useful, reflected on the differences between her younger and older daughters, and specifically on the need to allow a certain degree of autonomy to the older, despite the fear this increased autonomy brings: *"it may not cause problems up to when parents have the right and the duty of knowing where the child is. For our 11 year old daughter, we started to grant her more autonomy,*

but she is still young and she has to learn how to use her independence in a good way" (P3). In accordance with studies showing how needs and relations between parents and children continuously change [20], she reflected on the evolving nature of privacy boundaries that adults and children set, in relation to child autonomy and changing power relationships: *"The more they grow, the more it is necessary to give autonomy, so it becomes a matter of relationship, of education, of spaces and trust, of autonomy. For a young child, the parent has almost full power, for good or for bad, so no big issues arise. The more they grow, the more these problems arise"* (P11).

5 DISCUSSION

Based on our findings, we next reflect on recommendations and implications for the design of technologies for child independent mobility, especially for primary school children.

A Disappearing Device: Values and Privacy Issues

We highlighted how children and adults interacted with the proximity-based device and the smartphone app and how these were socially appropriated within the walking bus practice, describing how the BLE device quickly withdrew into the background. We described how this device disappearance actually sustained the values of the walking school bus, especially social connectedness. Spending time together, both for parents and children, represented a key value of the walking bus. Therefore, parents appreciated that the device was not drawing the children's attention away from the other people of the morning walking bus. Further, parents largely appreciated the simplicity of the proximity detection device, which was not perceived by children as a tracking device, thus sustaining children's self-concepts of autonomy.

On the other hand, we uncovered an issue in the adults' understanding of how the BLE device works. Parents were unclear of the timing of data collection through the smartphone app, and of the accessibility, usage and storage of their children's data. Differently from the observations reported by Ervasti et al. [5], we noted this was a critical issue at the beginning of the experimentation. In Vela, parents trusted the overall experimental context while also acknowledging scarce awareness of the system functionality. Instead, in Cognola some privacy concerns arose regarding the type of data collected, the transmission of data to servers and the overall management of child data. We note that in Cognola, there were communication problems between the school personnel and the walking bus volunteers, and this may, in part, explain the confusion and the difference between Cognola and Vela. Further, the different urban contexts of the two schools may have played a role: Vela is a small, isolated neighborhood where most parents know each other, while the Cognola school serves students from several nearby villages and parents do not always know each other, resulting in weaker social relationships. We suggest that communication related to data management should be clarified through simple indicators that may increase awareness of the functioning of the sensor technology and the data management process.

Designing for Surveillance or Trust?

We reported how proximity detection technology designed for child independent mobility was positively evaluated by parents in terms of control and trust.

A crucial issue for parents was their struggle to find a balance between monitoring their children to ensure their safety and trusting them to support their autonomy. These two conceptual extremes may be associated with opposite approaches with regard to technology, and different parenting styles [7]. One extreme, that relying on surveillance, is currently well-served and targeted by smartphones with GPS-based location tracking apps [1, 23]. It is also more in line with authoritarian parenting, which has been shown in to negatively affect youth outcomes [7]. At the other extreme, that relying on trust, we may place the non-use of technology for monitoring children. Nevertheless, we acknowledge the complexity of the interplay between parenting styles, contextual and cultural factors, interpreting with caution the association of authoritarian parenting to negative outcomes.

Interestingly, our adult participants, especially those with children finishing primary school, were very proactive in their desire to help us design a technology in the middle between these two extremes. They were unwilling to give a smartphone to their children because they valued trust and letting them experience the world without surveillance, but were also afraid. Our study suggests that proximity detection, rather than GPS tracking, could be the enabler of an appropriate technological compromise in the middle of the two extremes, supporting a parenting style based on trust that aims at promoting independent mobility, while also accepting a certain degree of risk.

Our results also stress the importance of considering the changing nature of family relationships in terms of trust-control balance and privacy rights in the design of technology for child independent mobility. Our study suggests, for instance, that especially for older children, who might need to negotiate a greater degree of independence, proximity detection could act as a safety net in specific contexts, like the journey from home to school, in which children could prove themselves in the urban environment and develop problem-solving strategies that can be effectively applied in non-protected contexts.

Balancing Surveillance and Trust in Future Technology

We reported previously on how parents valued the social aspect of the experience, not trusting the technology per se

but always with the mediation of other people, for example parents or volunteers. Considering additional uses of proximity detection devices besides the morning walking bus, parents suggested a scenario in which trust is guaranteed by the involvement of a network of people. As a mother suggested during the workshop, the presence of a child could be detected outside the time and space of the morning walking school bus, through the app of other parents, for example when a volunteer is in the bus or in the main square minding their own activities. For specific routes and places, such as the journey from school to the gym, or at the park, parents also envisioned a network of certified shops, volunteering as "friends of the walking bus", which could be infrastructured for detecting the presence of children: *"that perhaps, along the way, there would be shops 'friends of the walking bus', it would be possible to let Giulio go alone with two friends [to the gym]"* (P8). These shops might be equipped with some fixed technology working in the same way as the app on the volunteers' smartphones, i.e. detecting the presence of a nearby Bluetooth-based device. This information might be given back to parents, volunteers and shops with different levels of visibility. However, even assuming the largest possible level of disclosure to parents, i.e., accessing real-time information about new check-ins performed by their children, the technology would not reach the extreme of GPS location-tracking. Children could still decide whether visiting places where check-ins occur or not. Of course, children should be informed about these places, as stated in [27]: "Perhaps, if surveillance is applied in a well-judged manner based on the risks posed to children in a certain circumstance, and done with the knowledge and involvement of the children under surveillance, then it may be possible for trust to retain a place in a child's encounters with others" [27, p. 353].

Undoubtedly, balancing trust and risk is a complex matter: parents need to protect their children from harm, and decide whether technology can be appropriately employed to this end. However, they may also recognize when technology is used as an over-reactive response to their need for peace of mind, and when it may be appropriate to accept some risks [27]. To this end, further development efforts could be directed toward a more personalised and adaptive technology, which could gradually release the monitoring pressure as the children grow older, develop independence and negotiate the boundaries of control within the family. We also reported the interest of children to be engaged and active in the use of technology, in particular the smartphone app. This reflects a need for engagement, also found by [21], that contrasted with adults appreciation of a silent device not distracting children from their ongoing activities. This finding also sustains Rooney's considerations [27] on the importance of not considering children passive subjects of parental monitoring, but rather active actors. It can therefore be suggested that the technology could provide children with feedback on its status, for example by showing on a simple monitor either the last check-in, the history of last check-ins, or whether the parent has accessed the data or not. Even if this feature was in general negatively evaluated by parents since they appreciated the fact the device does not attract children's attention, further studies could explore the trade-off between degrees of active control and disappearance in the design of technology for this particular age group.

Limitations

Our study reflects the perspective of a limited sample of children and their parents living in two suburban areas in northern Italy, with no serious issues in relation to road safety. We acknowledge that more populated urban areas might have different issues regarding children's safety related to traffic. We also acknowledge that female parents are over represented in our sample. During recruitment, we asked for the participation of parents without targeting a specific gender but the majority of respondents were female and this might reflect the gender differences of parenting responsibilities in the context we investigated. Future studies considering larger and more balanced samples and different urban and organizational contexts would be a valuable contribution to complement our results.

6 CONCLUSION

In this paper, we investigated the views of parents and primary school children on a technology designed to support child independent mobility. We reported the process through which parents and children made sense of an socially appropriated the technology into their daily walking school bus experience. Our study provided evidence that proximity detection, rather than GPS or smartphone location tracking, could be the enabler of an appropriate technological compromise between the two extremes of surveillance and trust, supporting a parenting style based on trust that aims to promote independent mobility while also accepting a certain degree of risk. The unobtrusive design of the proximity detection device allowed it to disappear into the background while still supporting the walking bus and its values. Results were further elaborated to inform the future design of proximity detection technology for child independent mobility.

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REFERENCES

[1] Carol Margaret Barron. 2014. 'I had no credit to ring you back': Children's strategies of negotiation and resistance to parental surveillance via mobile phones. *Surveillance & Society* 12, 3 (June 2014), 401–413. https://doi.org/10.24908/ss.v12i3.4966

[2] Diana Baumrind. 2005. Patterns of parental authority and adolescent autonomy. *New Directions for Child and Adolescent Development* 2005, 108 (2005), 61–69. https://doi.org/10.1002/cd.128

[3] Hugh Beyer and Karen Holtzblatt. 1998. *Contextual design: defining customer-centered systems.* Morgan Kaufmann.

[4] Julie Boesen, Jennifer A. Rode, and Clara Mancini. 2010. The Domestic Panopticon: Location Tracking in Families. In *Proceedings of the 12th ACM International Conference on Ubiquitous Computing (UbiComp '10)*. ACM, New York, NY, USA, 65–74. https://doi.org/10.1145/1864349.1864382

[5] Mari Ervasti, Juhani Laitakari, and Mika Hillukkala. 2016. 'I want to know where my child is at all times' — field study of a location-aware safety service for schoolchildren. *Behaviour & Information Technology* 35, 10 (Oct. 2016), 833–852. https://doi.org/10.1080/0144929X.2016.1201144

[6] Arup Kumar Ghosh, Karla Badillo-Urquiola, Shion Guha, Joseph J. LaViola Jr, and Pamela J. Wisniewski. 2018. Safety vs. Surveillance: What Children Have to Say About Mobile Apps for Parental Control. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, 124:1–124:14. https://doi.org/10.1145/3173574.3173698

[7] Arup Kumar Ghosh, Karla Badillo-Urquiola, Mary Beth Rosson, Heng Xu, John M. Carroll, and Pamela J. Wisniewski. 2018. A Matter of Control or Safety?: Examining Parental Use of Technical Monitoring Apps on Teens' Mobile Devices. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, 194:1–194:14. https://doi.org/10.1145/3173574.3173768

[8] Davide Giovanelli, Bojan Milosevic, Csaba Kiraly, Amy L. Murphy, and Elisabetta Farella. 2016. Dynamic group management with Bluetooth Low Energy. In *2016 IEEE International Smart Cities Conference (ISC2)*. IEEE, Trento, Italy, 1–6. https://doi.org/10.1109/ISC2.2016.7580822

[9] Barney G. Glaser and Anselm L. Strauss. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research.* Aldine.

[10] Leilani Greening, Laura Stoppelbein, and Aaron Luebbe. 2010. The Moderating Effects of Parenting Styles on African-American and Caucasian Children's Suicidal Behaviors. *Journal of Youth and Adolescence* 39, 4 (01 Apr 2010), 357–369. https://doi.org/10.1007/s10964-009-9459-z

[11] Amy Adele Hasinoff. 2017. Where Are You? Location Tracking and the Promise of Child Safety. *Television & New Media* 18, 6 (Sept. 2017), 496–512. https://doi.org/10.1177/1527476416680450

[12] Caroline Heary and Eilis Hennessy. 2006. Focus Groups Versus Individual Interviews with Children: A Comparison of Data. *The Irish Journal of Psychology* 27, 1-2 (Jan. 2006), 58–68. https://doi.org/10.1080/03033910.2006.10446228

[13] Karen Holtzblatt and Sandra Jones. 1993. Contextual inquiry: A participatory technique for system design. *Participatory design: Principles and practices* (1993), 177–210.

[14] Jacqueline Howard. 2017. When kids get first cell phone around the world — CNN. (Dec. 2017). https://edition.cnn.com/2017/12/11/health/cell-phones-for-kids-parenting-without-borders-explainer-intl/index.html

[15] Marco Hüttenmoser. 1995. Children and Their Living Surroundings: Empirical Investigations into the Significance of Living Surroundings for the Everyday Life and Development of Children. *Children's Environments* 12, 4 (1995), 403–413. https://www.jstor.org/stable/41514991

[16] Robin A. Kearns, Damian CA Collins, and Patricia M. Neuwelt. 2003. The walking school bus: extending children's geographies? *Area* 35, 3 (2003), 285–292.

[17] Tamara Kisovar-Ivanda. 2014. Thematic Analysis of the Children's Drawings on Museum Visit: Adaptation of the Kuhn's Method. *World Journal of Education* 4, 3 (2014), 60–67.

[18] Clara Mancini, Yvonne Rogers, Keerthi Thomas, Adam N. Joinson, Blaine A. Price, Arosha K. Bandara, Lukasz Jedrzejczyk, and Bashar Nuseibeh. 2011. In the Best Families: Tracking and Relationships. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 2419–2428. https://doi.org/10.1145/1978942.1979296

[19] Ana Maria Marhan, Mihai Ioan Micle, Camelia Popa, and Georgeta Preda. 2012. A review of mental models research in child-computer interaction. *Procedia - Social and Behavioral Sciences* 33 (Jan. 2012), 368–372. https://doi.org/10.1016/j.sbspro.2012.01.145

[20] Alice E Marwick and Danah Boyd. 2014. Networked privacy: How teenagers negotiate context in social media. *New media & society* 16, 7 (2014), 1051–1067.

[21] Brenna McNally, Priya Kumar, Chelsea Hordatt, Matthew Louis Mauriello, Shalmali Naik, Leyla Norooz, Alazandra Shorter, Evan Golub, and Allison Druin. 2018. Co-designing Mobile Online Safety Applications with Children. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, 523:1–523:9. https://doi.org/10.1145/3173574.3174097

[22] Helen Nissenbaum. 2004. Privacy as contextual integrity. *Washington Law Review* 79 (2004), 101–158.

[23] Anne-Marie Oostveen, Asimina Vasalou, Peter van den Besselaar, and Ian Brown. 2014. Child Location Tracking in the US and the UK: Same Technology, Different Social Implications. *Surveillance & Society* 12, 4 (Nov. 2014), 581–593. https://doi.org/10.24908/ss.v12i4.4937

[24] Martin Pinquart. 2017. Associations of parenting dimensions and styles with externalizing problems of children and adolescents: An updated meta-analysis. *Developmental psychology* 53, 5 (2017), 873. https://doi.org/10.1037/dev0000295

[25] Miretta Prezza, Stefania Pilloni, Carmela Morabito, Cinzia Sersante, Francesca Romana Alparone, and Maria Vittoria Giuliani. 2001. The influence of psychosocial and environmental factors on children's independent mobility and relationship to peer frequentation. *Journal of Community & Applied Social Psychology* 11, 6 (2001), 435–450. https://doi.org/10.1002/casp.643

[26] Yvonne Rogers. 2006. Moving on from Weiser's Vision of Calm Computing: Engaging UbiComp Experiences. In *UbiComp 2006: Ubiquitous Computing (Lecture Notes in Computer Science)*, Paul Dourish and Adrian Friday (Eds.). Springer Berlin Heidelberg, 404–421.

[27] Tonya Rooney. 2010. Trusting Children: How do surveillance technologies alter a child's experience of trust, risk and responsibility? *Surveillance & Society* 7, 3/4 (July 2010), 344–355. https://doi.org/10.24908/ss.v7i3/4.4160

[28] Stephanie Schoeppe, Mitch J. Duncan, Hannah M. Badland, Melody Oliver, and Matthew Browne. 2014. Associations between children's independent mobility and physical activity. *BMC Public Health* 14, 1 (Jan. 2014), 91. https://doi.org/10.1186/1471-2458-14-91

[29] Masayo Uji, Ayuko Sakamoto, Keiichiro Adachi, and Toshinori Kitamura. 2014. The Impact of Authoritative, Authoritarian, and Permissive Parenting Styles on Children's Later Mental Health in Japan: Focusing on Parent and Child Gender. *Journal of Child and Family Studies* 23, 2 (01 Feb 2014), 293–302. https://doi.org/10.1007/s10826-013-9740-3

[30] Asimina Vasalou, Anne-Marie Oostveen, and Adam N. Joinson. 2012. A Case Study of Non-adoption: The Values of Location Tracking in the Family. In *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work (CSCW '12)*. ACM, New York, NY, USA,

779–788. https://doi.org/10.1145/2145204.2145321

[31] Pamela Wisniewski, Arup Kumar Ghosh, Heng Xu, Mary Beth Rosson, and John M. Carroll. 2017. Parental Control vs. Teen Self-Regulation: Is There a Middle Ground for Mobile Online Safety?. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17)*. ACM, New York, NY, USA, 51–69. https://doi.org/10.1145/2998181.2998352

[32] Julia Woodward, Zari McFadden, Nicole Shiver, Amir Ben-hayon, Jason C. Yip, and Lisa Anthony. 2018. Using Co-Design to Examine How Children Conceptualize Intelligent Interfaces. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, 575:1–575:14. https://doi.org/10.1145/3173574.3174149