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Socially adaptive electronic partners for improved support of children's values: An empirical study with a location-sharing mobile app☆

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ABSTRACT

Mobile location-sharing technology is increasingly being used by parents to locate their children. Research shows that these technologies may pose risks to important user values such as privacy and responsibility, while they aim to promote others such as family security. As a solution, we proposed the use of Social Commitment (SC) models for governing the sharing and receiving of data. A social commitment represents an agreement between two people about which data should (not) be shared and received in which situation. We hypothesize that the use of SCs in mobile location sharing applications provides improved support for user values since it allows for a more flexible, context-aware location sharing. In this paper, we present a user study to test this hypothesis. The study focuses on primary school children ($n = 34$) as the main target group, who's values may be demoted through the use of location-sharing technology. Children were provided with two versions of a mobile location sharing app: one with basic check-in functionality –the basic app –and one augmented with an SC model, which we call a *Socially Adaptive Electronic Partner* (SAEP). Our findings suggest, among other things that the SAEP would provide improved support for children's values compared to the basic app.

1. Introduction

1.1. Motivation

Social media applications have become an integral part of our interaction. Platforms such as Facebook, Twitter, and Instagram are consistently gaining new users, sharing content such as text, photos, videos, and location information. In this paper we are specifically interested in the latter. Examples of existing location sharing mobile applications are Life360, Glympse, and wearables such as KizON. These can be used for providing what we call *socio-geographical support* for families with children in primary school age, i.e. between six and twelve years. Socio-geographical support includes assisting children in exploring their environment, through e.g. helping them go to school on their own, make new friends, and participate in neighborhood events and playdates, as well as increasing parents' awareness of the location of their children. It should be noted here that, although parents and children can of course make commitments through simply talking to each other, when using technology to implement this information sharing commitments the mediating technology would also need to be informed about these commitments. This has to be done in an easy and acceptable way for both parties avoiding situations that one part imposes its will on the other, or that the mediating technology has to be instructed on every potential future situation.

Research in value-sensitive design and ethics of technology [1,2] shows that such location sharing technology may pose risks to important user values while it aims to promote others—for example, trying to promote a child's safety through allowing parents to see where their children are at all times, may pose risks to children's privacy and independence.

This paper builds on previous research we conducted to address this issue: an exploration of the values and social context relevant to the family life domain [3] and an introduction of the idea of using Social Commitment (SC) models to govern the sharing and receiving of data in mobile location sharing applications [4], complementing traditional social platforms' preferences. In the aforementioned papers we identified seven key values relevant to the domain of location sharing in the family life, created conceptual models that links norms (a core component of SCs) governing potential location sharing applications with elements of the domain's

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social context through the concept of human values, and built a mobile app that can be used to test potentially relevant hypotheses. SC models were proposed by Singh [5,6] to describe a commitment between two parties in a socio-technical system, namely a *debtor* who is committed towards a *creditor* for bringing about a certain proposition, or a *consequent*, when a certain *antecedent* comes to hold. For example, a commitment between a father Bob and his daughter Alice could be that Alice should share her location with Bob when Alice is at the park. We showed how SC models can be used to create commitments for sharing and receiving data in mobile applications through a case study of location sharing in the family life domain.

We refer to such applications that can take into account commitments from people in the user's social context as *Socially Adaptive Electronic Partners* (SAEPs), following the vision outlined in [7]—where we argue that supportive technology should be able to adapt to diverse and evolving norms of people in unforeseen circumstances, in order to better support people in their daily lives. Based on research in ethics of technology [8] we expect that SAEPs will provide improved support for user values since the use of SCs allows for a more flexible, context-aware data sharing. In this paper we aim to test this hypothesis. In addition, inspired by research in persuasive technology [9,10] we aim to evaluate the technology in two functional roles, namely as a *tool* – focusing on usability, and as a *social actor* – addressing the extent to which the technology creates a relationship with the user. The latter is especially relevant for technology that is envisaged to form a partnership or act as a teammate to its user [3,11–13], which is the case for SAEPs. We expect that users will evaluate a SAEP more positively as a tool and as a social actor than their non- SAEP counterparts, since SAEPs provide support that is more tailored to the user and the user's social context.

In this paper we present a user study to test these hypotheses in the domain of mobile location sharing in family life. The study focuses on primary school children ($n = 34$) as the main target group who's values may be demoted through the use of location-sharing technology. Children were provided with two versions of a mobile location sharing app: one with basic check-in functionality – the basic app (BA) – and one augmented with an SC model, the SAEP. Our results suggest that children expect (1) that the presence of a mobile location sharing app would positively support their values, and that they perceive the technology positively as a tool and as a social actor; and (2) that the SAEP would provide improved support for children's values compared to the BA, i.e., the version of the app without an SC model, and that they perceive the SAEP more positively as a tool than the BA.

In the remainder of this section we present the necessary background information in research areas related to this paper, a domain analysis of family life, and proposed hypotheses. In Section 2 we describe the research method and procedure in detail, including the socio-geographical support application. We present our results and discussion in Sections 3 and 4 respectively.

1.2. Background

1.2.1. Values and norms

A value is defined in the Cambridge Dictionary as "the importance or worth of something to someone". Within the academic world, Rokeach [14] published a surveyed list of human values that has become widely used; the list included 18 terminal values, i.e. end states of existence, such as social recognition, freedom, family security and a comfortable life, and 18 instrumental values, i.e. means of achieving terminal values, such as ambition, self-control and honesty.

Taking into account values when designing new (software) technology is necessary in order to account for what is important to different users and stakeholders [1,15–18]. The research area of Value-Sensitive Design in particular has developed tools and methods for identifying stakeholders, eliciting their values, and translating these values into concrete design requirements [19,20].

Research in philosophy and normative systems [19,21,22] as well as our previous empirical research [3] shows that values can be promoted, i.e. further fulfilled, and demoted, i.e. placed at risk, by norms. Norms are *action guiding* statements, i.e. obligating or prohibiting actions [23], for example, one should not cross on red, or one should greet people when entering a room. An action changes an old situation into a new situation. If the new situation is better or worse than the old one with respect to a certain value, we say that the action respectively promotes or demotes that value. Therefore, norms can be used to influence behavior to promote or demote certain user values.

1.2.2. Socially adaptive electronic partners (SAEPs)

The key idea underlying SAEPs is that this technology will be able to provide improved support for user values if it can *adapt* its behavior to people's diverse and evolving norms *at run-time* [7]. Frameworks for representing and reasoning about norms have been extensively investigated in the area of *normative multi-agent systems* [24]. Norms can exist as guidelines for the behavior of humans in society, and similarly, can be used to regulate the behavior of software entities. A Social Commitments [5,6] can be viewed as a kind of norm that in its representation emphasizes "directedness" in the sense that the parties involved in the commitment (i.e. debtor and creditor) are explicitly represented.

In our previous work [4] we have projected this research on social commitments in multi-agent systems to the context of data sharing in social platforms, with a particular focus on location sharing in the family life domain. As part of that research, we have developed a smartphone app[1] that allows users (in particular parents and children) to create commitments with one another regarding sharing and receiving of location data. The app shares and receives location data in accordance with the commitments that the user has subscribed to. The SC model and interface of this app form the basis for the research we describe in this paper.

The development of the concept of a SAEP was also inspired by research on Electronic Partners (or *ePartners*), which are defined as "computerized entities that partner with a human and share tasks, activities, and experiences" [11]. An ePartner differs from traditional software in the sense that it functions not only as a tool, but also as a social actor. An ePartner can for example support its user by receiving information regarding the user's cognitive task load, and adaptively automating some of their tasks, to keep their cognitive load at an optimal level. ePartners have been investigated in various critical application domains such as simulated space missions [25], naval command and control [26], and virtual reality exposure therapy [27]. SAEPs can be viewed as a type of ePartner that supports its user through understanding the norms that govern social interaction between human users and acting on these norms within the social context in which it operates.

1.3. Values in family life

In Kayal et al. [3], qualitative user studies (e.g. cultural probes, focus groups) and data analysis (grounded theory) identified several categories of elements that make up the social context of the family life domain (in specific, three sessions with six parents and six of their children between 6–12 years of age, based in a town of approximately 30,000 inhabitants in the Netherlands). These categories were "activities" e.g. visiting family, going to

[1] A 3-minute tutorial video (with subtitles) can be viewed at http://bit.do/ePartner.

the park, playing outside, "concerns" e.g. anxiety about children going places on their own, children's exposure to the internet, and "limitations" e.g. friends living at a distance, difficulty using certain technologies, etc. The analysis also found that many of the transcribed user statements, discussing the elements of these three categories, can be directly linked to certain user values. We annotated user statements in the data from [3] with the values from Rokeach's list relevant to these statements (e.g. a statement from a parent discussing their child's going to school by themselves was annotated with Rokeach's values of independence and family security, a statement by a child discussing a playdate with a friend was annotated with Rokeach's value of friendship, etc.). We have then selected the user values that appeared in the annotations at least more than one time:

- Family security: parents keeping their family members safe and secure.
- Freedom: children expressing their desire to have less parental monitoring.
- Independence: parents and children expressing their desire that children do more activities on their own.
- Friendship: parents and children alike expressing the importance for the children to build true friendships with their peers.
- Social recognition: organized social activities for children (e.g. at school, playgrounds, friends', etc.). Parents and children stressed how social activities and interaction can provide a sense of social achievement or recognition for the children.
- Inner harmony: parents' "peace of mind", as opposed to the anxiety typically experienced with the activities that their children have to do away from their supervision.
- Responsibility: the importance for children to become responsible when it comes to school, homework, and free time.

This analysis was corroborated with research findings in [1,2], which highlight the importance of a similar set of values in this domain. To illustrate how location sharing commitments may promote or demote certain values, consider the following commitment:

1. Peter (Mary's father): "I want Mary to share her location with me between 7:00 a.m. and 9:00 p.m."

obligates a location sharing action which would arguably promote the value "family security". Moreover, the following commitment:

2. Peter: "I want Mary to not share her location with me if she's at school".

prohibits an action in a manner that would arguably lead to the promotion of the value "independence".

1.4. Hypotheses

Based on the research discussed in the previous subsections, we propose that the presence of a location sharing app (in general) would positively contribute to children's values, and would be perceived positively as a tool and as a social actor. Moreover, we propose that a version of the app augmented with an SC model, i.e., the SAEP, will contribute *more positively* to children's values, and be perceived more positively as a tool and a social actor than the version without an SC model, i.e., than the basic app (BA). This is formulated in the following hypotheses:

- H1: children expect that the presence of a location sharing app in their life will have a positive effect on each of their values individually.
- H2: children perceive a location sharing app positively as a tool (H2a) and as a social actor (H2b).
- H3: children expect that the SAEP will provide better support for the individual values than the BA, the location sharing app without the SC model.
- H4: children perceive the SAEP more positively as a tool (H4a) and more positively as a social actor (H4b) than the BA, the location sharing app without the SC model.

2. Method

2.1. Experimental design

The experiment had a single factor within-subject design as all participants used both the app version without the SC model (BA) and the app version with the SC model (SAEP). To avoid an order bias, the order was counter-balanced: in the first session, half the participants tested (BA) while the other half tested the (SAEP). In the second session, app versions were interchanged between the two group. Participants were randomly assigned to the groups.

Approval for the user study was granted by the university's ethics committee.

2.2. Participants

Thirty-four children, six to eleven years of age ($M = 8.6$, $SD = 1.4$), participated in this user study. Twenty-eight of the participants were female, and six were male. Using convenience sampling [28], participants were found through personal connections with day-care centers (Dutch: *buitenschooolse opvang* or *BSO*) in the province of South-Holland in the Netherlands. The participants came from three different BSOs, eight, twelve, and fifteen participants from the first, second, and third BSO respectively.

2.3. Material

Please note that the original language of all material used by participants and described in this section is Dutch. Depictions are translated into English.

2.3.1. Application

The app ran on the Android platform and it permitted its users to share *check-ins* in certain locations with other users of the system, similar to applications such as Swarm and Facebook.

Two versions of the app were developed. One of the two versions included an additional feature based on the SC model representation.

Version without the sc model (BA). The BA was modeled after the behavior and capabilities of currently available social applications. In this version, participants could place other participants of the system in one of two lists (*family* or *friends*) or in neither, in which case the application would place them in the list *others*. Participants could select with which lists they share their check-ins (Fig. 1), and from which lists they received check-ins. Participants could place or remove other users from either list, and change sharing and receiving preferences at any time. Participants could at any time see, through an event log, the last five check-ins that were visible to them.

Participants could create locations in two ways: (1) through selecting a specific point, corresponding to a GPS position on an integrated Google map, and then assigning to it a name of their

choice, and (2) through detecting the current position automatically if a GPS signal was available, and then assigning a name. In both cases, a location is added to a list of available user locations, defined by a name, a GPS position, and a square area of a side length of 50 m centered around that GPS point. Locations could be removed by the user at any time.

If a participant wanted to check-in (Fig. 2), the list of locations that fell within a radius of 300 m (according to the currently detected GPS position) would be displayed, with the option of adding a location using the second method described above, in case the current location was not yet on the list. The participant could then select a location, and confirm their check-in, which would be shared with the participants that belong to the lists with which the first participant was sharing, according to their settings. Participants with whom this check-in is shared would get a pop-up with the sharer's name and location information, viewable also on an integrated Google map, assuming they had selected to receive check-ins from the list to which the sharer belongs. An "event log" was available, that showed a participant's own latest check-in information, as well as the five most recent check-ins seen from others.

Version with the sc model (SAEP). This version contained all the features in the BA, and additionally included a "commitment" menu as described in [4], which can be represented using a grammar of the form:

⟨*commitment*⟩ ::= 'I want' ⟨*debtor*⟩ 'to' ⟨*norm type*⟩ ⟨*action*⟩ 'with/from' ⟨*third party*⟩ 'if' ⟨*condition*⟩.

A user (creditor) could create a commitment with another user (debtor) consisting of a specific normative action, i.e. to (or to not) share or receive a check-in from one or a number of users (third party), if a certain condition, based on time or geographical location, was active.

For example, Bob could create the following commitments: (1) I want Paula to share her check-ins with me if she's at the park (Fig. 3), and (2) I want Paula to not receive check-ins from the list "friends" between 18:00 and 21:00. In commitment (1), Bob is creditor, Paula is debtor, sharing check-ins is the normative effect, and entering and leaving the park are the triggering and expiry conditions. In commitment (2), Bob is creditor, Paula is debtor, not receiving check-ins is the normative effect, and the times 18:00 and 21:00 are the triggering and expiry conditions.

When the creditor creates a commitment, it is sent to the debtor, who can either directly accept it, or "decide later". In case the latter was selected, the debtor can later decide whether to accept or reject the proposed commitment. Users can, at any time, review the list of commitments they created or received, delete commitments they created or received, and accept received commitments that are still pending. A user action such as accepting or deleting a commitment notifies the other user involved with that action.

Conflicts between basic preferences and an accepted, active commitment were solved in favor of the commitment. For example, if Bob was in Paula's family list, and Paula opted in her basic preferences to "not share check-ins with family", accepting commitment (1) above meant her check-in would be shared with Bob if she entered the park. Similarly, conflicts between two accepted, active commitments would be solved in favor of the commitment most recently accepted.

Participants could access two sub-menus for sent and received commitments respectively, which showed commitments already accepted and commitments that still required a decision, with the possibility to make a decision within these sub-menus.

2.3.2. Mobile devices

During testing sessions, every participant was in possession of a Samsung Galaxy S6310 with one of two version of the app

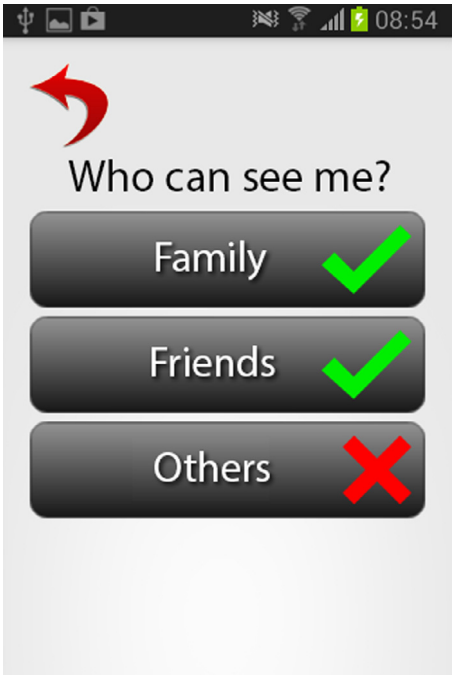

Fig. 1. Selecting which lists of users can see your check-ins (translated from Dutch).

Fig. 2. The main screen in the app, showing the check-in button (translated from Dutch).

installed. The devices were running Android version 4.1.2. All other apps were disabled.

2.3.3. Mission cards

To engage children with the functionalities of the apps during the time-limited test sessions, 37 "mission" cards were created (Fig. 4). Every mission card had a unique number and contained a short, interactive task for a child to perform. The missions were categorized as follows:

Fig. 3. Commitment (1) as it appears on the app (translated from Dutch).

- Of the 37 missions, 17 were instructional, i.e. directly asking the child to perform an action on the app(s), and the remaining 20 were simulated life situations, i.e. contained an interactive scenario where the app's usage could be of benefit.
- Of the 17 instructional missions, six tasks were created to assist children in learning to use the SC menu.
- Of the 37 missions, 21 required the child to go to a certain location within the BSO.
- Of the 37 missions, 11 required offline interaction with another child.
- Of the 37 missions, 17 could be completed similarly using both versions of the app, while the remaining 20 had additional solutions utilizing the SC menu available in the SAEP version.
- Out of 20 missions with additional SC menu solutions, five required an obligation to share, five required a prohibition to share, five required an obligation to receive, and five required a prohibition to receive. Conditions, i.e. place and time, were also distributed equally amongst the 20 missions.

Examples of the missions can be found in Appendix A, translated to English from Dutch, the original language.

2.3.4. Instructional videos

Two instructional videos were created. The first video was an app tutorial, showing examples of all features of the version without the SC model. No mention of the SC menu was included whatsoever in this part; to avoid creating bias in the group testing the BA in the first session. The second video included instructions that help children understand and answer the post-session questionnaires.

2.4. Measurement

This section is describes measurement instruments that are specifically developed to test the hypotheses in this paper.

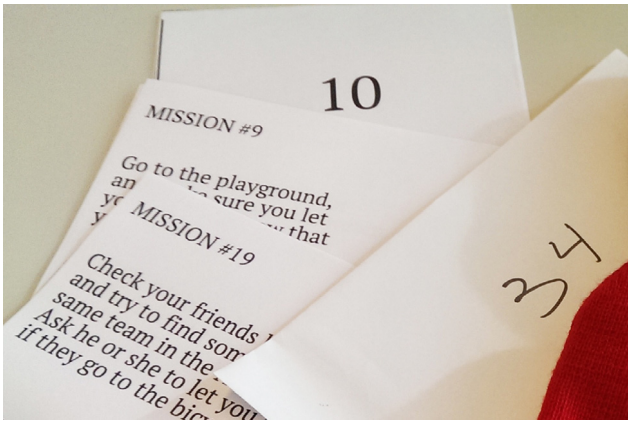

Fig. 4. Mission cards (translated from Dutch).

2.4.1. Fulfillment of domain-relevant values

In the past, children's values have mainly been measured using the Portrait Values Questionnaire which had originally been designed for adults. Responding to the gap in literature on a values instrument designed for use with children, Döring et al. (2010) [29] developed the Picture-Based Value Survey for Children (PBVS-C). Most recently, Collins, Lee, Sneddon, & Döring, (2017) experimented and tested a more interactive instrument, namely the AVI (Animated Values Instrument) [30]. However, and to the best of our knowledge, questionnaires to measure how far certain children's user values are fulfilled were not available for the social location sharing domain. We therefore needed to design a questionnaire for this study that could, to an extent, measure how fulfilled are the seven relevant values we identified earlier, in the lives of our user group.

Due to the aforementioned lack of literature on the subject, we initially established a list of 24 questionnaire items based on the tree nodes resulting from grounded theory analysis in Kayal et al. [3]. These items dealt with issues such as going to school or visiting friends and family, playing with friends and playdates, self-efficacy while going to places on their own, permissions to do activities on their own, amongst others. The grounded theory analysis [3] followed an iterative approach whereby user statements were coded (i.e. tagged) with relevant concepts. These concepts were grouped into themes (i.e. activities, limitations, and concerns). Based on these themes, and the concepts within them, the initial pool of questionnaire items was created.

To determine which items would be included in the final questionnaire, a content validity analysis (CVA) [31] was performed, with the assistance of a panel of 11 experts in value-sensitive design and human–computer interaction.

Content validity analysis in essence a consensus issue whereby a panel of experts may decide on whether an item loads on a certain construct. [32] presents a quantitative method to determine that: a formula that determines Content Validity Ratio (CVR), and sets two thresholds (strict and relaxed) for the inclusion of an item in a construct.

Members of the panel were provided with detailed context information regarding the values and the domain. Their task included filling a table where rows represented the 24 questionnaire items, and columns represented the seven values discussed in Section 1.3. To fill the table, a panel member rated how useful every questionnaire item would be to measure the fulfillment of each value–the instructions provided three possibilities: "essential", i.e. that this item is essential to measure the fulfillment of that value, "useful", i.e. helpful but not necessarily essential, or "unrelated", i.e. this item cannot measure the fulfillment of that value.

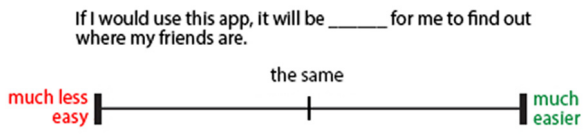

Fig. 5. An example of one of the questionnaire items (translated from Dutch).

All members of the panel provided their response. Using a relaxed threshold [32], an item was added to the final questionnaire if a significant majority of the panel, including a *chance margin*, rated the item at least as "useful"[2] – for a panel of 11 members, a significant majority with a chance margin required at least nine members to rate an item at least as "useful", or a content validity ratio of .64.[3]

This process resulted in 19 out of the original 24 items being included in the questionnaire. Every one of the seven values had a least one related item in the questionnaire: five items scored sufficiently to measure social recognition, four for freedom, seven for friendship, 11 for independence, two for family security, two for responsibility, and one for inner harmony.

These 19 items were then re-written in a form that would allow children to determine, on a continuous scale, the expected effect of the app on their values were they to use it in the future. For example, the item

"I can easily find out where my friends are".

was re-written as

"If I would use this app, It will be [blank space] to find out where my friends are".

Followed below by a semantic differential scale, in the form continuous line labeled e.g. "much less easy" on the left end, "much more easy" on the right end, and "the same" in the middle, see Fig. 5.

The fulfillment of each value was measured through taking the average score of the items that measure its fulfillment according to the panel.

2.4.2. Influence as a tool and a social actor

Influence as a tool was measured in two ways: (1) perceived usability, using two items from the System Usability Scale [33], and (2) behavioral sampling, i.e. recording the codes of body posture and engagement of participants at regular intervals. The codes used were divided into negative and positive. The negative codes (i.e. passive, bored, frustrated, sad) were obtained using a part of the coding scheme used by Markopoulos et al. [34]. The scheme does not include positive codes, therefore the antonyms of the negative codes (i.e. engaged, excited, confident, happy) were used for the positive part of the scheme.

Influence as a social actor was measured using the average of four constructs based on a formal model of social relations for artificial companions [35], namely (1) liking, (2) trust, (3) dominance (reversed) and (4) intimacy. Liking was operationalized using three items from the attitude section in the original Unified Theory of Acceptance and Use of Technology model [36]. Trust was operationalized using five items from the same model's enhanced edition, with "trust" included [37]. We then created one item for dominance and one item for intimacy. When needed, items were written or reworded in a manner suited to the age of participants.

Similar to the values part of the questionnaire, every item in the tool and social actorship part was followed with a continuous line with a negative caption on the left end, a positive caption on the right end, and a neutral one in the middle. For the entire questionnaire, the assigned numerical values ranged from zero for the most negative to ten for the most positive, and five for the neutral, halfway point. The full questionnaire can be found in Appendix B, translated to English from Dutch, the original language.

2.5. Procedure

2.5.1. Earlier preparation

A pilot study with two children aged seven and eight was conducted to assess the ability of similarly aged children to effectively use the app, as well as understand and answer the questionnaire items. The pilot consisted of a short usability study where children successfully performed app-related tasks (including commitment creation), as well as free-testing the app (with their parents) for a period of two weeks, after which children successfully answered the questionnaire we developed. This pilot study validated the ability of children of this age to perform the tasks required for this user study.

2.5.2. Introductory session and preparation

For every BSO, a short introductory session was held one week before the first testing session. During the introductory session, the researchers were introduced to the participating children, and the tutorial video was played. All questions regarding the video and the app's functionalities in general were answered. The children's nicknames and age data was collected, as well as the location names within the BSO. Finally, the signed parental consent forms earlier distributed to the parents through the BSO's employees were collected. Usernames for the participating children and six location objects were created after the end of the session, to be available in the app for the testing sessions. Participating children were split into two groups, each testing a different version of the app and switching the following session as earlier discussed. Children had only members of their own group available in the user list, because children testing the SAEP must not be able to create commitments with children testing the BA.

2.5.3. Testing sessions 1 and 2

Since participants came from three different BSOs, $2 \times 3 = 6$ sessions were conducted in total, two for every BSO (see Section 2.1 for conditions). A testing session lasted approximately one hour, with a period of one week between the two (per BSO) sessions. The following procedure was conducted similarly during both testing sessions.

First, the researchers distributed the mobile devices to the children. Numbered hats of two different colors were distributed, making it easier for the children to distinguish the members of each group, and for the behavioral sampling observer to identify the participant. The 17 instructional mission cards were placed in a box. Every child picked one of the cards, attempted to perform the task, and returned to replace the card with another one. These relatively simple missions were dispatched first to alleviate the learning curve, including the usage of the SC menu for the relevant group, a feature that was not explained in the introductory session. Fifteen minutes into the testing, the remaining 20 missions were added to the pile. At approximately one hour of testing time, the cards were collected from the children and no new cards were handed out. Children were shown the video which contained instructions on answering the questionnaires. Children filled the questionnaires and handed them to the researchers. Researchers

[2] A strict threshold would only include the item if the majority of the panel rated the item as "essential".

[3] For example, questionnaire item 1 in Table B.8 had been rated by at least 9 out of the 11 panelists to be at least a useful item for the value constructs of social recognition, friendship, freedom, and independence, while less than 9 thought it was at least useful for the constructs of inner harmony, responsibility, and family security.

Table 1
Internal reliability analysis before items were removed.

Item	α	
	BA (*WithoutSC*)	SAEP (*WithSC*)
Values		
Friendship (7 items)	.86	.75
Independence (11 items)	.4	.7
Social actorship		
Trust (5 items)	.75	.61

Table 2
Internal reliability analysis after items were removed.

Item	α	
	BA (*WithoutSC*)	SAEP (*WithSC*)
Values		
Friendship (7 items)	.86	.75
Independence (7 items)	.69	.73
Social actorship		
Trust (3 items)	.86	.77

Table 3
Mean and SD for individual values for the app in general, i.e. average of the BA and the SAEP.

	M(*SD*)
Friendship	7.1(1.4)**
Independence	6.4(1.4)**
Family security	
FamSec 1	6.3(1.8)**
FamSec 2	7.7(2.1)**

Note $H0: \mu = 5$, $^{*}p < .05$, $^{**}p < .01$.

were available to assist participating children with technical issues relevant to the app when present, and to explain any questionnaire item children found difficult. During a testing session, one of the researchers (an observer with pedagogical experience) recorded, at regular intervals of approximately seven minutes, the behavior of every child as observed over the designated six locations within the BSO.[4] At the end of each session, mobile phones, hats, and mission cards were collected by the researchers.

2.6. Data preparation and pre-analysis

Thirty-one out of the 34 children participated in both testing sessions. The value of each questionnaire item was measured with a ruler (continuous scale with zero on the extreme left to ten on the extreme right, and a granularity of 0.1), and was digitally stored. Values of the items that had negative captions were reversed. The behavioral sampling data from all 34 children, including the three who participated in only one session, was also digitally stored in longitudinal form, and the codes were enumerated into 1 for positive codes, and −1 for negative codes

The "numerical value" of each of the seven user values earlier identified (i.e. family security, freedom, independence, friendship, social recognition, inner harmony, and responsibility) was calculated for every participant, using the average of the related questionnaire items. That numerical value was calculated once for the BA version and once for the SAEP version. The average of both versions for each of the seven values was also calculated.

The values "social recognition" and "freedom" were measured by sets of items entirely contained within the sets of items measuring "friendship" and "independence", respectively—that is, all questionnaire items that e.g. loaded on "social recognition" were a subset of the items that loaded on "friendship" and so forth. We therefore decided to drop the notion of "social recognition" and "freedom" as separate values. The values "inner harmony" and "responsibility" were measured with only one item, and were subsequently dropped from the list of values. Three values remained, namely "friendship", "independence", and "family security". Family security was split into its two items, i.e. the child's beliefs about (1) parents worrying about their child going to school on their own (FamSec 1), and (2), how well can parents know exactly where they are (FamSec 2).

All of the following statistical analyses were done using R version 3.2.1. An internal reliability analysis was conducted on values and social actorship factors that were measured by more than three items. If Cronbach's α was unsatisfactory for one or both of the two versions, we iteratively removed the least correlating item, until an acceptable α was reached for both versions. Table 1 shows the number of items and α values before items were removed, and Table 2 shows the number of items and α values after the final iteration. Items which were removed during this process are highlighted in the Appendix.

To examine the app's effect on values, value items, perceived usability, and its influence as a social actor, one-sample *t*-tests with $\mu = 5$ were conducted on the averages of individual values (and value items), perceived usability, individual social actorship factors, and social actorship overall. To compare the two versions (i.e. the BA and the SAEP), in terms of their effect on values, value items, perceived usability, and their influences as social actors, paired *t*-tests were conducted for individual values (and value items), perceived usability, individual social actorship factors, and social actorship overall.

To examine the app's effect on children's body posture and engagement, overall as well as between the two versions, two linear mixed-effects (LME) models were created in R using the *nlme* [38] package:

(1) A baseline model $Model_{baseline}$, with behavioral sample as a response variable, random intercepts for BSO and participants (a nested structure, participant inside BSO), using an AR1 correlation matrix and maximum likelihood (ML) as an estimation method.

(2) An updated model $Model_{updated}$, which includes a fixed effect of the app version as an add-on to $Model_{baseline}$.

Data, analysis scripts, and output are available online[5]

3. Results

Table 3 suggests that the app significantly supports all individual values and value items measured: friendship, independence, and FamSec 1 and 2. In all these cases, the value was rated above the neutral cutoff point of 5 of the scale (Fig. 5). Similarly, Table 4 suggests that the app's perceived usability and social actorship were significantly positive, as well as the social actorship items of liking, and trust, while dominance was significantly below the neutral cutoff point.

Table 5 suggests that the SAEP supported the values friendship and independence significantly better than the BA, while no significant difference was found for FamSec 1 and 2.

Table 6 suggests that the perceived usability of the SAEP was significantly higher than the BA, but no significant difference was found for social actorship nor individual social actorship items.

Table 7 shows the frequency of positive and negative behavioral codes for each version.

$Model_{baseline}$ showed that the fixed intercept was significantly above 0, ($b = .51, p < .001$), suggesting that regardless of whether children used the SAEP or the BA, the body language and engagement observed were more often positive than negative.

[4] This time interval was selected as the researcher required approximately seven minutes to perform one round of observation within a BSO.

[5] https://doi.org/10.4121/uuid:3027758d-5b78-46ee-8be6-4eb1727e9764.

Table 4
Mean and SD for perceived usability, individual social actorship factors, and social actorship overall, for the app in general, i.e. the average of the BA and the SAEP.

	M(*SD*)
Usability	7.7(1.7)**
Social actorship	7.4(1.3)**
Liking	8.6(1.3)**
Dominance	1.9(2.3)**
Trust	6.6(3.2)**
Intimacy	6.1(3.1)

Note $H0 : \mu = 5$, * $p < .05$, ** $p < .01$.

Table 5
Mean and SD for individual values, for each of the two versions.

	M(*SD*)	
	BA (*WithoutSC*)	SAEP (*WithSC*)
Friendship	6.8(1.7)	7.4(1.4)*
Independence	6.2(1.4)	6.6(1.5)*
Family security		
FamSec 1	6.0(2.6)	6.5(2.9)
FamSec 2	8.0(2.0)	7.5(2.6)

Note: * $p < .05$, ** $p < .01$.

Table 6
Mean and SD for perceived usability, individual social actorship factors, and social actorship overall, for each of the two versions.

	M(*SD*)	
	BA (*WithoutSC*)	SAEP (*WithSC*)
Usability	7.3(2.2)	8.2(1.8)*
Social actorship	7.5(1.6)	7.5(1.3)
Liking	8.7(1.3)	8.4(1.8)
Dominance	1.5(2.1)	2.2(3.0)
Trust	6.7(3.3)	6.5(3.0)
Intimacy	5.7(3.8)	6.5(3.5)

Note: * $p < .05$, ** $p < .01$.

Table 7
Frequency of positive and negative behavioral codes for each version.

	BA (*WithoutSC*)	SAEP (*WithSC*)
Positive	97	158
Negative	72	9

Comparing $Model_{baseline}$ with $Model_{updated}$, which included the app's version as fixed effect, suggests that adding the app's version as a predictor had a significant effect, with $\chi^2(1) = 52.8, p < .001$ and $R^2 = .21$. This suggests that significantly more positive behavior was observed in the SAEP condition than the BA condition.

4. Discussion and conclusion

4.1. Hypotheses

The analysis of results in Table 3 suggested that children in this experiment expect the presence of a location sharing app to positively contribute to their values of friendship, independence, and family security (confirming H1), while the analysis of results in Tables 4 and 7 suggested that they perceive the app positively both as a tool (confirming H2a) and a social actor (confirming H2b). Analysis of Table 5 also suggested that children in this experiment expect a version of the location sharing app enhanced with the SC model, the SAEP, to provide significantly better support for their values of friendship and independence than the BA, but no significance was found for family security items (partially confirming H3), while the analysis of results in Tables 6 and 7 suggested that they perceive the SAEP more positively as a tool than the BA (confirming H4a), but no significance was found for social actorship (not confirming H4b).

4.2. Contributions and implications

We implemented and evaluated a location sharing application that encompassed a normative regulatory structure, namely an SC model. Results suggested that the addition of the SC model could provide a significant improvement in the application's support for several of the user's values. This is the first study that provides empirical evidence for the argument underlying the vision of SAEPs [7] that social adaptivity in supportive technologies will provide improved support for user values. Moreover, to the best of our knowledge, SC models have not yet been implemented within mobile applications, and for direct user manipulation e.g. through a menu. Additionally, the study brought forth a questionnaire capable, to an extent, of evaluating how certain user values in the family life domain are fulfilled. This questionnaire can be used in future user studies in similar research areas, and be further enhanced upon more frequent usage.

Results also suggest that the SAEP provides improved perceived usability, and according to the behavioral sampling users showed a positive attitude towards the technology (which was significantly more positive in the SAEP case, i.e. when we added the SC model). This provides evidence to counter a possible critique that manual creation of commitments may be too difficult or cumbersome. Although research suggests that the simpler the interaction, the more the technology is likely to be accepted [36], we conjecture that the importance, benefit, and daily routine compatibility of the use of location sharing commitments outweigh the required effort for their creation. That is, people are used to asking others explicitly, for example, to let them know that they got home safely, and acquiring this information is typically important to their peace of mind. Although in future work we may also study how to derive commitments automatically, ensuring transparency and trust in the system's behavior will still require user interaction.

We did not find a significant difference for the value of family security between the BA and the SAEP. It will be interesting to conduct a similar study where parents are involved. Possibly, this value is specifically salient for parents with regards to their children. This may mean that the ability to make commitments with their children on what (not) to share with whom may have a more of a (positive) effect on how *parents* perceive fulfillment of this value in comparison to how it is perceived by children.

Moreover, we did not find a significant difference between the BA and the SAEP for perception as a social actor. It would be interesting to further investigate how the social adaptivity of SAEPs affects social actorship factors such as trust. In particular, the aspect of (perceived) control over the SAEP behavior from the perspective of the supported person may be relevant here. In the BA one could say that the child is in full control, without influence from others: check-ins are only shared when the child explicitly does so. In the SAEP, there is some outside influence since others can propose commitments regarding location sharing that may differ from what the child would normally do. Nevertheless the child does have the freedom to decide whether or not to accept a commitment, and commitments can be made specifically for those contexts where data sharing is desired by the two parties. In applications such as Life360 on the other hand, one might say that parents have full control as the app allows them to see where their children are at all times. Further studies will have to be conducted to investigate the relation between social adaptivity and perception of social actorship.

4.3. Limitations

Conducting user studies involving children in the primary school age can be a challenging task [39]. Because evaluating a location-sharing app with social adaptivity required the simultaneous engagement of multiple users, we conducted our user

Table B.8
Questionnaire part used to measure user values, and the values each item measures (translated from Dutch).

No.	Statement	Labels	SR	FR	FD	ID	IH	RS	FS
1	If I would use this app, it would be [blank] for me to make appointments with friends, for example to go to the park, playground or school.	Much less easy, the same, much easier	×	×	×	×			
2	If I would use this app, it would be [blank] for me to find out if my friends are playing outside.	Much less easy, the same, much easier	×	×					
3	If I would use this app, it would be [blank] for me to go to the playground with friends.	Much less easy, the same, much easier		×					
4	If I would use this app, it would be [blank] for me to remain in contact with my friends.	Much less easy, the same, much easier	×	×					
5	If I would use this app, it would be [blank] for me to go and play at one of my friends'.	Much less easy, the same, much easier	×	×		×			
6	If I would use this app, it would be [blank] for me to find out where my friends are.	Much less easy, the same, much easier		×					
7	If I would use this app, it would be [blank] for me to visit family members (like my grandfather, grandmother, aunts, uncles, and cousins.	Much less easy, the same, much easier			×	×			
8*	If I would use this app, the number of arguments with my parents would probably become [blank].	Much less, the same, much more					×		
9*	If I would use this app, it would be [blank] to go on a family visit on my own.	Much less scary, the same, much scarier				×			
10*	If I would use this app, it would be [blank] to go visit a friend on my own.	Much less scary, the same, much scarier				×			
11*[i]	If I would use this app, it would be [blank] to go to school on my own.	Much less scary, the same, much scarier				×			
12*[i]	If I would use this app, my parents would [blank] tell me what to do, like my homework for example.	Much less often, the same, much more often			×	×			
13*	If I would use this app, my parents would worry [blank] if I go to school on my own.	Much less, the same, much more							×
14*[i]	If I would use this app, my parents would probably treat me [blank] like a child.	Much less, the same, much more			×	×		×	
15[i]	If I would use this app, my parents would allow me [blank] to visit friends who live far from me.	Much less, the same, much more				×			
16	If I would use this app, I would be [blank] to go to certain places in my neighborhood.	Much less confident, the same, much more confident				×			
17	If I would use this app, my parents would allow me [blank] to go to school on my own.	Much less often, the same, much more often				×			
18	If I would use this app, my father and mother would know [blank] exactly where I am.	Much less often, the same, much more often							×
19	If I would use this app, my friends would know [blank] where I am.	Much less often, the same, much more often	×	×					

Values: SR = social recognition, FR = friendship, FD = freedom, ID = independence, IH = inner harmony, RS = responsibility, FS = family security. Items with an asterisk (*) are reversed during calculations. Items marked with (i) were removed as a measure of the value "independence" during reliability analysis.

studies within day-care centers–simulating real life situations with a game of "missions". This setup allowed us to test the app with groups of children as the main target group, but we could not test for parents–children interaction. Moreover, the study tested the app only in a simulated setting. A follow up step would be to extend the evaluation to involve both parents and children, in a real life setting for a prolonged period of time. This would also help rule out the novelty effect of the app, which may have influenced the children's perception and attitude towards the technology, as well as their behavior during the user studies.

Further, the experiment was setup through creating a situation where the presence of an SC model was itself of benefit to the usage of the mobile app—i.e. the tasks provided an opportunity for the SC model to show its capabilities. In less ideal situations, no significant difference (or even a significant opposite effect) may be found. Therefore, future research is needed: this experiment only shows that at least under these conditions the SC model made a positive contribution.

Had the results of the analysis, however, shown that the BA provided a significantly better support for any of the measured

values than the SAEP, this would have provided grounds for us to reject hypotheses H3 and H4.

Moreover, we used convenience sampling, i.e. children who were able to obtain permission from their legal guardians to participate. This limits our ability to generalize our findings.

Furthermore, a questionnaire that measures fulfillment of user values for children was, to the best of our knowledge, unavailable. We therefore developed and validated the content of our own questionnaire for that purpose. Some of the items of the questionnaire suffered from low reliability, and a confirmatory factor analysis would have proven ineffective with a small sample size of 31 [40], as well as below threshold subject-to-variable ratio of 31/19 [41]. Furthermore, the behavioral sampling data was collected by a single observer and thus is subject to bias, and it may be difficult to determine how the sampling approach affected our findings. Also, though the observer was not informed which group was testing which version, this could have been inferred through observing how certain participants interacted with the SC menu, which may have added to the observer's bias.

However, and to the best of our knowledge, we were the first to conduct a user study of simulated real-life tasks with primary school children within a day-care environment using measurement tools specifically created for human values. The novelty of the methods and tools used within this user study could prove very useful for researchers conducting studies with similar target groups.

4.4. Future work

An interesting next step would be to investigate possible conflict resolution policies, which would allow the SAEP to automatically determine the precedence of active social commitments in case of conflicts. Such policies may rely on contextual data (e.g. location, time, motion), and users' value profiles.

Moreover, the SC model which was used in this study was developed specifically for location sharing apps in the family life domain, and was kept simple enough to be used by children of primary school age. Interesting future work could include (1) testing the validity of our findings on social apps that share more than just location information, e.g. text, photos, and videos, and (2) increasing the expressivity of the syntax involved to fit such wide range of applications and users, while maintaining its usability. It would also be interesting to embed such SC models in the specifications of even more complex socio-technical systems, and investigate the type of conflicts that may occur as a result of multiple stakeholders with different requirements, as well as the solutions for such conflicts.

Further, conducting a prolonged, real-life user study with the app(s) involving a larger sample size including both parents and children will allow to run a confirmatory factor analysis which would allow the questionnaire developed specifically for this study to become more reliable, as well as more usable by researchers within this domain.

4.5. Final remarks

As the findings suggest, the presence of a location-sharing app such as the one presented in this paper can provide support to children's values on average, as well as a positive influence as a tool and social actor. The findings also show the potential that the normative, SC models have in allowing location-sharing applications, and potentially other social media applications, to play a more positive role in the lives of their users.

Table B.9
Questionnaire part used to measure perceived usability and social actorship (translated from Dutch).

No. & Statement	Labels
Usability	
20. The app was easy to use.	No, in between, yes
21. I understand how he app works.	No, in between, yes
Social actorship	
Liking	
22. I liked using the app.	No, in between, yes
23. I would like to use the app in the future.	No, in between, yes
24. I would tell others about the app.	No, in between, yes
Dominance	
25. I feel like the app acts like a boss over me.	No, in between, yes
Trust	
26. I feel that the app does what I want it to do.	No, in between, yes
27. I think the app does nothing sneaky.	No, in between, yes
28^{t}. I think the app is honest.	No, in between, yes
29. I think the app would never tell on me.	No, in between, yes
30^{t}. I think the app can keep a secret.	No, in between, yes
Intimacy	
31. The app is a friend.	No, in between, yes

Items marked with (t) were removed as a measure of the social actorship item "trust" during reliability analysis.

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Appendix A. Mission cards examples

- Go to the school yard. Ensure that your friends know that you are there.
- Ask a friend to always let you know if he/she is in the atelier.
- Try to find out where everyone is via the event log. If you can find a few, add them to your friend list. If not, try to find someone outside that you can add to your friend list.
- You'd like to know whenever someone specific is at the day-care center. Ask him/her to let you know whenever he/she arrives at the bicycle parking.

Appendix B. Questionnaire

Table B.8 shows the questionnaire part used to measure user values, and the values each item measures. Table B.9 shows the questionnaire part used to measure perceived usability and social actorship.

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